TEMPORAL FACTORS ASSOCIATED WITH MEASUREMENTS OF ORAL STEREOGNOSIS

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

KENNETH GORDON SMITH

1973

This is to certify that the

thesis entitled

Temporal Factors Associated with
Measurements of Oral Stereognosis

presented by

Kenneth Gordon Smith

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Speech Pathology

[signature]
Major professor

Date August 24, 1973

TEMPORAL FACTORS ASSOCIATED WITH MEASUREMENTS OF ORAL STEREOGNOSIS

By

Kenneth Gordon Smith

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Audiology and Speech Sciences

1973

ABSTRACT

TEMPORAL FACTORS ASSOCIATED WITH MEASUREMENTS OF ORAL STEREOGNOSIS

By

Kenneth Gordon Smith

In the recent study of oral sensation and perception the question of temporal factors associated with measurements of oral stereognosis has received scant attention. This study compared the effects of varying three temporal factors associated with administrating a test of oral stereognosis.

The first factor was intra-oral duration of stimulation by a single form (3, 5, and 7 seconds). The second factor was the interval between the two items within each pair of forms (3, 5, and 7 seconds). The third factor was the interval between presentation of pairs of forms (5, 7, and 9 seconds). These three factors were referred to in abbreviated form: intra-oral duration, within-pairs interval, and between-pairs interval respectively. The stimuli employed in this investigation were ten geometric plastic forms known as the Ringel Forms.

Before the actual experiment, cassette tapes were prepared with tones marking time periods appropriate for presenting the stimuli. These tones provided auditory cues to the examiner and the subjects indicating the various combinations of the three temporal factors. 45 young adults with normal articulation and hearing received 27 treatments, including all possible combinations of the three intra-oral durations, the three within-pairs intervals, and the three between-pairs intervals. Each treatment consisted of 55

pairs of Ringel Forms which was the total number of pairings possible when each form was paired with itself and with every other form. The subjects were required to indicate verbally whether the two items in each pair of forms were the same or different in a simple discrimination task, as the forms were placed on the tip of the tongue for passive perception.

Results indicated significant differences in number of errors ($p<0.05$) for the factors of within-pairs interval and between-pairs interval. Although there was not a statistically significant main effect for the factor of intra-oral duration, there was more difference in number of errors between the three-second and five-second durations than between the five-second and seven-second durations. The results indicated that as the within-pairs interval increased the error score increased, but that as the between-pairs interval increased the error score decreased. These results support the suggestion that short-term memory is a significant consideration in performance on this task.

It was concluded that in the clinical application of a test of oral stereognosis, employing the stimuli and techniques described in this study, the intra-oral duration should be five seconds, the within-pairs interval should be three seconds, and the between-pairs interval should be nine seconds. It was also suggested that some of the pairs of forms were redundant and could be eliminated in the clinical situation.

TEMPORAL FACTORS ASSOCIATED WITH MEASUREMENTS OF ORAL STEREOGNOSIS

By

Kenneth Gordon Smith

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Audiology and Speech Sciences

1973

Accepted by the faculty of the Department of Audiology and Speech Sciences, College of Communication Arts, Michigan State University, in partial fulfillment of the requirements for the Doctor of Philosophy degree.

Thesis Committee:

Daniel S. Beasley, Ph.D. Director

Y. Pal Kapur, M.D. Co-Director

Abram M. Barch, Ph.D.

Leo V. Deal, Ph.D.

Herbert J. Oyer, Ph.D.

ACKNOWLEDGMENTS

In the course of investigation as reported in this thesis, I have expressed by heartfelt thanks to the members of my committee. Now, I take this opportunity to formally express my gratitude to Dr. Barch, Dr. Deal, Dr. Oyer, and the Co-Director of my thesis, Dr. Kapur. The words of encouragement, and the detailed constructive criticisms these professors have offered have been most welcome support during the months of research and writing.

I wish to pay special tribute to my Director, Dr.Beasley for his sustained moral support, clear discernment of the issues important to my research, as well as detailed suggestions at every stage of the research.

Lastly, and most importantly, I thank my dear wife, Elfriede, for her patience, love and prayerful support through many trying months.

Kenneth G. Smith

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

CHAPTER Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The case load of a speech pathologist typically reveals a predominance of individuals with articulatory deficits (Johnson, Darley and Spriestersbach, 1963). Many of these individuals are categorized as having "functional articulation" problems. The speech pathologist has either accepted this label from other professional personnel or has himself so diagnosed the deficit. The diagnosis is typically based on an evaluation in which an articulation test and an oral examination are important aspects. The oral examination consists of a visual inspection of the oral cavity and observation of the response elicited when the client is told to move the articulators in certain prescribed ways.

Recently, some investigators (Jenkins and Lohr, 1964; McDonald, 1964; Aungst, 1965; Ringel et al., 1968; Fucci and Robertson, 1971; Fucci, 1972; and Ruscello and Lass, 1973) have questioned the use of terms such as "functional," "non-organic," and "developmental" as applied to articulatory-impaired individuals. They have contended that these terms may be misleading if applied to articulatory deficits which are not recognized as organically based because of the lack of precision of the presently available measuring devices.

Whereas the auditory channel has been employed predominantly in diagnosis and therapy of speech disorders, the evidence suggesting that certain cases of "functional" speech disorders are related to reduced feeling in the mouth may have important implications for speech pathology (La Pointe and Williams, 1972). If, in diagnosis of articulatory defective speech, appropriate tests can determine whether the cause is primarily motor or sensory, then planning therapy would be greatly enhanced.

Recent considerations in the theory of speech production, to be discussed later, have influenced researchers in speech pathology to look upon speech as a behavior which can be modified more effectively by training procedures that involve speech rather than nonspeech acts (Shelton et al., 1970b). If, as Fucci and Robertson (1971) suggest, the term "functional" is not always appropriate for non-organic articulation cases, then perhaps speech pathologists should consider the employment of a therapeutic approach which would allow for correction of, or compensation for, sensory deficits. Fucci and Robertson suggest using an oral-tactile orientation which may be more suitable in some individual cases as a rehabilitative method.

Building on the concepts of Fairbanks' servosystem model of speech production (Fairbanks, 1954), "servotherapy" has been suggested as an alternative treatment for use by speech therapists (Mysak, 1959). In such an approach, the therapist tries to superimpose his speech system upon the client's. The aim is to begin with this open cycle control (using stimulation and guidance techniques), which hopefully will become a closed cycle control as the client internalizes the new formations and begins monitoring his own performance (Mysak, 1959).

Recognition of the limitations of the procedures now in use in speech pathology has prompted considerable effort to study and develop methods of testing oral sensation and perception (Bosma, 1967 and 1970). Studies in the area of oral sensation and perception may be divided into those studies concerned with oral sensory thresholds (McCall, 1969; Ringel, 1970; McCall and Cunningham, 1971; Fucci, 1971 and 1972; Fucci et al., 1972; Hall et al., 1972; Lass et al., 1972a; Telage et al., 1972; and Williams and La Pointe, 1972), and oral sensory discrimination (Aungst, 1965; Arndt et al., 1970a; Arndt et al., 1970b; Fucci and Robertson, 1971; Bain, 1973; La Pointe and Williams, 1973; and Torrans and Beasley, 1973).

The review of literature pertinent to a study of oral sensation and perception has been divided into four sections: (1) Definitions, (2) Theoretical considerations on oral stereognosis, (3) Relative sensitivity of oral structures, (4) Intra-oral discrimination versus visual matching tasks. This chapter closes with a Statement of the problem.

Definitions

Kinesthesis

This sense conveys knowledge of position as well as movement and is probably man's most important sensitivity, enabling a person to maintain an erect posture as well as walk, talk, and engage in other skilled activities (Jenkins, 1951). Kinesthetic sense is mediated by the nerve endings embedded in the tissues of the muscles, tendons and joints. These nerve endings are stimulated by the pressure and strain resulting from movement (Gray and Wise, 1959). The primary stimulation of the tendon endings occurs when the muscle contracts. The muscle endings are activated as a muscle relaxes and lengthens when its antagonist contracts. So the muscle and tendon endings complement each other in recording muscular changes. Sensitivity at the joints may be mediated by Pacinian corpuscles which are found abundantly in the tissue surrounding the joints (Jenkins, 1951).

Proprioception

A proprioceptor is a sense organ for detecting the position and spatial relations of a muscle and is located in the muscles or tendons. Proprioception is generated within the body from kinesthetic sensations and sensations of equilibrium or balance or of any deep sensation of muscle and joint position (Gray and Wise, 1959; Chusid and McDonald, 1967; and Zemlin, 1968). Information from these proprioceptors is transmitted to the central nervous system. "This is the principle of feedback whose essential machinery is the stretch reflex and whose governing centers are, to an appreciable extent, below the cerebrum, making these reflexes basically unconscious" (Kaplan, 1960, p. 9).

Kinesthesis involves consciousness of muscle movement, position, and tension (Shelton, Arndt, and Hetherington, 1967). Consequently the term "kinesthesis" is probably more appropriate than "proprioception" for oral perception since the former term allows reference to sense of position <u>and</u> movement.

Stereognosis

Etymologically, the word derives from two Greek words: <u>sterio</u>, solid, and <u>gnosis</u>, knowledge. Manual stereognosis perception is the ability to recognize, without the visual sense, the size, weight and shape of objects. Stereognosis is not a separate sense, but is a combination of the senses of touch, spatial discrimination, cutaneous localization, and kinesthesis (Best and Taylor, 1961). Stereognosis requires the integrity of the central integrating processes of the cerebral cortex (Chusid and McDonald, 1967; and Shelton et al., 1967).

