THE MEASUREMENT OF HOMOPHENOUS WORDS

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THE MEASUREMENT OF HOMOPHENOUS WORDS

By

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AN ABSTRACT OF A THESIS

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ABSTRACT

THE MEASUREMENT OF HOMOPHENOUS WORDS

by Ann Joergenson

Homophenous words are those which appear highly similar on the lips but do not sound the same. It has been said that a person who is hard of hearing or deaf can distinguish these words only from the context.

Research has shown, however, that homophenous words can be identified correctly by untrained lipreading subjects a greater number of times than can be attributed to chance alone. This finding suggested that there were visible, measurable differences in lip patterns during the utterance of homophenous words.

The purpose of this study was to make physical measurements of the mouths of four speakers as they uttered forty-eight homophenous words. This was accomplished by a frame-by-frame analysis of a moving picture film to determine the variables, if any, that existed in mouth openings, mouth widths, and visibility of the teeth during the pronunciation of homophenous words.

The size of the mouth opening at the philtrum was first measured. Analysis of the data revealed visible

differences in mouth openings during the utterance of homophenous words.

In the second phase of the study measurements of mouth width from corner to corner were plotted. There appeared to be minute differences in mouth widths during the utterance of homophenous words. Measurements were also computed of the time it took speakers to say homophenous words. To determine if the time differences were significant a t test was employed. Results revealed that the differences in time required for uttering homophenous words within each group considered in this study were not statistically significant.

Teeth visibility was measured in three categories: one-half or more of the tooth visible; less than one-half visible; and non-visible. A t test for significant differences was computed on a sample of four words. The differences in time during which the teeth were visible or nonvisible were not statistically significant when the words dome, dope, tome, gnome were produced.

The present study was exploratory in nature. The data collected suggested areas of further study which might be explored.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Lipreading has been the subject of a limited amount of research, most of it concerned with constructing tests to determine accurately expert and inept lipreaders, as well as psychological and personality traits that correlate with good lipreading ability. The writer finds evidence of only one other scientific research study thus far that has dealt with homophenous words.

Homophenous words are those that appear highly similar on the lips but do not sound the same. It has been said that a person who is hard of hearing or deaf can distinguish these words only from context.[1]

It is estimated that there are, in the English language, words homophenous to approximately 50 per cent of all words. If this is accepted as fact, it is conceivable that every other word spoken could be mistaken for another word

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[1]Martha E. Bruhn, The Mueller-Walle Method of Lip-Reading for the Hard of Hearing (Boston 15, Mass.: M. H. Leavis, 1949), p. 13.

by a deaf or hard-of-hearing individual.[2] Nitchie suggested that 40 per cent of the sounds used in speech have other sounds homophenous to them and that 50 per cent of the words employed in colloquial speech have other words that are homophenous.[3]

There are no strictly homophenous sounds among the vowels. The consonants are the sounds that are homophenous.[4] According to Nitchie the homophenous consonants are:[5]

(p), (b), (m), (mb), (mp).
(f), (v), (ph), (gh).
(wh), (w).
(s), (z), (soft---c).
(sh), (zh), (ch), (j), (soft---g).
(t), (d), (n), (nd), (nt).
(k), (hard---c), (hard---g), (ng), (nk), (ck).

The attitude that has prevailed among lipreading teachers is that homophenous words may be distinguished only from contextual association and to be a proficient lipreader one should memorize or become very familiar with long lists of them.

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[2] Ibid.

[3] Elizabeth Helm Nitchie, Advanced Lessons in Lip-Reading (New York: Frederick A. Stokes Co., 1923), p. 185.

[4] Elizabeth Helm Nitchie, New Lessons in Lipreading (New York: J. B. Lippincott Company, 1950), p. 55.

[5] Ibid., p. 56.

Snow,[6] at the turn of the century, was among the first to focus attention on homophenous words. She compiled long lists of homophenous words with the idea that the acoustically handicapped should memorize these lists and put the words into sentences and phrases to familiarize themselves with them. This seems to have been the plan accepted by others regarding lipreading of homophenous words.

A view somewhat divergent from this was expressed by Davidson in an editorial appearing in the Association Review.[7] He stated that homophenous words are not exactly alike, but that they are similar and their appearance on the lips is approximately the same; he admitted, however, that they can be distinguished out of context. This is as far as Davidson carried the idea. For years no one attempted to find out if there were visible differences among homophenous words, and, if so, the nature of those differences. In recent literature it appears that most authors seem to have accepted the premise that homophenous words are the

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[6]Emma Snow, "My List of Homophenous Words," The Association Review, 5 (1903), 29-31.

[7]S. G. Davidson, "Editorial: Homophenous Words," The Association Review, 5 (1903), 92-93.

"same" in appearance and let it go at that.

Jacoby[8] recognized the need for research in this area and felt strongly that the statements in the literature are erroneous that imply that it is impossible for a lip-reader to comprehend 100 per cent of what is being said. Jacoby contended that the eye is capable of making as fine visual discriminations as the ear is in detecting sounds; the emphasis in training then should be placed on fine rather than gross discrimination. However, before fine visual discrimination can be taught the lipreader's eyes must be directed to the significant visible elements. Jacoby maintained that there is a great need for research on the visible aspects of language. "We need descriptive studies of the visible movements of the speech mechanism that go beyond Nitchie's descriptions of the revelations of sound."[9]

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[8] Beatrice Jacoby, "Lipservice to Lipreading," Hearing News, September, 1959, 18.

[9] Ibid.