Oral Stereognosis

Within the oral cavity the synthesis of different sensations, particularly kinesthesis and touch, is referred to as oral stereognosis (McCall, 1969). Obviously this is a complex perception involving not only touch and kinesthesis, but also a higher degree of neural integration than the basic senses. The speech pathologist is interested in oral

stereognosis since it may prove to be a sensitive indicator of the ". . . complex oral somesthetic feedback which is an essential part of the sensory-motor process by which speech is produced" (Aungst, 1965, p.3).

If a person is unable to perceive and identify the form of an object through oral manipulation, the appropriate term is astereognosis regardless of whether the deficit is of an organic or functional nature (Woodford, 1967). Avoiding the term oral stereognosis, Moser, LaGourgue, and Class (1967) use the term "lingual form perception" and suggest that a deficiency here may be an indication of delayed development or "organic disintegration of faculties" resulting in the hindrance of normal speech development (p. 244).

Theoretical Considerations on Oral Stereognosis

Many of the reported studies on oral stereognosis have discussed speech production in terms of the feedback theory described by Fairbanks (1954). The Fairbanks' model depicted speech production as analogous to a servosystem which could be regulated by automatic controls. In his system, Fairbanks theorized that the speech output is monitored by a control mechanism, where the output is compared with the input, Then, the output producing device is manipulated so that the output will have the same functional form as the input. Thus, the speaker monitors his output by reference to how an utterance sounds and feels when it is produced (Fairbanks, 1954, p. 135).

If Fairbanks' servomechanistic (or closed-loop) theory of speech control is valid, then speech under conditions of neurosensory deprivation should be more seriously disturbed and less intelligible than has thus far been demonstrated. Schliesser and Coleman (1968) reported a study in which five normal-hearing male subjects were required to read sentences under the condition of auditory masking and reduction of tactile sensation by anesthetization of the oral area. The judgment of the investigators was that, under this condition, the intelligibility of the speech was adequate and that the speech was less defective than a "moderate" clinical speech problem. Schliesser and Coleman concluded that, at least for the short term, an individual can speak satisfactorally in terms of accuracy of articulation, rate of speaking, and inflection in the absence of auditory or tactile sensation.

In a similar, though informal, experiment five subjects read a test passage and made spontaneous remarks, while deprived of auditory and tactile feedback. The results of this experiment indicated that although speech was "very disorganized" in the absence of auditory and tactile feedback, it was still intelligible (Ladefoged, 1967).

On the other hand, an open-loop theory of speech control, postulating no dependence on sensory feedback, would presuppose no change in articulatory accuracy under the same conditions. Consequently, experimental results would tend to support not a closed-loop <u>or</u> open-loop system, but rather one which indicated that precision in articulation is dependent on a combined open-loop <u>and</u> closed-loop system. Scott and of speech control is valid, then speech under conditions of neurosensory deprivation should be more seriously disturbed and less intelligible than has thus far been demonstrated. Schliesser and Coleman (1968) reported a study in which five normal-hearing male subjects were required to read sentences under the condition of auditory masking and reduction of tactile sensation by anesthetization of the oral area. The judgment of the investigators was that, under this condition, the intelligibility of the speech was adequate and that the speech was less defective than a "moderate" clinical speech problem. Schliesser and Coleman concluded that, at least for the short term, an individual can speak satisfactorally in terms of accuracy of articulation, rate of speaking, and inflection in the absence of auditory or tactile sensation.

In a similar, though informal, experiment five subjects read a test passage and made spontaneous remarks, while deprived of auditory and tactile feedback. The results of this experiment indicated that although speech was "very disorganized" in the absence of auditory and tactile feedback, it was still intelligible (Ladefoged, 1967).

On the other hand, an open-loop theory of speech control, postulating no dependence on sensory feedback, would presuppose no change in articulatory accuracy under the same conditions. Consequently, experimental results would tend to support not a closed-loop <u>or</u> open-loop system, but rather one which indicated that precision in articulation is dependent on a combined open-loop <u>and</u> closed-loop system. Scott and

Ringel (1971a) explain that the speech mechanism

> . . .operates in response to autonomous motor commands (or target specifications) which are largely manner types of instructions. Having issued such instructions, however, the speech mechanism calls for certain closed-loop refinements which are particularly prominent for phonemes involving precise types of apical and blade configurations, such as sibilants and the consonant /r/. Information from oral receptors appears to be a necessity for the successful execution of certain labial, apical and blade refinements which are more important for some phonemes than for others. (p. 815)

Fairbanks (1954) recognized auditory and tactile-proprioceptive sensory systems operating to monitor speech production. He theorized that the control system was primarily influenced by auditory feedback, whereas the tactile-proprioceptive (or somesthetic) afferent system was considered to be of secondary importance. Although Fairbanks could not deny the possibility that the tactile-proprioceptive system might supply information about the operation of the speech mechanism, he did suggest that this sense probably did not supply the more refined information about speech output which he assigned to auditory feedback. Ringel (1970) has offered a modification of the servosystem, suggesting that tactile information about articulatory contacts made during the production of <u>some</u> consonants may not be crucial to the feedback mechanism operating for speech and that theories about the relative importance of feedback systems should consider interaction with age as an important factor. It is quite possible that as a person matures, the feedback system which is primarily important during the stage of speech acquisition is replaced by a different system of feedback when speech activities are stabilized (Ringel, 1970).

The progression from one type of feedback control to another as an individual matures, has been stated clearly by Van Riper and Irwin (1958), who maintained that the auditory sense is primarily important as a check on the correctness or incorrectness of speech during the stage of learning the patterns of speech utterance. However, once these patterns are learned and internalized, it is the tactile or kinesthetic feedback which is of primary importance (Van Riper and Irwin, 1958).

As an illustration of the importance of tactile or kinesthetic monitoring systems over time, sixteen children, ages 7-9, enrolled in speech therapy, were tested for articulation competency and oral tactile perception over a nine month period. The results showed a positive relationship between articulation proficiency and oral tactile perception (Ruscello and Lass, 1973). The authors did not state whether they consider the observed improved scores a function of maturation or administration of therapy since there was no control group of subjects. On the other hand, Shelton et al. (1973) demonstrated that the relationship which exists between oral sensation and articulation competency did not indicate that manipulation of one variable is effective in influencing the other.

Drawing a parallel from the sense of hearing, Hardy (1970) has noted that auditory discrimination, which appears to be an imprecise skill in the young child, improves as a function of age. That is, with increasing age, the auditory monitoring system (error-detector) imposes progressively narrower limits on the latitude of allowable error. Hardy has suggested that a similar pattern of development is likely for tactile-proprioceptive networks.

> As the sensori-motor system improves its ability to reproduce the signal that its auditory error-detecting system is perceiving, the tactile and proprioceptive patterns become more restricted and, thus, learned through the less variable muscular behavior. Eventually, then, those tactile-proprioceptive patterns will become relatively fixed as the precision of the speech-producing musculatures stabilize. (Hardy, 1970, p. 62)

In keeping with the foregoing discussion several investigators (Ringel, Burke and Scott, 1968; Robertson, Fucci and Fokes, 1969; Fucci, 1972; and Shelton et al., 1973), have found that adult subjects showed decreased oral sensitivity in proportion to the severity of articulatory problems. Other investigators (Aungst, 1965; Locke, 1969; Arndt et al., 1970b; and Madison and Fucci, 1971), however, found that when children were the subjects there was no reliable relationship between articulation errors and performance on tests of oral stereognosis.

Several studies (Shelton et al., 1967; Arndt et al., 1970a; Ringel, 1970; and Ringel et al., 1970b) have shown that increasing age, or maturation in articulatory ability, plays an important role in the proficiency of an individual's use of oral stereognostic skills. Ringel (1970) has suggested that in the adult the motor abilities and oral cavity size are more fully developed than in the child, permitting more efficient oral palpation of the stimulus forms.

Relative Sensitivity of Oral Structures

Although the oral cavity consists of many different structures, it performs uniquely as a single sensorimotor organ; and it is within this organ that the highest sensorimotor integrations are achieved (Bosma, 1967). Lass et al. (1972a) tested the sensitivity of lips, tongue and finger tip since these areas of the body surface are the most sensitive to touch (Kenshalo, 1971). They found that, within the limits of their study, the tongue tip showed the most sensitivity and the tongue dorsum and lower lip showed the least sensitivity. Also midline regions of the oral structures were more sensitive than the lateral margins; and some difference in sensitivity existed between left and right sides of these structures, although these lateral differences appeared random and unrelated to handedness (Rutherford and McCall, 1967; McCall and Cunningham, 1971; and Lass et al., 1972a). Other studies have consistently reported that of all the oral structures, the tongue tip is the most sensitive and shows the least variability to light touch and two-point discrimination (Grossman, 1964 and 1967; Gibson, 1967; Henkin and Banks, 1967; McCall, 1969; Fucci and Robertson, 1971; Kenshalo 1971; and Lass et al., 1972b). Moser et al. (1967) have noted that the tongue is a midline structure with half left and half right (double) innervation. Therefore, as the tongue becomes narrower towards the tip, the nerve endings become proportionately more numerous resulting in the great sensitivity of the tip of the tongue.

The two-point discrimination task referred to above has been employed as a method for establishing a threshold of tactile sensitivity. The two-point threshold is lowest at the point of the tongue tip, where clear discrimination between two points measured 1 mm. By comparison, the two-point threshold for some parts of the back, thigh or upper arm measured 68 mm (Woodworth, 1938; Bosma, 1967; and Paine, 1967). The perception of the difference between one and two points is not clear-cut, but rather a progression through stages: point, line, circle, oval, dumbell, and so on, before two distinct points are recognized (Jenkins, 1951; and McCall, 1969).

Another measure of cutaneous sensitivity is the pressure threshold. Referring to an experiment by von Frey (1894), Woodworth (1938) reports that the stimulus threshold for pressure on the tip of the tongue is 2 grams/mm^2.

It is evident, therefore, that the tongue tip is of paramount importance in oral sensitivity and manipulative ability for study of the skills involved in oral stereognosis (Ringel, 1970).

Intra-Oral Discrimination Versus Visual Matching Tasks

In oral stereognosis testing two principle methods which have been employed require a subject to (1) identify a form in the mouth by pointing to a form or picture of a form on a visual display or (2) make a "same" or "different" decision about a pair of forms examined intra-orally. Bosma (1967) has noted that the hand is most sensitive tactually at the finger

The two-point discrimination task referred to above has been employed as a method for establishing a threshold of tactile sensitivity. The two-point threshold is lowest at the point of the tongue tip, where clear discrimination between two points measured 1 mm. By comparison, the two-point threshold for some parts of the back, thigh or upper arm measured 68 mm (Woodworth, 1938; Bosma, 1967; and Paine, 1967). The perception of the difference between one and two points is not clear-cut, but rather a progression through stages: point, line, circle, oval, dumbell, and so on, before two distinct points are recognized (Jenkins, 1951; and McCall, 1969).

Another measure of cutaneous sensitivity is the pressure threshold. Referring to an experiment by von Frey (1894), Woodworth (1938) reports that the stimulus threshold for pressure on the tip of the tongue is 2 grams/mm^2.

It is evident, therefore, that the tongue tip is of paramount importance in oral sensitivity and manipulative ability for study of the skills involved in oral stereognosis (Ringel, 1970).

Intra-Oral Discrimination Versus Visual Matching Tasks

In oral stereognosis testing two principle methods which have been employed require a subject to (1) identify a form in the mouth by pointing to a form or picture of a form on a visual display or (2) make a "same" or "different" decision about a pair of forms examined intra-orally. Bosma (1967) has noted that the hand is most sensitive tactually at the finger tips and that a comparable arrangement applies to the mature human mouth. The tongue probes with its very sensitive tactile tip within the mouth which is lined with receptor-rich walls like a "chambered sensorium" similar to the eye or inner ear. Within the mouth, the tongue measures and manipulates, using a reference of dimensions and meaningful measurements unique to the oral cavity. The sensations the tongue receives are relayed to the nervous system in terms of oral anatomical relationships. On the other hand, the fingers and the eye receive sensations in terms of the geometric relations of the external world; and information received through the hand or the eye is conveyed to the nervous system in that frame of reference (Bosma, 1967, p. 351).

Recognizing the probability of different kinds of information being conveyed by two different modalities, Ringel et al. (1968) expressed concern about the confusion which may result from the intersensory approach in testing oral stereognosis. Therefore, these authors suggested that if an experimenter is attempting to obtain information about the tactile modality in the oral cavity, his measurements must be limited primarily to that modality in order to avoid the contamination which may result from involving other sensory channels, such as vision. La Pointe and Williams (1973) have also shown that some subjects will perform better with a unimodal presentation than with a presentation involving more than one sensory modality.

In an attempt to decide on a method yielding consistent

performance in oral stereognosis, Lass, Tekieli, and Eye (1971) compared an intra-oral discrimination task with an inter-sensory matching procedure. These investigators employed 30 female subjects who exhibited normal hearing, speech articulation, neurological history, superficial tactile sensation, oral cavity structure, and vision. The authors found that 21 of their subjects made fewer errors on the visual matching task than on the intra-oral discrimination task. They hypothesized that there was a memory factor involved; this hypothesis was partially supported by their subjects' introspective statements that they performed poorer because they had had so little experience in the discrimination task. In their discussion, the authors noted that their procedure was different from that of Ringel et al. (1968) who had found consistent results on the intra-oral discrimination task. One of the differences between the Lass et al. and Ringel et al. studies was that the former investigators used eleven forms instead of ten, as used by Ringel et al. As pointed out by Torrans (1972), the additional form used by Lass et al. was a triangle, and it is significant to note that the largest number of errors made under both conditions (intra-oral discrimination and visual matching) involved the triangular shapes (Lass et al., 1971).

Lass, Tekieli, and Eye expressed surprise at the results of their experiment since the discrimination task, *prima facie*, would be expected to prove easier than visual matching. Whereas in the former case the probability of making a correct choice by chance alone was 0.5, in the latter case the probability of such an occurrence was only 0.2. In two recent investigations the question of type of response has been further studied. Torrans and Beasley (1973) compared the performance of forty young adults on different combinations of form sets, two oral form retention times (five seconds and unlimited) and two types of responses (a visual matching task and an intra-oral discrimination task). The results of this study indicated that scores on a test of oral stereognosis varied significantly depending upon the methodology employed. One of the results was that the intra-oral discrimination task was easier and yielded more consistent findings than the visual matching task. Bain (1973) investigated subject performance on the task of intra-oral discrimination and found more consistent results than the visual matching task, thereby corroborating the results reported by Torrans and Beasley (1973).

Thus contradictory reports are found in the literature; some investigators contending that the preferred method of oral stereognostic testing is intra-oral discrimination, whereas others have found better results by employing the visual matching method. Based upon their results, Torrans and Beasley (1973) have speculated that if Lass et al. (1971) had used the same set of ten forms as used by Ringel et al. (1968) and Torrans and Beasley (1973), their results would have supported the claims made for the intra-oral discrimination task and would have paralleled the results reported by

Torrans and Beasley.

In a study comparing the methods employed in testing oral stereognosis (Torrans, 1972), a lack of consistency in results was traced to failure to use standardized methodology in test construction, test administration, and scoring and reporting results, to mention some of the more important uncontrolled variables. As expected, the intra-oral form discrimination task, involving no intermodality confusion factors, yielded the most consistent results (Torrans and Beasley, 1973). Consequently, this method will be followed in the present study. Of the many parameters examined in the study of oral stereognosis, time intervals and duration of stimuli have received only casual consideration when reporting the use of geometric forms. Sometimes the subject has been given unlimited time for oral exploration of the form, whereas in other experiments the subject was limited to a maximum duration of five seconds for the same task (Torrans, 1972).

The temporal factor in auditory perception has been investigated by Beasley and Shriner (1973). In this study, the authors covaried stimulus duration and interstimulus interval ratios of sentential approximations. The results of this study indicated that temporal factors were important in auditory perceptual processing, the stimulus duration being more crucial for perception than the inter-stimulus interval.

To this investigator's knowledge, the within-pairs temporal interval and between-pairs temporal interval have not been subjected to critical examination. Arndt et al. (1970b) proposed a "pure" measure of oral stereognosis that required a subject to discriminate between a pair of simultaneously presented forms (attached to a single wand) which the subject could explore orally. It was thought that this technique would provide a unimodality task while avoiding the problem of short-term memory (a problem which might arise if two items of a pair were presented successively with a five second interval). However, the authors failed to consider another problem, namely the differential sensitivity within the mouth. This problem might arise if the two items of a pair of forms, presented simultaneously, were not available at the same time to the most sensitive part of the tongue.

The question of short-term memory was studied by Lass and Clay (1973). They found that there was no significant difference between the conditions of simultaneous presentation of forms and pairs of forms presented with a five second interval. This would indicate that memory (at least up to five seconds) is not a factor which would make a task of intra-oral discrimination more difficult than when the pair of items are presented simultaneously. The authors suggest that the reason for this may be the differential sensitivity of the various parts of the mouth, especially the tongue which is most sensitive at the midline and at the tip.

The authors suggest that further research should look at this question of time intervals to determine whether intervals of time longer than 5 seconds will have an adverse effect on performance.

Torrans and Beasley (1973) found that another factor contributing to score variability of oral stereognostic measures was form retention time which interacted with answer type and form set. This variable was limited to a five second retention time and unlimited retention time for manipulation of the geometric forms. In order to include an oral stereognosis test in the clinical setting, it would be useful to know whether, and to what extent, temporal variables are important.

Statement of the Problem

The possibility exists that temporal factors which have been shown to be significant in auditory perception (Beasley and Shriner, 1973) may also play an important role in oral sensation and perception. Several temporal factors may contribute to differential oral sensory responses: (1)intra-oral duration of stimulation by a form, (2) interval between the two items within each pair, and (3) interval between presentation of pairs of items. (In future references to these three conditions, they will be abbreviated as follows: (1) intra-oral duration, (2) within-pairs interval, and (3) between-pairs interval.)

The purpose of the present investigation is to explore the effect of varying the temporal factor in three ways as indicated above, noting the manner in which these variables interact with one another. Specifically, the following questions will be investigated:

(1) Will intra-oral durations of 3, 5, and 7 seconds

result in different oral stereognostic scores for young adult subjects with normal articulation and normal hearing?

(2) Will within-pairs intervals of 3, 5, and 7 seconds result in different oral stereognostic scores for young adult subjects with normal articulation and normal hearing?

(3) Will between-pairs intervals of 5, 7, and 9 seconds result in different oral stereognostic scores for young adult subjects with normal articulation and normal hearing?

CHAPTER II

EXPERIMENTAL PROCEDURES

This chapter provides details concerning the subjects, experimental conditions, and experimental procedures employed.