Statement of the Problem and Purpose of the Study

The purpose of this investigation was to follow up the results of the Roback study completed at Michigan State University in 1961.[10] The problem in Roback's study was to determine the ability of viewers to identify correctly homophenous words presented in isolation on a silent film. Two questions were asked: "1) Is it possible for college students without formal training in lipreading to lipread homophenous words presented on a silent film? 2) Does the recognition of homophenous words by college students occur significantly beyond chance expectancy?" A Chi square analysis of Roback's data revealed that correct selection of homophenous words as seen on a speaker's lips occurred above that which is expected from chance alone. Since viewers were able to recognize homophenous words in isolation beyond chance expectancy this suggested that there must be visible, measurable differences among homophenous words.

The present study was exploratory in nature. It attempted to make physical measurements of mouths as filmed

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[10] Ila Mae Roback, "Homophenous Words" (unpublished Master's thesis, Department of Speech, Michigan State University, 1961), pp. 4-5.

speakers uttered homophenous words. A frame-by-frame analysis was made in order to determine whether there were measurable differences among homophenous words. Only the mouth area including the apex of the nose and the chin was filmed.

The following questions were asked. Is there a difference in:

1) The size of the mouth opening at the philtrum at specific times among the homophenous words considered in the present study?

2) The distance from one corner of the mouth to the other at specific times among the homophenous words considered in the present study?

3) The visibility of the teeth at specific times among the homophenous words considered in the present study?

4) The amount of time required for utterance of the homophenous words considered in this study?

Importance of the Study

An analysis of the facial movements associated with the production of homophenous words may yield information as to the subtle differences that are available to viewers.

This information may have implications for further research and lipreading training of the acoustically handicapped.

Limitations

The small sample used in the present study imposed a limitation. Only forty-eight words and four speaker subjects were employed. Originally the plan was to measure the visibility of subjects' teeth with a planimeter, but this instrument, it was discovered, was not sensitive enough to measure some of the small areas of teeth that were exposed. The method that had to be substituted was not so precise as the planimetric measurements.

Definition of Terms

Homophenous sounds. Sounds with visible patterns that are highly similar on the face of the speaker.

Homophenous words. Words with visible patterns that are highly similar on the face of the speaker.

Word list. Twelve groups of four homophenous words each that were filmed when spoken by subjects. (See Appendix for word list.)

Subjects. Two female and two male college students filmed while speaking the homophenous words.

Sixteen millimeter Tri-X reversal film. Black and white single system motion picture film computed for exposure at 200 ASA.

Mitchell sixteen millimeter camera. Motion picture camera employed for filming.

Two hundred and fifty foot candles of light. Amount of light used during the filming. Two 750-watt spots and one 300-watt fill were employed to provide this amount of light.

Frame. Section of film 5/16 of an inch. Twenty-four frames equal one second of shooting time.

Head clamp. Fastened to the back of the chair to prevent movement of the heads of the speakers. The construction was such that it did not inhibit free jaw movement.

Lipreading. The act of comprehending speech by the visible movements of the lips.

Rear projection screen. The screen on which the film was projected. It was constructed of a double thickness of plate glass with a piece of frosted acetate (frosted side out) stretched over the glass. The clearer image then appeared on the frosted side of the screen.

Bell and Howell sixteen millimeter movie projector. Projector used for projecting film onto the rear projection screen. Film could be shown at regular speeds, or frame-by-frame when operated manually.

Linear measurements. Measurements made by a ruler from one fixed point to another fixed point.

Anatomical terms.

Crown. The portion of the tooth projecting above the gum.

Apex. The tip of the nose.

Philtrum. The shallow groove running down the center of the outer surface of the upper lip.

Organization of the Thesis

Chapter I, which is introductory, discusses the purpose of the study, states the problem, lists the questions that are raised, considers the importance of the study, the limitations, defines the terms, and outlines the organization.

Chapter II consists of a survey of the literature pertinent to a study of homophenous words.

Chapter III describes the subjects, equipment, filming procedure, and measuring techniques employed in this study.

Chapter IV discusses the analysis and results of the study.

Chapter V contains the summary, lists the conclusions, and the implications for further research.

CHAPTER II

SURVEY OF THE LITERATURE

Introduction

This chapter considers literature pertinent to the present study of homophenous words. The main ideas of contributors to the literature have been reviewed in chronological order.

1900 - 1939

White[1] in 1901 was among the first to recognize the problem of homophenous sounds. She maintained that the eye alone cannot distinguish the consonants m, b, and p; t, d, n, and l; and f and v. To teach a deaf child how to distinguish these sounds, she made use of the sense of touch and a mirror.

The term "homophenous" was first used in 1903 by Snow,[2] who became interested in the problem after noticing

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[1] Stella K. White, "The Home Instruction of a Little Deaf Child," The Association Review, 3 (December, 1901), 20.

[2] Emma Snow, "My List of Homophenous Words," The Association Review, 5 (1903), 30.

the similarities in many different words. She proceeded to make lists of homophenous words and arrange them in alphabetical order. It was soon seen that the difficulties in distinguishing these words on the lips of various speakers were further complicated because no two mouths are the same and everyone has his own distinct manner of expression. Snow felt that:

> The greatest difficulties are found in distinguishing the following consonants, t, d, n, l, formed by placing the tip of the tongue against the front teeth . . . ; p, b, m, produced by lip sounds . . . ; f, v, ph, also produced by lip sounds . . .; s, c, z, formed by pressing the teeth . . .; c, g, k, which cannot be seen at the beginning of a word produced by throat sounds . . .; ch, sh, j, at the beginning of a word, produced by hissing sounds. . . .[3]

This problem was met by requiring the hard-of-hearing students to memorize these lists and to practice putting words in sentences and phrases to facilitate their recognition in context.

This has been the recommendation generally accepted by most lipreading teachers, but it has been an almost impossible task to expect of any hard-of-hearing individual.

Snow's lists of homophenous words have been accepted

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[3] Ibid.

with little question by most lipreading instructors. With the exception of Roback's study,[4] this writer was unable to find any literature reporting scientific research dealing specifically with homophenous words.

The most emphatic protest against the fact of homophenous words was voiced by Davidson[5] in an editorial appearing in the same issue of <u>The Association Review</u> that contained Snow's lists of homophenous words. Davidson reviewed her lists with an expert lipreader and concluded that many of the words were only approximately the same and could be recognized in isolation by close observation of the mouth and face.

Nitchie[6] developed one of the main schools of thought regarding lipreading. He believed that the eye and the mind must be trained together. The eye cannot function alone because of the obscurity of many movements and the rapidity of their formation. He advocated studying

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[4]Roback, <u>op. cit</u>., pp. 4-5.

[5]S. G. Davidson, "Editorial," <u>The Association Review</u>, 5 (1903), 92-93.

[6]Edward B. Nitchie, <u>Lip Reading Principles and Practice</u> (Philadelphia, New York: Frederick A. Stokes Co., 1912), pp. 14-19.

the movements in words and sentences rather than in individual sounds. Individual sounds tend to become exaggerated when spoken singly; therefore lip movements would not be exactly what they are in ordinary conversation. Nitchie maintained that it was impossible for the eye to see every movement, but that the mind would nevertheless grasp the thought of the conversation.

> Methods of mind-training should aim to develop this power of grasping thoughts as wholes, and to avoid strictly anything that will enhance the opposite tendency of demanding verbal accuracy before anything is understood at all.[7]

It was Nitchie's contention that homophenous words could be distinguished only by exaggerated movements. This seemed to this writer to contradict his main theory regarding lipreading--that words should be spoken naturally and rapidly as they occur in conversational speech. If homophenous words were spoken in this manner, Nitchie asserted, they could not then be differentiated except by the context.[8]

The method Nitchie advocated for learning homophenous words involved strictly a memorization of the homophenous words in each lipreading lesson. When an individual

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[7] Ibid., p. 20.

[8] Ibid., p. 176.

observed an homophenous word he should then be able to remember all the words in that group and select the correct one to complete a conversational thought. Nitchie felt that practice with homophenous words was the best training in lipreading.[9]

The eye alone could not possibly read the lips with accuracy because lipreading is a psychological process and because 40 per cent of the speech sounds have some other sound homophenous to them. This was the opinion of Elizabeth Nitchie,[10] who pointed out further that it was possible, though not probable, that two out of every five sounds could be misunderstood when judged by visible facial appearance. She further estimated that 50 per cent of colloquial speech was homophenous; therefore it was conceivable that every other word in ordinary conversation could be misunderstood.

Morgenstern[11] regarded homophenous words as a

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[9] Ibid., pp. 317-318.

[10] Elizabeth Helm Nitchie, Advanced Lessons in Lipreading (New York: Frederick A. Stokes Company, 1923), p. 185.

[11] Louise I. Morgenstern, Lip-Reading for Class Instruction (New York: Noble and Noble, 1926), pp. 25-26.

stimulus to training the mind to grasp whole sentences from the recognizable parts. Since homophenous words cannot be distinguished, reasoned Morgenstern, why not use them as an exercise to develop the student's ability to grasp entire sentences from fragments? Thus homophenous words become a tool to develop in the student the ability to correlate the mind and the eye.

Stowell[12] agreed that homophenous words could be discriminated only by context, and therefore the lipreader must have a good knowledge of homophenous words to enable him quickly to substitute the right one. She further pointed out that the widely different meanings of homophenous words facilitated contextual association.

Goldstein[13] in his book, Problems of the Deaf, has written a little more realistically regarding the similarities in words. To be understood, similar words must be associated with other words. Goldstein made a statement that was unusual for the literature of the period:

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[12] Agnes Stowell, Estelle E. Samuelson, and Ann Lehman, Lip Reading for the Deafened Child (New York: The Macmillan Co., 1928), pp. 40-41.

[13] Max A. Goldstein, Problems of the Deaf (U.S.A.: The Laryngoscope Press, 1933), p. 297.

> The ear has been so commonly regarded as the only sensory organ through which speech may be conveyed to the brain that few realize that the same result, difficult as it may seem, may be reached by another sensory organ -- the eye.[14]

This seemed to imply that the eye can see everything that the ear can hear. If this were true then the problems of homophenous words and sounds could be solved. However, this writer felt that Goldstein was not saying anything so extreme, rather that he believed it was possible to train the eye to identify homophenous words and thus greatly facilitate the whole process of lipreading.

The foregoing concepts regarding homophenous words evolved during the first forty years of the twentieth century. Most of the authors of this period accepted the premise that homophenous words could not be recognized except by context.

1940 - 1949

The literature of the forties does not approach the problems of homophenous words any more scientifically than the literature reviewed thus far.

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[14] Ibid., p. 299.

Bunger[15] emphasized the association of sounds, pictures, and sensations as they are related to homophenous words. Spoken singly, homophenous words are impossible to distinguish; however, in composite speech they can be understood from context.