Subjects

The subjects of this study were 45 young adults (16 - 30 years of age) having no history of neurological or sensory defects. All subjects were required to (1) pass a pure tone audiometric screening test at 500, 1000, and 2000 Hz at 25 dB (re ANSI), (2) exhibit normal conversational speech articulation as judged by a speech pathologist, and (3) refrain from smoking, eating or drinking anything except water for two hours prior to being tested. In addition, all subjects were blindfolded during the testing session to eliminate visual cues.

Experimental Conditions

The stimuli employed in this investigation were ten geometric plastic forms known as the Ringel Forms. This set of forms was chosen because of its demonstrated discriminatory effect on varying degrees of subject sensitivity to oral sensation and perception (Torrans and Beasley, 1973).

All 45 subjects received pairs of forms at the three

between-pairs intervals (5, 7 and 9 seconds). Of these 45 subjects, 15 were randomly assigned to the three-second intra-oral duration condition; 15 were randomly assigned to the five-second condition; and 15 were randomly assigned to the seven-second condition. The three within-pairs intervals were crossed with intra-oral durations so that for each intra-oral duration, five subjects were randomly assigned to the three-second within-pairs interval condition, five subjects were randomly assigned to the five-second condition and five subjects were randomly assigned to the seven-second condition. The order of presentation of the pairs of forms in each condition was randomized for each subject.

Every form was paired with itself and with every other form in the set. The Ringel set of forms contained ten items. Therefore, 55 pairings were possible. All possible pairs of forms were presented in random order to every subject.

Procedures

By reference to Appendix B, showing the data matrix for this study, it is evident that there were twenty-seven treatments employed in the total experiment. These treatments correspond to sequences of time intervals. For example, the first five subjects received the first three treatments or temporal sequences, and so forth, so that 45 subjects received twenty-seven treatments. In order to insure accurate measurements of time durations and intervals, it was decided to employ auditory cues. Twenty-seven tape loops corresponding to the twenty-seven treatments were constructed in the

following manner. The time intervals were marked on the tape by recording a 500 Hz pure tone which was on continuously for the temporal duration that the first of a pair of forms was on the tongue. This was followed on the tape loop by an interval accompanied by no auditory stimulus for the appropriate within-pairs interval between the first and second of a pair of forms. The end of this interval was marked on the tape loop by recording a 400 Hz pure tone which was on continuously for the temporal duration that the second of a pair of forms was on the tongue. At the end of this tone there followed an interval accompanied by no auditory stimulus for the appropriate between-pairs interval marking the interval from one pair to the next pair of forms. When the twenty-seven tape loops were finished each one was checked for accuracy. It was found that all time intervals were correct to 1/24 sec. Each loop was then re-recorded 55 times on a tape cassette.

During the testing sessions these tape cassettes were played back and provided auditory cues to the examiner enabling him to adhere to the correct time durations and intervals as he administered the stimuli. Since the subjects were blind-folded, the same auditory signals were cues to them indicating when they should be prepared to receive a form on the tongue. Two equal rest periods were allowed between the three treatments for each subject. Since an essential part of the experiment involved varying the time sequences for groups of five subjects, these two rest periods were necessarily adjusted from group to group in order to achieve a total time of ninety minutes for the testing session for each subject.

Before each testing session began, written standard instructions were given to each subject to read (Appendix C). Any part of the instructions which was not clear to an individual subject was explained in greater detail. A Maico portable audiometer (model MA-2B), which had been calibrated in accordance with ANSI norms, was used to test the subjects' hearing. Subjects were then allowed five minutes to examine the Ringel set of forms before testing began. This orientation involved both visual and oral examination of the forms. When the subject was ready for the testing session, he was blind-folded, the examiner put on a new disposable examination glove of the type used by physicians, and the testing session began with the examiner and subject listening to the cassette tape for auditory cues as described earlier in this chapter.

When the 500 Hz tone was on the subject opened his mouth and slightly protruded his tongue while the examiner placed the first of a pair of forms on the tip of the tongue for the duration of the tone. The subject was allowed to perceive the shape of the form only through passive use of the tongue. That is, as the form was placed on the tip of the tongue, he was allowed to push upward on the inferior surface of the form but no manipulation of the form was allowed. At the end of the tone the form was removed from the tongue, turned over and replaced in its proper place on the tray. After the within-pairs interval, the 400 Hz tone signaled the duration for presentation of the second of the pair of forms which was perceived by the subject in the same manner as the first form. At the end of the 400 Hz signal the form was removed from the tongue, turned over and replaced on the tray. During the ensuing between-pairs interval the subject told the examiner whether the two forms were the same or different. At the end of this interval the 500 Hz tone signaled the presentation of the first of the next pair of forms. Thus, the procedure was repeated for the remainder of the 55 pairs.

After a rest period the next temporal sequence was presented for the second treatment for that subject. This was followed by a second rest period and the third treatment for that subject. The subjects received no feedback on the correctness or incorrectness of their responses until after the testing was finished.

A list of the pairs of forms to be presented was prepared for each treatment for each subject. Forms were listed by number on the lists and on a specially prepared tray on which the forms were placed. Each subject's responses were recorded on the list for his individualized random order of presentation. The forms and the tray on which they were placed were sterilized in isopropanol ($CH_3CHOHCH_3$) and rinsed in water prior to presentation to each subject. Appendix E contains an illustration of the arrangement of the equipment used in conducting the experiment.

CHAPTER III

RESULTS

An analysis of variance using arcsin transformations was performed upon the raw scores obtained for the several variables under study (the three levels of intra-oral duration, the three levels of within-pairs interval of time, and the three levels of between-pairs interval of time) and their respective interactions. Significant main effects were found for the factors of within-pairs interval and between-pairs interval. There was no significant main effect associated with the intra-oral duration factor. Mean data for all variables and interactions can be found in Table 1. A complete analysis of variance table can be found in Appendix A.

Effect of Different Levels of Within-Pairs Interval

There was a significant main effect ($F = 4.22$, $df = 2$, $p < 0.05$) for the factor of within-pairs interval. As can be seen in Figure 1, the three-second interval yielded the least number of errors overall, followed by the five-second interval, and the seven-second interval, respectively. Post hoc procedures revealed a significant difference from the five-second to the seven-second within-pairs interval ($t = 2.6$, $df = 14$, $p < 0.05$) and from the three-second to the seven-

Table 1. Mean error scores for each level of each factor under study (Intra-Oral Duration, Within-Pairs Interval, Between-Pairs Interval).

Intra-Oral Duration	Within-Pairs Interval	Between-Pairs Interval		
		5 sec.	7 sec.	9 sec.
	3 sec.	7.2	5.8	5.2
3 sec.	5 sec.	4.6	4.0	5.0
	7 sec.	7.0	7.2	7.2
	3 sec.	4.6	3.4	2.6
5 sec.	5 sec.	6.4	5.6	3.6
	7 sec.	6.0	6.4	5.8
	3 sec.	4.6	3.4	3.4
7 sec.	5 sec.	5.0	4.4	4.2
	7 sec.	6.6	5.4	5.6

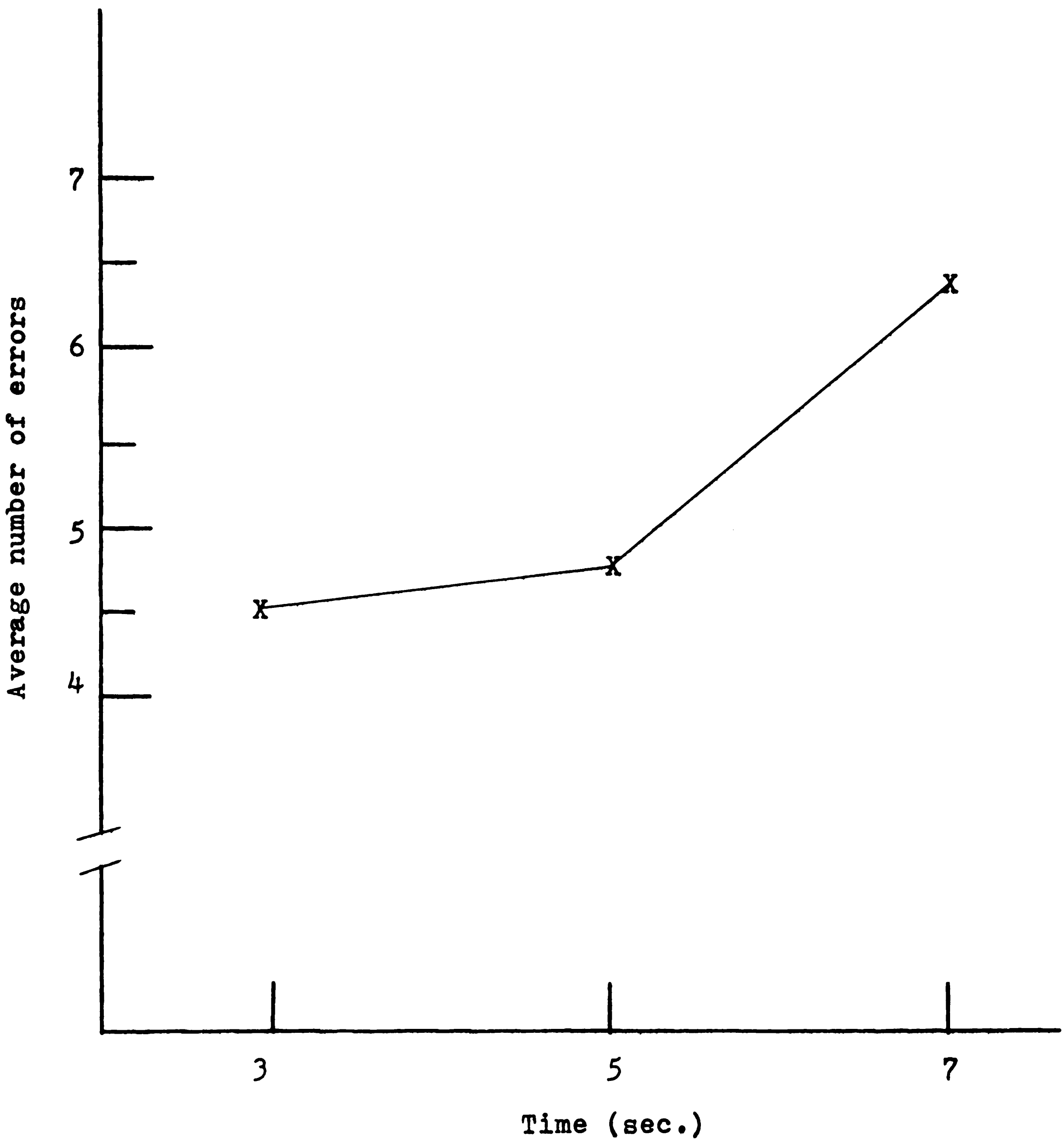


Figure 1. Main effect of the within-pairs interval.

second within-pairs interval ($t = 3.19$, $df = 14$, $p < 0.05$). Thus different within-pairs intervals did result in significantly different scores.

Effect of Different Levels of Between-Pairs Interval

There was a significant main effect ($F = 3.18$, $df = 2$, $p < 0.05$) for the factor of between-pairs interval. As can be seen in Figure 2, the between-pairs interval of five seconds yielded the greatest number of errors overall followed by the seven-second and nine-second between-pairs intervals respectively. Post hoc procedures revealed a significant difference between the five-second and nine-second between-pairs intervals ($Z = 1.90$, $p < 0.05$). Thus different between-pairs intervals resulted in significantly different scores.

Effect of Different Levels of Intra-Oral Durations

The difference between the three levels of intra-oral durations (three, five, and seven seconds) was not statistically significant ($F = 1.62$, $df = 2$, $p > 0.2$). As can be seen in Table 2, the three-second intra-oral duration yielded the greatest number of errors overall, followed by the five-second and seven-second intra-oral durations respectively. Although not significant, there was more difference in number of errors between the three-second and five-second durations than between the five-second and seven-second durations.

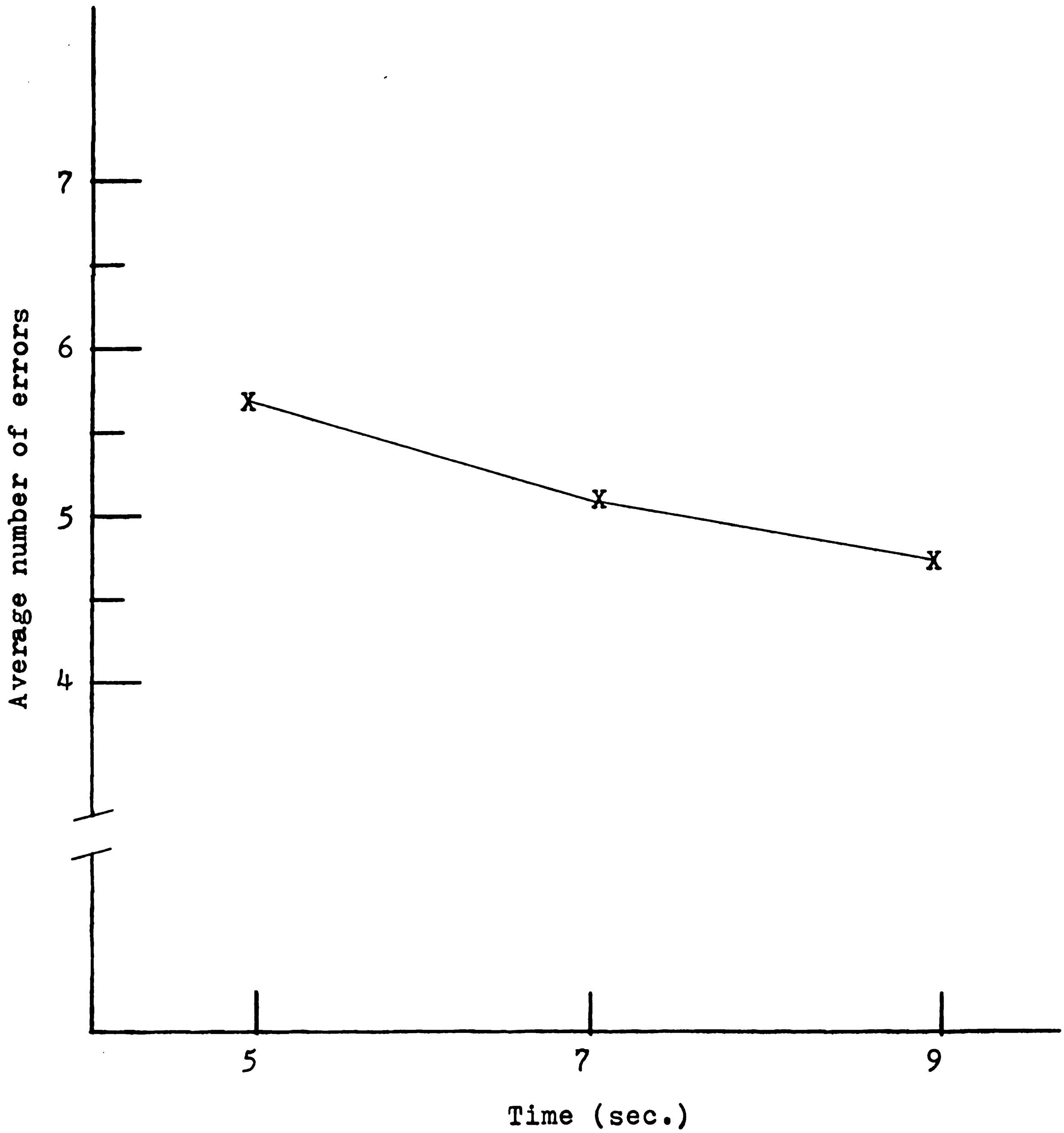


Figure 2. Main effect of the between-pairs interval.

Table 2. Mean number of errors as a function of Intra-Oral Duration

Intra-Oral Duration	Number of Errors
3 sec.	5.9
5 sec.	4.9
7 sec.	4.7

Table 3. Percentages of errors made on pairs of forms from the Ringel Set

	1	2	3	4	5	6	7	8	9	10
1	23.0									
2	52.0	11.0								
3	00.7	00.7	08.0							
4	01.5	00.0	43.0	15.0						
5	03.0	03.0	00.7	06.7	15.0					
6	00.0	00.0	02.2	08.0	18.5	17.7				
7	02.2	00.7	00.7	09.6	26.0	41.5	27.4			
8	02.2	01.5	00.7	00.7	07.4	00.0	21.5	11.0		
9	00.0	00.0	00.7	01.5	06.7	20.0	06.7	00.0	19.0	
10	00.7	00.7	00.0	00.0	00.7	04.4	00.7	00.7	46.0	27.4

Difficulty in Discriminating Pairs of Forms

The degree of difficulty in discriminating pairs of forms is reported in Table 3. This table indicates for each pair of forms the percentage of errors made during the complete experiment. It may be noted that the four most difficult pairs of forms (1-2, 9-10, 3-4, and 6-7) account for 35% of the errors made during the experiment. The next fifteen pairs, including the ten identical pairs, accounted for 52% of the errors; the next twenty-seven pairs accounted for only 13% of the errors and nine pairs were always correctly discriminated.

CHAPTER IV

DISCUSSION

This study compared the effects of varying intra-oral duration, within-pairs interval and between-pairs interval on the number of errors made by normal young adult subjects on an oral stereognosis task. All subjects (N = 45) received twenty-seven treatments, including all possible combinations of the three intra-oral durations (3, 5 and 7 seconds), three within-pairs intervals (3, 5 and 7 seconds), and three between-pairs intervals (5, 7 and 9 seconds) under study.

Intra-Oral Duration

The questions of how long a duration is necessary for the tongue-tip to perceive the shape of an object has received some attention by Torrans and Beasley (1973). In this present study intra-oral duration was not a significant factor in score variability. So that whether the duration was three, five or seven seconds, the subjects seemed to achieve comparable scores. This result corroborates that reported by Torrans and Beasley (1973) who found that score variability was not affected by form retention time alone. In their study there were two levels of form retention time, five seconds and unlimited time. They suggested that a shorter or longer time limit than the five seconds level in their study might produce a significant main effect. Within the limits of this study, it would seem that this question has been answered negatively.

Torrans (1972) found that when some of her subjects were given unlimited time for intra-oral duration for some of the forms, they needed only two to four seconds for perception. This was found to be the case in the present study also. Since only one answer type (a same-or-different discrimination) was utilized in this study, an additional observation may be made. The first of a pair of forms was usually made the object of concentration for the full duration allowed. When the second form was placed on the tongue, however, the subject knew that he only had to decide whether it was the same or different from the first and he tended to need considerably less perceptual time to make this decision.