The importance of hearing in the natural process of acquiring speech by imitation was stressed by Berry and Eisenson.[16] Obviously then, they contended, vision alone was inadequate for the lipreader who could not distinguish all sounds. These authors maintained specifically that, without hearing, it was impossible to learn certain sounds (t, l, g, s) made in the mouth and throat; and that it was also impossible to differentiate such sounds as m, b, p, which appear overtly alike. "A lipreader can never see a complete version of every word because some speech movements are invisible. . . ."[17]

The consonants that are homophenous in visible speech are: [f] and [v]; [θ], [ð], [d] and [n]; [p], [b],

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[15]Anna M. Bunger, Speech Reading -- Jena Method (Danville, Illinois: The Interstate, 1944), p. 52.

[16]Mildred Berry and Jon Eisenson, The Defective in Speech (New York: F. S. Crofts & Co., 1945), p. 322.

[17]Irene R. Ewing, Lipreading and Hearing Aids (Manchester University Press, 1946), pp. 26-27.

and [m]; [k] and [g]; [s] and [z]; [tʃ] and [dʒ]; and [ʃ] and [tʃ]. "A person with normal hearing can detect by ear alone the difference between each pair of consonants, but these differences are not often discernible by the eye."[18]

The opinions of the majority of the authors of this period are reiterated by Faircloth.[19] He agreed with other writers that homophenous words "look the same on the mouth," but adds, "Maybe two or three may appear in one thought. They are found in groups of two to fourteen words. They give little trouble, being told apart by the context."

The Kinzie[20] sisters defined homophenous words as those that are formed by like lip movements and cannot be identified by the eye alone. They substantiate their opinion with four facts:

1) Fifty per cent of the sounds in ordinary speech are formed by obscure movements.

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[18] Ibid.

[19] M. Faircloth, Lip-Reading Study and Practice (Toronto: The Ryerson Press, 1946).

[20] Cora E. Kinzie and Rose Kinzie, Lip Reading for Juniors III (N.P., 1947), pp. 10-11.

2) The rapidity of normal lip movements. The average number of speech movements per second is thirteen; the eye is capable of seeing only from eight to ten speech movements per second, or about three-fourths of all speech movement.

3) Many sounds are homophenous.

4) Variations in lip motions.

The problem of teaching children to lipread homophenous words was easily disposed of by Leavis.[21] Just tell them, she said, "Some words look alike on the lips." Use one sentence for every homophenous word, she explained, and show the children how these words look alike on the lips.

Bruhn,[22] in her book on lipreading, added nothing new to concepts of homophenous words and their recognition. She reiterated that about 50 per cent of English sounds are homophenous; that they could be distinguished only by context and therefore should be practiced in sentences only.

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[21]May Hudnutt Leavis, Beginning Lip Reading (Boston 15, Mass., 386 Commonwealth Avenue, 1949), p. 19.

[22]Martha E. Bruhn, The Mueller-Walle Method of Lip Reading for the Hard of Hearing (Boston 15, Mass.: M. H. Leavis, 1949), pp. 9-13.

Bruhn added that although theoretically there were no homophenous vowel sounds, in rapid speech some vowels became difficult to distinguish. Bruhn concurred with Nitchie that the mind must be trained to grasp complete thoughts as well as to recognize lip movements. This training, she believed, developed the intuitive powers of the mind.

This concludes a review of the literature from 1940 to 1949. No new scientific theories have been propounded. The same concepts have been restated in slightly more sophisticated fashion.

1950 - Present

Literature of the fifties, to which we now turn, presents early research on lipreading. This research includes the investigation of factors in visual recognition and auditory cues.

Harris,[23] in his book on relations between vision and audition, came to interesting conclusions that cast doubt on some of the statements of lipreading teachers previously reviewed in his chapter.

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[23] J. Donald Harris, Some Relations Between Vision and Audition (Springfield, Ill.: Charles C. Thomas, Publisher, 1950), p. 6.

> It is clear, he declared, that a very slight amount of energy should be required to produce minute amplitides and the ear compares favorably with the eye in this matter. . . . In terms of energy at threshold, in spectral regions where the organs are most efficient, the eye and ear are very roughly similar. . . . In both organs, sensitivity is almost at theoretical limit.[24]

Any further increase in this sensitivity would be useless.

It seemed to this writer that Harris was stating that the eye and ear are equally sensitive and therefore the eye can detect any movement the ear can hear.

In 1950 Black[25] did a study on the pressure component in the production of consonants. He defined a consonant as "a sound that results from an obstructed column of air during exhalation. This implies that there is essentially a pressure component in the saying of a consonant, the air pressure that is built up by the obstruction."[26]

The aim of Black's study was to investigate the relative amounts of air pressure present during the pronunciation of different types of consonants. The adapted Pioneer rate-of-climb indicator yielded the most significant

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[24] Ibid.

[25] John W. Black, "The Pressure Component in the Production of Consonants," Journal of Speech and Hearing Disorders, 15 (September, 1950), 207-210.

[26] Ibid.

results. Analyses of Black's data established that voiceless consonants required greater amounts of pressure than voiced ones and that the consonant was accompanied by diminishing pressure as it receded in the word. Greater pressures accompanied the continuants than the plosives; the pressure diminished from the initial to the final position. From these results, it was assumed that voiced and voiceless consonants were dissimilar in vocal chord action and in oral pressure. It followed, therefore, that homophenous sounds might have some distinguishing characteristics that accompanied these differentiating behind-the-lip pressures. Final consonants were spoken with less pressure than initial ones. Black did not know that this was a pertinent cue for a lipreader; however, it was the first positive scientific evidence of a difference in the so-called homophenous words.

Di Carlo and Kataja[27] undertook a study to determine whether or not the Utley film was a valid and reliable instrument to test lipreading achievement and whether or

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[27] Louis M. Di Carlo and Raymond Kataja, "An Analysis of the Utley Lipreading Test," Journal of Speech and Hearing Disorders, 16 (September, 1951), 229-239.

not the test discriminated between good and poor lipreaders. Their results showed that the test was so difficult that the average score was only 19 per cent of the total number possible. Experienced and inexperienced lipreaders performed equally well. The investigators concluded that the Utley test was not a valid and operationally efficient instrument. In this study homophenous words were regarded as a variable impossible to control that interfered with results and as an obstacle that the researchers did not know how to control.

The negative approach toward homophenous words was taken by Fiedler in her book, Deaf Children in a Hearing World. She stated, "It becomes obvious that, without knowing context, it is impossible to distinguish these homophenous words by lipreading alone."[28]

Very little research had been done to establish the role of lipreading in regular communication of normal hearing individuals until O'Neill[29] conducted his study in 1954.

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[28]Miriam Forster Fiedler, Deaf Children in a Hearing World (New York: The Ronald Press Company, 1952), p. 204.

[29]John J. O'Neill, "Contributions of the Visual Components of Oral Symbols to Speech Comprehension," Journal of Speech and Hearing Disorders, 19 (December, 1954), 437.

His study measured vision and audition alone and simultaneously.

The results indicated that normal hearing individuals make appreciable use of lipreading to gain information. Visual recognition was always greater than non-visual recognition. "Vision contributed 44.5 per cent to the understanding of vowels, 72 per cent for consonants, 64.1 per cent for words, and 25.9 per cent for phrases."[30] Vision was most important in the recognition of consonants. If, for a normal hearing person, vision contributes 72 per cent to the recognition of consonants, it seems safe to assume that it would contribute much more for a hard-of-hearing person.

O'Neill also concluded that when the visual channel supplements the auditory channel there is an increase in the understanding of consonants, vowels, words, and phrases. He further discovered that the sound pressure level of vowels and consonants was not an important factor in their visual recognition.[31] This contradicts Black's statement that the

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[30] Ibid., p. 438.

[31] Ibid.

pressure component could possibly be a clue in lipreading of homophenous words.

Another conclusion of O'Neill's that is significant to a study of homophenous words was that it was "possible to attribute to the eye in the instance of lipreading some of the properties assigned to the ear in hearing. It would then be possible to suggest that lipreading may be a substitute communication channel."[32]

The authors of The Rehabilitation of Speech[33] took a more positive approach to homophenous words, and offered several concrete suggestions as to how the lipreader could master them. They agreed that the visible patterns of homophenes are almost identical. The student of speech reading was advised to become familiar with the positions of difficult speech sounds, then with all speech sounds. When this had been mastered the student was taught combinations of two sounds first from a static position, then from a position of motion. The most visible sounds were

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[32] Ibid., p. 439.

[33] Robert West, Merel Ansberry, and Anna Carr, The Rehabilitation of Speech (New York: Harper and Brothers, Publishers, 1957), pp. 239-240.

learned first, proceeding to the more obscure sounds. When the student had learned these techniques he was ready for homophenous sounds, which were easier to master because the student had a solid foundation on which to build.

When the problem of homophenous words arose in lipreading, Silverman[34] stressed the use of situational cues reinforced by sensory cues.

Fusfeld[35] interviewed ten expert lipreaders in an effort to determine what factors accounted for their success. These lipreaders all agreed that "educated guesswork" -- filling in obscure and hidden elements in seen speech -- was an active and basic part of their lipreading. The point was that these lipreaders seemed to accept the fact that there was a great deal of guessing required and they assumed that much of what was being said could not be precisely understood. There seemed to be no attempt at fine discrimination -- perhaps because fine discrimination had

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[34] S. Richard Silverman, "Clinical and Educational Procedures for the Deaf," Handbook of Speech Pathology, ed. Lee Travis (New York: Appleton-Century Crofts, Inc., 1957), pp. 114-115.

[35] Irving S. Fusfeld, "Factors in Lipreading as Determined by the Lipreader," American Annals of the Deaf, 103 (March, 1958).

not been emphasized nor taught.

Ten inexpert lipreaders who were also interviewed all stressed the point that visible lip movements were the same or nearly so for many sounds. This underlined the need for more acute discrimination.

Jacoby was the only dissenting author who could be found. She stated that although many sounds in the English language look alike, they are not identical. It is time that textbooks, which have been emphasizing gross discrimination, turned to fine visual discrimination, Jacoby contended. "The eye is capable of recognizing visible phenomena as exquisitely as the ear can recognize audible phenomena."[36] The differences that can be apprehended by the ear can also be apprehended by the eye; however, the lipreader's eye must be directed to the significant visible elements to teach fine discrimination.

Jacoby quoted from an article appearing in the American Journal of Ophthalmology by Dr. Sells and Col. Fixott, which discussed this discrimination:

> There is acceptable evidence that in motivated subjects, even myopes, visual acuity . . . can be improved

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[36] Beatrice Jacoby, "Lipservice to Lipreading," Hearing News, 27 (September, 1959), 18.