The form which was the easiest to perceive was the true square (form number 3). The size of this form seemed to be significantly larger than any of the other forms so that it proved to be relatively easy to identify. On the other hand, the small rectangle (form number 5) appeared to be the most confusing of the forms. Subjects reported that the corners of the rectangle were not clearly perceived by the tongue.

Perception through passive use of the tongue was found to yield certain advantages:

1) Subjects did not complain of a soreness or irritation of the tongue.

2) Subject technique for perception of the forms was uniform.

3) The experimenter retained complete control during the presentation of the forms.

Within-Pairs Interval

The results of this study have a direct bearing on the question of short-term memory and the studies of Lass and Clay (1973) and Arndt et al. (1970b). The results of the study by Lass and Clay led them to conclude that memory (at least up to five seconds) was not a significant factor in oral stereognosis. They studied the effects of presenting the forms in pairs simultaneously and with five seconds between two items of a pair of forms. They recognized that their results may have been confused by the fact that in the simultaneous presentation it was not possible for both of the forms to be centered in the midline of the tip of the tongue. As a result one of the forms was usually positioned lateral to the midline, while the other form was usually on the other lateral portion of the tongue.

In the present study the indication is that when the forms are presented to the same part of the tongue (the tip) the error scores will increase as the within-pairs interval is increased. This suggests that short-term memory is indeed a significant factor in a discrimination task in a test of oral stereognosis, and that the best discrimination performance can be achieved with a relatively short within-pairs interval.

What has been said above about the limitations inherent in a simultaneous presentation of forms applies to the study by Arndt et al. (1970b). Probably these investigators were justified in their concern for a "pure" measure of oral stereognosis in which only the oral tactile sense was perceptually involved. However, in the simultaneous presentation of a pair of forms, they also failed to consider the differential sensitivity of the oral cavity in general and the tongue in particular.

Because of the above-mentioned problem associated with simultaneous presentation of forms, it seems that the interests of consistency and test-retest reliability may be served best by presenting pairs of forms with a short within-pairs interval.

In auditory perceptual processing, Beasley and Shriner (1973) found that temporal factors were important variables. As stimulus duration and interstimulus ratios of sentential approximations were covaried it was found that the stimulus duration was more crucial than the interstimulus interval for perception. Comparing these results with the results of the present study, it may be stated in general terms that temporal factors are important variables in both auditory and tactile perceptual processing. Specifically, whereas stimulus duration was shown to be significant in auditory perception, oral tactile perception has been shown to be sensitive to the interstimulus or within-pairs interval. This conclusion is supported by reference to Figure 1.

The results of this study suggest that memory may very well have played an important role in subject performance on a test of discrimination between items of a pair of forms. During the experiment those subjects who were tested with a seven-second within-pairs interval often indicated uncertainty when presented with the second of a pair of forms. These subjects reported that their uncertainty was due to a short-term memory problem or an attention problem. The attention problem was more crucial as the testing progressed for an individual subject. Especially was this so for those subjects who received the longer within-pairs interval of seven seconds. The common complaint of such subjects was not fatigue, but of boredom. It seems that with the seven-second within-pairs interval, especially, subjects had a distinct problem in attending to the task at hand. Norman (1969) very clearly connects attention with memory, observing that an object attended to may remain in the memory, whereas one inattentively allowed to pass will leave no traces behind.

Differential Difficulty of Pairs of Forms

Since the same fifty-five pairs of forms as used by Torrans (1972) were also used in the present study it is interesting to note some comparisons regarding the varying difficulty of different pairs of forms. The four pairs of forms which were most difficult in this study were 1-2, 9-10, 3-4 and 6-7. These same four pairs were also among the first five most difficult pairs of forms in Torrans' study.

Rothkopf (1957) conducted a study to provide a measure of similarity among the signals of the International Morse Code. The subjects of the experiment were exposed to pairs of auditory Morse signals sent at a high speed and required to indicate whether the two signals in each pair were the same or idfferent. In this auditory task it was found that the subjects socred the highest correct "same" discrimination responses on the group of objectively identical stimulus pairs.

The results of this present investigation involving the tactile modality do not agree with the results of Rothkopf involving the auditory modality. The nine pairs of geometric forms which in this study were judged correctly all the time by all the subjects were all composed of different stimulus items. Those pairs of forms which were identical were grouped together in the area of medium difficulty. The pair 3-3 was discriminated correctly 92% of the time, and the pair 7-7 was discriminated correctly 72.6% of the time (Table 3.). The remaining eight identical pairs were found to have a degree of difficulty in discrimination somewhere between these two percentages. These results, while differing from those reported by Rothkopf, do corroborate the results reported by Torrans (1972) in which nine of the identical pairs of forms were found to be more difficult than thirty-nine of the different pairs. In the present study the same nine identical pairs of forms were found to be more difficult than thirty-eight of the different pairs.

These two reported corroborations of the Torrans study lend support to the view that the tactile sense is a unique modality (Bosma, 1967) which must be studied independently without bias from investigation of other modalities. The results of that study indicate that oral tactile perceptual processing is influenced by a unique set of categories which do not necessarily conform to the categories which are meaningful for visual or auditory perceptual processing.

Procedural Considerations

The Ringel set of ten forms used in this study were also used by Ringel et al. (1968) and Torrans and Beasley (1973). It is interesting to note that these three studies are in mutual agreement on the question of employing a unimodality approach to oral stereognostic testing in preference to a visual matching procedure. This finding assumes some importance when considered in view of the different results reported by Lass et al. (1971). In this study a third triangular form was added to the Ringel set of forms. Torrans and Beasley have speculated that if Lass et al. had omitted the third triangular shape, their results would also agree with the other studies cited above. This speculation has received further support from the results of this study.

There is general agreement in the literature that of all cutaneous surfaces in the mouth, the tongue-tip is the most sensitive to touch (Grossman, 1964 and 1967; Gibson, 1967; Henkin and Banks, 1967; McCall, 1969; Fucci and Robertson, 1967; Kenshalo, 1971; and Lass et al., 1972b). In the course of this study, some subjects reported that the tip of the tongue was very sensitive to the exact position of the forms and that discrimination was best when two forms of a pair were presented on exactly the same part of the tongue.

Considerations for Clinical Application

Many investigators have commented on the relationship between speech articulation and the oral tactile and kinesthetic monitoring systems (Van Riper and Irwin, 1958; Ringel, 1970; and Ruscello and Lass, 1973). These studies have indicated that as a person matures the tactile and kinesthetic sensory mechanisms increase in importance for monitoring articulatory accuracy. When testing began, the subjects in this study were usually doubtful about their ability to discriminate between several of the forms. Thus, when the testing session finished, their performance, indicated by the test results, surprised them. Most subjects acknowledged that they did not expect their tongues to be so sensitive to the fine differences between forms.

During the past decade much of the research in the area of oral stereognosis has yielded information which could eventually result in a practical tool for speech pathologists. This present study may be considered another step in the direction of presenting a test of oral stereognosis which could be used with confidence in the assessment of an individual's oral sensitivity to tactile and kinesthetic cues. If a test is to be used in a clinical setting the results reported at a given time and place should be understood and should be amenable to replication at another time and place. Therefore, there is a need for outlining detailed procedures which may be easily understood and which control for as many variables in the testing procedure as it is possible to control. Clearly, in a test of oral stereognosis, the temporal factors are important variables which should be controlled. From the information obtained during this investigation the following suggestions seem warranted for use with the ten Ringel forms as applied in a same-or-different discrimination task:

1) The intra-oral duration should be five seconds.
2) The within-pairs interval should be three seconds.
3) The between-pairs interval should be nine seconds.

It may be reasonably expected that the results of the investigations into oral sensation and perception could yield useful techniques in diagnosis and therapy for speech pathologists.

In terms of the administration of a test of oral stereognosis, as in any other test or measuring device used in diagnosis, the clinician needs to become familiar with the testing procedures. These are not difficult to understand although care should be exercised in keeping to the correct time intervals suggested above. The best method to insure accuracy in the temporal sequences is the use of auditory signals as suggested in the procedures of this study. If a clinician intends to use this test for the first time, a certain amount of practice time is recommended so that the testing session may proceed smoothly. It may not be necessary to administer all the fifty-five pairs of forms as used in this experiment. Further research is needed to determine which stimulus items may be omitted and which ones should be included. The results of this study suggest that nine of the pairs of forms, those which were never missed (Table 3), may be redundant and perhaps these may be omitted from the test as used in a clinical setting. Such a decision, however, needs to await further research with pathological populations.

If the results of diagnostic testing of an individual indicate a reduced sensitivity to tactile and kinesthetic oral sensation and perception, this information may be used by the speech pathologist as he plans for a program of therapy. Thus, more effective therapeutic techniques could conceivably be devised in a rehabilitative program, emphasizing subject recognition of correct placement of his articulators, or training him to use compensatory techniques.

Considerations and Suggestions for Future Research

The results of this study have highlighted the importance of careful attention to the factor of time in the administration of a test of oral stereognosis.

During the present investigation it was observed that many subjects were confident about making a same-or-different discrimination judgment after the second of a pair of forms was on the tongue for a much shorter time than was required for the perception of the first of the pair of forms. A comparative type of study could be conducted to test the hypothesis that when presenting pairs of forms for discrimination, scores are unaffected by presenting the second form for time periods shorter than used in presenting the first form.