> with visual training. Such improvement must be considered perceptual. Visual training procedures depend upon the general hypothesis that through appropriate conditions of learning particular functions can be improved. Since seeing is only partly a matter of the image on the retina and the sensation it produces, but is in still larger part a matter of the cerebral process of synthesis, in which memories play a principal role; it follows that by repetition, by practice, by exercises, one builds up a substratum of memories for the interpretation of sensations and facilitates the syntheses which are the major part of seeing.[37]

To realize this goal more information is needed on how language looks. Jacoby suggested that we need descriptive studies of the movements of the speech mechanism.[38]

The authors of Hearing and Deafness[39] said that it might seem impossible to speech read when only one-third of the sounds are visible; however, even normal hearing individuals have somewhat the same problem with many words that are spelled alike, sound alike, and have similar meanings. The speech reader must employ many more cues than the normal reader; he must anticipate and integrate all the cues that are available to him.

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[37] Ibid.

[38] Ibid.

[39] Hallowell Davis and S. Richard Silverman, Hearing and Deafness (New York: Holt, Rinehart, and Winston, 1960), p. 355.

The purpose of Woodward's and Barber's[40] investigation on phoneme perception in lipreading was to apply the theory and method of structural linguistics to problems of visual perception. Their results demonstrated that there are only four visually contrastive groups of consonants consistently available to the lipreader. These four units are: 1) bilabial: p, b, m; 2) rounded labial: w, r; 3) labiodental: f, v; and 4) nonlabial: l, d, n, l, θ, , s, z, č, ǰ, š, ž, k, g, h. Although these four groups contrast visually with each other, they are internally homophenous.

Wang and Fillmore[41] studied the effects of intrinsic secondary cues, their objective being to evaluate the influence that the consonant-vowel intereffects have on the perception of the consonant. These secondary cues are extrinsic as opposed to those that are intrinsic. The subjects for this study were ten phonetically trained

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[40]Mary F. Woodward and Carroll G. Barber, "Phoneme Perception in Lipreading," Journal of Speech and Hearing Research, 4 (September, 1960), 212-222.

[41]William S-Y. Wang and Charles J. Fillmore, "Intrinsic Cues and Consonant Perception," Journal of Speech and Hearing Research, 4 (June, 1961), 130-136.

listeners. Four hundred five consonant-vowel-consonant syllables consisting of nine consonants and five vowels in all combinations were selected for identification. The results of correct identifications of initial consonants suggest that vowel amplitude, degree of format blend, and vowel nasalization are significant parameters in the vowel for identifying the consonant that precedes it.

O'Neill and Oyer,[42] in their recent book on visual communication, reviewed the research in this area and concluded that thus far it has not been established that a definite relationship exists between lipreading ability and visual skill. "The relationship of visual skill to lipreading ability is one of the frontier areas for research," they pointed out. It is their recommendation that "the eye should be brought back into the lipreading picture."[43]

The literature of the 1950's and 1960's emphasized the fact that there has been no specific research on homophenous words or sounds. Recent studies on lipreading centered more attention on lipreading variables.

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[42] John J. O'Neill and Herbert J. Oyer, <u>Visual Communication for the Hard of Hearing</u> (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1961), p. 42.

[43] <u>Ibid</u>., p. 69.

Summary

This review of the literature on homophenous words and the problems they create for the lipreader brought several facts into focus. First, there is a great need for more scientific research -- research on all facets of homophenous words and how language looks.

Secondly, the literature made startlingly clear that the initial concepts regarding homophenous words -- that they looked alike on the lips, that they could be distinguished only by contextual association, and that they were impossible to recognize in isolation -- are still generally accepted. These, if accepted, are static, futile concepts that stifle progress in the field.

CHAPTER III

SUBJECTS, EQUIPMENT, AND PROCEDURES

Introduction

The problem in this study was to determine the physical differences on the faces of speakers as they uttered homophenous words. A film was made with four subjects saying twelve groups of four homophenous words each. These words were then analyzed frame by frame.

Subjects

Selection of speaker subjects. Four individuals were selected as speaker subjects. The only criteria employed in the selection of the four subjects were sex and dialect; none had previous knowledge of what was being attempted in this study. Two were male and two were female with general American dialects. Three of the subjects were graduate students actively engaged in the field of speech and hearing and the fourth subject was an undergraduate in English.

Equipment

The following equipment was employed in this study:

Motion picture camera (Mitchell 16 mm., Ser. No. 462).

Lens (101 mm. Ektar 6.3).

Film (Tri-X reversal, black and white).

Lamps (two 750-watt spots and one 300 watt fill).

Chair (with head clamp attached to the back).

Cue cards (48 with one homophenous word each).[1]

Number cards (48 with numbers 1 - 48).

Movie projector (Bell and Howell 16 mm., Mo. 173, Ser. No., AH 41829).

Rear projection screen.

Linear rule (K & E Architects' Triangular Scale 1621W).

Procedures

Homophenous word list. The word list used in this study was selected from the Homophenous Word Test employed by Roback.[2] Selection of the twelve groups of four words each was made by inspecting the raw data obtained by Roback. Those twelve groups in which there were the greatest

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[1]See Appendix.

[2]Herbert Oyer, "Homophenous Word Test," 1958, The Ohio State University, Columbus, Ohio (unpublished).

percentage of correct identification were selected. The reasoning was that in these groups, physical differences regarding facial configurations would probably be more evident.

Filming situation. The filming of the speaker subjects was carried out in the Michigan State University Audio-Visual Film Production Studio.

The subjects were seated in a chair with a head clamp attached to the back. Each subject's head was immobilized by means of the head clamp. The head clamp held the subject's head secure at the temples but did not inhibit free jaw movement. The chair and camera were stabilized by sand bags to avoid any movement during the filming process.

Before filming each subject, a black ink dot was placed on the apex of the nose and on the center of the chin. The distance between these two points was measured and recorded. The dots remained on the subjects during the filming. The purpose of this measurement was to provide information as to life size image during the measurement phase of the study.

The distance from the subject's mouth (teeth) to the film plane was seventy inches. The film exposure was computed for 200 ASA with one hundred and seventy degree shutter on the camera at twenty-four frames per second. Two hundred and fifty foot candles of light were employed for the filming. Only the subject's mouth was filmed, including the apex of the nose and the bottom of the chin. A seven hundred and fifty watt spot lamp lit up the interior of the subjects' mouths. This lamp was situated to the right and slightly in back of the camera. A three hundred watt fill lamp was placed to the left and slightly in front of the camera and another seven hundred and fifty watt spot lamp was located to the left and in back of the speaker chair (see Figure 1).

The writer stood to the left of the camera and held up a cue card on which an homophenous word was printed; at the same time an assistant held a small number card by the subject's left cheek. The number on the card correlated with the number of the word the speaker uttered. This procedure substituted for the use of a sound track. Each speaker spoke the forty-eight word list. Voice was employed by the speaker as he was filmed saying each word. The directions given to each speaker were as follows:

Figure 1--Filming Situation

You will be asked to say forty-eight isolated words. As you say these words your mouth will be photographed. Say these words as you normally speak them. You will start each word from a closed mouth position. Do not smile or frown. After you have said each word close your mouth to be ready for the next word. For example: Fan, Fad, Van, Vat. (The writer demonstrated using these four words.)

You will each be given a copy of the words to look over briefly to make sure of their pronunciation. You will then give the list back to me and sit in the chair with the head rest attached. The head rest will hold your head steady to avoid movement during the filming. A black ink dot will be placed on the apex of your nose and on the center of your chin to enable measurements to be made. Before the filming starts, the distance between the two dots will be measured. The words will be coded so with each word spoken a small number will be placed by the corner of your cheek. I will hold up a card with the word on it that you are to say. I will do this for the forty-eight words involved.

Measuring situation. The measurements were made in the Visual Communications section of the Speech and Hearing Science Laboratory in the Department of Speech at Michigan State University. The film was projected onto a rear projection screen and the measurements were made from the back of the screen. Life-size images were projected. This was accomplished by measuring the distance between the two dots on the apex of the nose and the center of the chin of each subject, and then adjusting the distance on the screen to correlate with the distance measured at the time of filming.

To avoid error in the measurements this distance was checked before each measuring session.

The first measurement was the distance from one corner of the mouth to the other. This measurement started at the first frame of noticeable movement from the rest position; it began before the mouth opened. A star was recorded by the frame where the mouth opened so as to relate it with the first measurement and to show how many frames of movement there were before the mouth opened. The same procedure was followed at the end of the word to show the number of frames of movement that occurred after the mouth closed until the rest position was resumed.

The third measurement was the visibility of the teeth. For each of the four subjects the crown of the following teeth were measured for both the upper and the lower jaw: first premolars, canines, lateral incisors, and central incisors. This measurement started at the first frame where the mouth opened and the teeth were measured. If one-half or more than one-half of the tooth was visible a plus sign was recorded for that frame; if less than one-half was showing a minus sign was recorded. For the second premolars, first molars, and second molars of both the upper and lower jaws, a check was made if the tooth was visible at all.

The fourth computation determined the amount of time required to say each word. This involved computing the frames measured for the second measurement.

The measurements for questions one (size of the mouth opening at the philtrum) and two (distance from one corner of the mouth to the other) were recorded on dittoed forms numbered horizontally, one through forty-eight, for the number of words and vertically for the number of frames. The measurements for the teeth were marked on similar forms except that the teeth were listed horizontally and the frames were numbered vertically.

CHAPTER IV

RESULTS, ANALYSIS AND DISCUSSION

Introduction

Physical measurements were made in an attempt to answer the four questions set forth in the first chapter. This was accomplished by a frame-by-frame analysis of a motion picture film.

The following questions were asked: Is there a difference in:

1) The size of the mouth opening at the philtrum at specific times among the homophenous words considered in the present study?

2) The distance from one corner of the mouth to the other at specific times among the homophenous words considered in the present study?

3) The visibility of the teeth at specific times among the homophenous words considered in the present study?

4) The amount of time required for utterance of the homophenous words considered in this study?

Results and Analysis

Mouth opening. Figures 2 through 13 present the average amount of the mouth opening of four subjects for each of the groups of homophenous words. The intervals along the ordinates represent distance measured in thirty-secondths of an inch. The abscissas represent time measured in seconds.

Came, Cape, Game, Gape. Figure 2 at .25 of a second, shows the four words with very similar mouth openings between 12 and 13/32 of an inch. At 1 second there is a wide range of variance. The mouth opening during the pronunciation of cape increases to 14/32 of an inch; for came it is 20/32 of an inch. Mouth openings for game and gape fell midway between those for cape and came. At 1.5 seconds the individual curves no longer represent a mean of four speakers; consequently there is considerable divergence from this point until the last speaker has finished pronouncing the words.