There are indications from Table 3 that some pairs of forms may be eliminated from an actual test of oral stereognosis without affecting the discriminating power of the testing instrument. It will be noted that no errors were recorded for nine pairs of forms and that only one error was recorded for each of thirteen pairs of forms. The remaining thirty-three pairs of forms may be sufficient to comprise an adequate test of oral stereognosis. If this could be demonstrated by experimentation the result would be an abbreviation of the test. Such a result would be desirable since there would be less possibility of a boredom factor as a confounding variable in the subject's response.

In order to restrict perception to one modality, the tactile sense, procedures in this investigation called for a same-or-different discrimination type of task while excluding the visual modality. In this type of test, however, some subjects reported a problem in being able to retain a clear perceptual image of the first form for comparison with the second of a pair of forms. Since the Ringel set comprises only ten forms, it should be possible to perform a test of absolute identification. In this case the above mentioned problem associated with the within-pairs interval would be eliminated, since a subject would be required to make an identification response immediately after a form would be removed from the tongue. In order for such a task to be possible, thorough familiarization with the forms would be necessary before administering the test. Although this familiarization procedure might be comparatively lengthy (perhaps ten or fifteen minutes), the actual testing could be much shorter than was the case in this present experiment.

Torrans and Beasley (1973) found that form set difficulty was a significant factor in subject performance. Specifically they found that the forms developed at Penn State were easier for subjects to discriminate than those used by Ringel and as used in this study. Thus, subject performance on one set (Penn State Forms) may be expected to yield a minimum of errors, whereas the other set (Ringel Forms) may be expected to provide a more difficult task for the same subjects (Torrans and Beasley, 1973). To what extent this factor interacts with temporal factors is as yet undetermined.

The subjects in this study were normal-hearing, normal-articulating young adults. Further research needs to be performed on subjects who exhibit different pathologies, such as cerebral palsy, cleft palate, aphasia, or stuttering, to mention a few.

There was not a significant main effect for intra-oral duration in this study. This may suggest that different durations should be applied in further investigations. It would be practical to use durations as brief as 1 second so that in further enquiries the experimenter could use intra-oral durations of 1, 3 and 5 seconds.

Another direction of inquiry is suggested by considering the relative sensitivity of different areas of the oral cavity. The tip of the tongue appears to be most sensitive in a test of oral stereognosis as indicated in this and previous studies. However, it would be helpful to know what comparative information could be obtained as other interior and exterior cutaneous surfaces of the oral cavity are stimulated with geometric forms.

BIBLIOGRAPHY

BIBLIOGRAPHY

Arndt, W. B., Gauer, Judith, Shelton, R. L., Crary, Dolores and Chisum, Linda, Refinement of a test of oral stereognosis. Bosma, James F. (Ed.), Second Symposium on Oral Sensation and Perception, Springfield, Ill.: Thomas (1970a).

Arndt, W.B., Elbert, Mary and Shelton, R.L., Standardization of a test of oral stereognosis. Bosma, James F. (Ed.), Second Symposium on Oral Sensation and Perception, Springfield, Ill.: Thomas (1970b).

Aungst, Lester F., The relationship between oral sterognosis and articulation proficiency. Unpublished Ph.D. Thesis, Pennsylvania State University (1965).

Bain, Sally J., Comparing two procedures for testing oral stereognosis abilities of children. Unpublished study, Michigan State University (1973).

Beasley, Daniel S. and Shriner, T.H., Auditory analysis of temporally distorted sentential approximations. J. Aud. Comm., in press (1973).

Best, C.H. and Taylor, N.E., The Physiological Basis of Medical Practice. Baltimore: Williams and Wilkins (1961).

Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Bosma, James F. (Ed.), Second Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1970).

Carhart, Raymond, Problems in the measurement of speech discrimination. Arch. Otolaryng., 82, 253-260 (1965).

Carrell, James A., Disorders of Articulation. Englewood Cliffs, N.J.: Prentice-Hall, Inc. (1968).

Chusid, Joseph G. and McDonald, Joseph J., Correlative Neuroanatomy and Functional Neurology. Los Altos, Cal.: Lange Medical Publications (1967).

Fairbanks, Grant, A theory of the speech mechanism as a servosystem. J.Speech Hearing Dis., 19, 133-139 (1954).

Fucci, Donald J., Vibration: a clinical tool for tomorrow. Ohio J. Speech Hearing, 6, 92-96 (1971).

Fucci, Donald J., Oral vibrotactile sensation: an evaluation of normal and defective speakers. J. Speech Hearing Res., 15, 179-184, (1972).

Fucci, Donald J., Arnst, Dennis J. and Telage, Kal M., The effects of pulsed and continuous stimulation on vibrotactile thresholds obtained from the tongue. Psychon. Sci. 29, 83, 84 (1972).

Fucci, Donald J. and Kelly, Dan H., New instrumentation for research on vibrotactile sensitivity of the tongue. Rev. Sci. Instr., 43, 1748-1751 (1972).

Fucci, Donald J. and Robertson, John H., "Functional" defective articulation: an oral sensory disturbance. Percept. Mot. Skills, 33, 711-714 (1971).

Gibson, James J., The mouth as an organ for laying hold on the environment. Bosma, James F. (Ed.) Symposium on Oral Sensation and Perception, Springfield, Ill.: Thomas (1967).

Gray, Giles Wilkeson and Wise, Claude Merton, The Bases of Speech, New York: Harper and Row, Pub. (1959).

Grossman, R.C., Sensory innervation of the oral mucosae: a review. J. S. Cal. State Dent. Assoc., 32, 128-133(1964).

Grossman, Richard C., Methods of determining oral tactile experience. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Hall, Donald Elliott, Fucci, Donald J., and Arnst, Dennis J., Vibrotactile stimulation: an investigation of psychophysical methods for establishing threshold. Percept. Mot. Skills, 34, 891-898 (1972).

Hardy, James C., Development of neuromuscular systems underlying speech production. In ASHA Reports #5, Washington D.C.: American Speech and Hearing Association (1970).

Henkin, Robert I. and Banks, Velma, Tactile perception on the tongue, palate and the hand of normal man. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Jenkins, E. and Lohr, F.E., Severe articulation disorders and motor ability. J. Speech Hearing Dis., 29, 286-292 (1964).

Johnson, Wendell, Darley, Frederic L. and Spriestersbach, D. C., Diagnostic Methods in Speech Pathology. New York: Harper and Row, Pub. (1963).

Kaplan, Harold M., Anatomy and Physiology of Speech. New York: McGraw-Hill Book Co., Inc. (1960).

Kenshalo, Dan R., The cutaneous senses. Kling, J.W. and Riggs, Lorrin A. (Eds.), Experimental Psychology. New York: Holt, Rinehart and Winston, Inc. (1971).

Ladefoged, Peter, Three Areas of Experimental Phonetics. London: Oxford University Press (1967).

La Pointe, Leonard L. and Williams, William N., Oral sensation and perception: an overview. Presented at the 48th Annual Convention of the American Speech and Hearing Association, San Francisco (1972).

LaPointe, Leonard L. and Williams, William N., Recognition of geometric shapes by unimodal and simultaneous multimodal presentation in aphasics. Folia Phoniatrica, in press (1973).

Lass, Norman J., Tekieli, Mary E. and Eye, Marcia P., A comparative study of two procedures for assessment of oral tactile perception. Central States Speech J., 22, 21-26 (1971).

Lass, Norman J., Kotchek, Cynthia L., and Deem, Jodelle F., Oral two-point discrimination: further evidence of asymetry on right and left sides of selected oral structures. Percept. Mot. Skills, 35, 59-67 (1972a).

Lass, Norman J., Bell, Richard R., Simcoe, Jeanne C., McClung, Nancy J., and Park, William E., Assessment of oral tactile perception: some methodological considerations. Central States Speech J., 23, 165-173 (1972b).

Lass, Norman J. and Clay, Teresa H., The effect of memory on subject performance on a test of oral form discrimination. J. West. Speech, 27-33 (Winter, 1973).

Locke, John L., Oral perception and articulation learning. Percept. Mot. Skills, 26, 1259-1264 (1968).

Madison, Charles L. and Fucci, Donald J., Speech-sound discrimination and tactile-kinesthetic discrimination in reference to speech production. Percept. Mot. Skills, 33, 831-838 (1971).

McCall, Gerald N., The assessment of lingual tactile sensation and perception. J. Speech Hearing Dis., 34, 151-156 (1969).

McCall, Gerald N. and Cunningham, Nancy Morgan, Two-point discrimination: asymmetry in spatial discrimination on the two sides of the tongue, a preliminary report. Percept. Mot. Skills, 32, 368-370 (1971).

McDonald, Eugene T., Articulation Testing and Treatment: A Sensory-Motor Approach. Pittsburgh: Stanwix House, Inc. (1964).

Moser, Henry, LaGourgue, John R., and Class, Lois W., Studies of oral stereognosis in normal, blind and deaf subjects. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill: Thomas (1967).

Mysak, Edward D., A servo model for speech therapy. J. Speech Hearing Dis., 24, 144-149 (1959).

Norman, Donald A., Memory and Attention. New York: John Wiley and Sons, Inc. (1969).

Paine, Richmond S., Manual stereognosis. In Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Ringel, Robert L., Oral sensation and perception: a selective review. ASHA Report #5, Washington D.C.: American Speech and Hearing Association (1970).

Ringel, Robert L., Burk, Kenneth W., and Scott, Cheryl M., Tactile perception: form discrimination in the mouth. Brit. J. Dis. Comm., 3, 150-155 (1968).

Ringel, Robert L., House, Arthur S., Burk, Kenneth W., Dolinsky, John P., and Scott, Cheryl M., Some relations between orosensory discrimination and articulatory aspects of speech production. J. Speech Hearing Dis., 35, 3-10 (1970).

Robertson, John H., Fucci, Donald J., and Fokes, J.B., "Functional" defective articulation: an oral sensory disturbance. Paper presented at the 45th Annual Convention of the American Speech and Hearing Association, Chicago (1969).

Rothkopf, Ernst Z., A measure of stimulus similarity and errors in some paired-associate learning tasks. Journal of Experimental Psychology, 53, 94-101, (1957).

Ruscello, Dennis M., and Lass, Norman J., Articulation improvement and oral tactile changes in children. Unpublished manuscript (1973).

Rutherford, David and McCall, Gerald N., Testing oral sensation and perception in persons with dysarthria. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Schliesser, Herbert F. and Coleman, Ralph O., Effectiveness of certain procedures for alteration of auditory and oral tactile sensation for speech. Percept. Mot. Skills, 26, 275-281 (1968).

Scott, Cheryl M. and Ringel, Robert L., Articulation without oral sensory control. J. Speech Hearing Res., 14, 804-818 (1971).

Shelton, Ralph L., Arndt, William B. and Hetherington, John J., Testing oral stereognosis. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Shelton, Ralph L., Harris, Katherine S., Sholes, George N., and Dooley, Patricia M., Study of nonspeech voluntary palate movements by scaling and electromyographic techniques. Bosma, James F. (Ed.), Second Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1970).

Shelton, Ralph L., Willis, Valerie, Johnson, Anita F. and Arndt, William B., Oral form recognition training and articulation change. Percept. Mot. Skills, 36, 523-531 (1973).

Telage, Kal M., Fucci, Donald J. and Arnst, Dennis J., Normative study of oral vibrotactile sensitivity. Percept. Mot. Skills, 35, 671-676 (1972).

Torrans, I. Annie, A comparison of methods for testing oral stereognosis. Ph.D. Dissertation, Michigan State University (1972).

Torrans, Ann and Beasley, Daniel S., Effect of varying forms set, answer type, and retention time on measures of oral stereognosis. J. Speech Hearing Res., in press (1973).

Van Riper, Charles and Irwin, J., Voice and Articulation. Englewood Cliffs, N.J.: Prentice-Hall (1958).

Williams, William N. and LaPointe, Leonard L., Relationships among oral form recognition and interdental weight discrimination. Percept. Mot. Skills, 35, 191-194 (1972).

Woodford, L.D., Oral Stereognosis. Unpublished Master's thesis, University of Illinois (1964). Cited by Shelton, Ralph L., Arndt, William B., and Hetherington, John J., Testing oral stereognosis. Bosma, James F. (Ed.), Symposium on Oral Sensation and Perception. Springfield, Ill.: Thomas (1967).

Woodworth, Robert S., Experimental Psychology, New York: Henry Holt and Company (1938).

Zemlin, Willard R., Speech and Hearing Science: Anatomy and Physiology. Englewood Cliffs, N.J.: Prentice-Hall, Inc. (1968).

APPENDICES

APPENDIX A

ANALYSIS OF VARIANCE TABLE

Analysis of Variance Table

Source of variation	df	MS	F	p
Intraoral	2	17.87	1.62	
Within-pairs	2	46.59	4.22*	$p < .05$
Between-pairs	2	12.81	3.18*	$p < .05$
Intraoral X Within-pairs	4	10.19	.92	
Intraoral X Between-pairs	4	2.27	.56	
Within-pairs X Between-pairs	4	2.02	.50	
Intraoral X Within-pairs X Between-pairs	8	1.62	.40	
Error 1	36	11.04		
Error 2	72	4.03		
Total	134			

* F-ratio significant at the $p = .05$ level

APPENDIX B

DATA MATRIX

SHOWING THE DESIGN OF THE STUDY

Data Matrix Showing the Design of the Study

Factors:

A - Intra-oral duration
A_1 - 3 seconds, A_2 - 5 seconds, A_3 - 7 seconds

B - Within-pairs interval
B_1 - 3 seconds, B_2 - 5 seconds, B_3 - 7 seconds

C - Between-pairs interval
C_1 - 5 seconds, C_2 - 7 seconds, C_3 - 9 seconds

S - Subjects

			C_1	C_2	C_3
A_1	B_1	S_1 : S_5			
	B_2	S_6 : S_{10}			
	B_3	S_{11} : S_{15}			
A_2	B_1	S_{16} : S_{20}			
	B_2	S_{21} : S_{25}			
	B_3	S_{26} : S_{30}			
A_3	B_1	S_{31} : S_{35}			
	B_2	S_{36} : S_{40}			
	B_3	S_{41} : S_{45}			

APPENDIX C

INSTRUCTIONS TO SUBJECTS

APPENDIX C

INSTRUCTIONS TO SUBJECTS

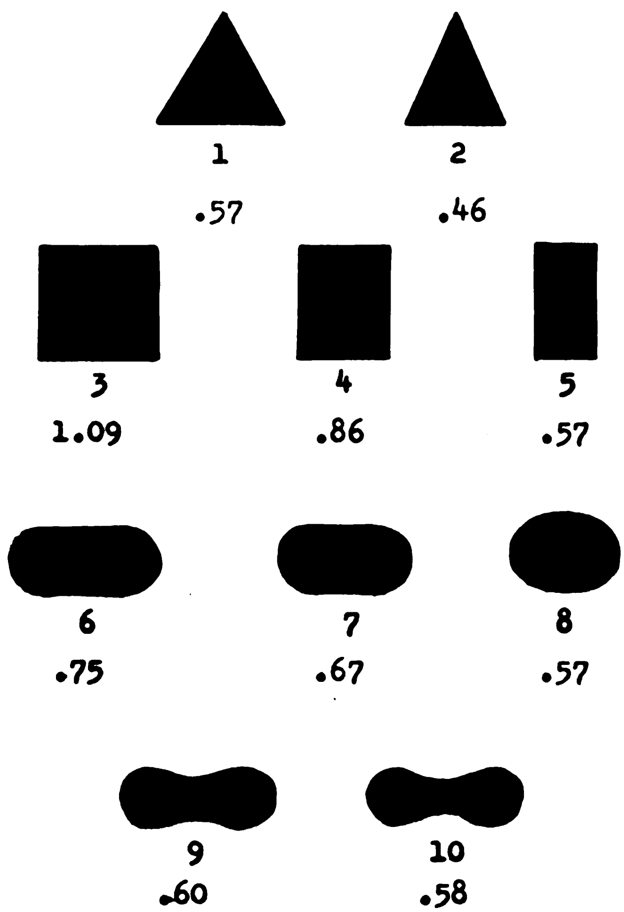
In this experiment the tactile sensitivity of the tip of your tongue is being tested. To eliminate visual cues you will be blindfolded. I shall place a geometric plastic form on the upper surface of the tip of your tongue for a few seconds, remove it for a few seconds and then place the same or a different form on your tongue for a few seconds. After removal of the second form you are to tell me whether the two forms were the same or different. This process will be repeated for many pairs of forms. During the presentation of each form, you will be allowed to push upward with your tongue, while I hold it, but you will not be able to manipulate the form in any other way.

After the first series of pairs of forms, you will have a short rest. Then another series of pairs of forms will be presented, followed by a short rest. A third series of pairs of forms will be presented and this will complete your part of the experiment.

In order to acquaint you with the tactile sensation of the forms you will be given an orientation before the test begins. During the orientation each form will be presented on your tongue as you will feel it during the actual test. Following the orientation, you will hear a tone. This is your cue to receive the first form, and it is my cue to place the form on your tongue. The form will stay on your tongue for the duration of the tone. The second form will be presented when a second, lower tone is heard. The second form will be on your tongue for the duration of the second tone. After the second form has been removed, you are to tell me whether the pair of forms were the same or different. This procedure will be repeated throughout the whole test.

APPENDIX D

ACTUAL SHAPES AND SIZES OF THE RINGEL SET FORMS



The actual shapes and sizes of the Ringel Forms. Under the number of each form is a number indicating its mass in grams.

APPENDIX E

ARRANGEMENT OF EQUIPMENT USED IN TESTING SUBJECTS

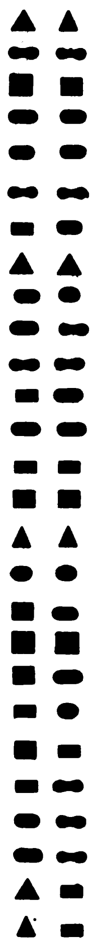
Arrangement of equipment used in testing subjects. The subjects' chair may be seen behind the tray of forms.

APPENDIX F

THE FIFTY-FIVE PAIRS OF FORMS USED IN THE EXPERIMENT

The fifty-five pairs of forms used in the experiment listed in descending order of difficulty.

1	1-2
2	9-10
3	3-4
4	6-7
5	7-7
6	10-10
7	5-7
8	1-1
9	7-8
10	6-9
11	9-9
12	5-6
13	6-6
14	5-5
15	4-4
16	2-2
17	8-8
18	4-7
19	3-3
20	4-6
21	5-8
22	4-5
23	5-9
24	7-9
25	6-10
26	1-5
27	2-5



28	1-7
29	1-8
30	3-6
31	1-4
32	2-8
33	4-9
34	1-3
35	1-10
36	2-3
37	2-7
38	2-10
39	3-5
40	3-7
41	3-8
42	3-9
43	4-8
44	5-10
45	7-10
46	8-10
47	1-6
48	1-9
49	2-4
50	2-6
51	2-9
52	3-10
53	4-10
54	6-8
55	8-9