Dead, Debt, Den, Ten. Divergence in mouth openings appears at .25 of a second on Figure 3. The mouth opening for ten is 7/32; for dead, 12/32 of an inch. The mouth openings are between 9 and 10/32 of an inch for debt and den -- between the openings for the other two words. At 1 second the mouth opening for debt is at its widest point -- 16/32 of an inch. Mouth openings for the other words continue to increase. At this point the greatest difference is between ten, at 13/32 of an inch and debt, at 16/32 of an inch; the other words fall evenly between. One and one-half seconds were required for the mouth opening, during the utterance of dead, to reach the widest point -- 16/32 of an inch. The curves for the other three words have started decreasing at this point, mouth openings ranging from 12 to 14/32 of an inch. At 2 seconds the curves scatter, due no doubt to the fact that the curves no longer represent a mean of four subjects.

Doubt, Down, Town, Noun. Figure 4. This graph shows variation of mouth openings at .25 of a second, doubt at 8/32; noun at 10/32; town at 11/32; and down at 12/32 of an inch. At 1 second down, town, and noun are similar with mouth openings between 12 and 14/32 of an inch. The mouth opening for doubt decreases at 1.5 seconds to 9/32 of an inch. The noun curve has descended, showing a mouth opening also at 9/32 of an inch. The mouth opening for town has leveled off at 12/32 of an inch. The fourth word, down, cannot accurately be compared because only three speakers are now computed in the mean. At 2 seconds doubt still follows its downward trend with the mean mouth opening reduced to 6/32 of an inch. Mouth openings for the remaining three words are highly divergent due in part to reduction of speaker subjects. Therefore, from this point on the curves appear very irregular.

Died, Tide, Tight, Dine. Figure 5. The mean mouth openings for the four subjects, at .25 of a second, are 6/32 of an inch for tight, 9/32 of an inch for died, 10/32 of an inch for dine, and 11/32 of an inch for tide. At 1 second the mouth opening for dine has increased to 15/32 of an inch. During the uttering of tight the mouth opened quickly and is gradually closing; at 1 second it is at 12/32 of an inch. The mouth openings increased quickly during the pronunciation of died and tide and at 1 second have decreased to 10 and 12/32 of an inch, respectively. At 1.5 seconds the mouth openings for died and tide have again increased to 16/32 of an inch, while the mean mouth openings for tight and dine have decreased to 11 and 15/32 of an inch. At 2 seconds died maintains its peak at 17/32 of an inch. Tide is declining at 15/32 of an inch. Dine and tight have receded to 11/32 of an inch. From this point on the curves are widely scattered due apparently to decreasing number of subjects.

Dome, Dope, Tome, Gnome. Figure 6. At .25 seconds there are differences in the mean mouth openings for the four words. The mean mouth opening for dome is 9/32; dope, 11/32; tome, 13/32; and gnome, 15/32 of an inch. All four curves rise to a low peak, then descend as the mouth closes. The curve for gnome makes the highest excursion -- to 16/32 of an inch -- and at 1 second is receding at 14/32 of an inch. The mean mouth opening for dope at this point is 12/32 of an inch. The mean for the other two words, dome and tome, falls between 10 and 11/32 of an inch. At 1.5 seconds, the curves continue to descend, but from here on the mean is no longer for four subjects, consequently the curves scatter.

Fade, Feign, Vain, Fete. Figure 7 shows that the mean mouth openings are not greatly divergent for the four words at .25 of a second. For feign the mouth opening is 7/32 of an inch; for fete 10/32 of an inch; for fade and vain it falls in between. At 1 second the mouth openings of the four words differ sharply. Mouth openings for fade and feign have increased to 12 and 13/32 of an inch, then decreased to 11/32 of an inch. The mouth opening for vain is 9/32 of an inch at 1 second. The curve for fete is grossly different from those for the other three words. The mouth closes then opens. At 1 second the mouth opening for fete is 5/32 of an inch; at 1.5 seconds it has increased to 9/32 of an inch. The curve for vain reaches a valley at 6/32 of an inch. At 2 seconds all mouth openings increase slightly; for fete the mouth opening is 10/32, for feign 11/32, for vain and fade, 12/32 of an inch. The curves diverge greatly from here on, probably due to the reduction of subjects.

Fight, Vine, Fine, Vied. Figure 8 shows identical mouth openings for fight and vied -- 8/32 of an inch -- at .25 of a second; the openings for vine and fine are 9 and 10/32 of an inch. At 1 second the mouth opening for vine has decreased to 6/32, fine to 7/32 of an inch. The mouth opening for vied increases, then decreases and at 1 second is 9/32 of an inch. The mouth opening for fight increases slightly to 12/32 of an inch, then declines to 10/32 of an inch at 1 second. At 1.5 seconds the curve for fine reaches its lowest point at 5/32 of an inch. The path for fight is still receding at 7/32 of an inch, while the curves for vied and _vine_ are rising at 10 and 12/32 of an inch respectively. At 2 seconds only 3 curves can be accurately compared. Mouth openings for _vine_ and _vied_ are widest at 2.25 seconds -- 13 and 16/32 of an inch. At 2.50 seconds the mouth opening for _fine_ is 14/32 of an inch. There appears to be great irregularity from here on due at least partially to the decrease in the number of subjects.

Cane, Gain, Gate, Kate. Figure 9 shows mouth openings for the four words at .25 seconds to be very similar ranging between 10 and 12/32 of an inch. The four curves rise from this point in a very similar pattern and at 1 second the curves are still rising. The average amount of mouth opening for _gain_ has risen to 15/32; _gate_ to 16/32; _cane_ and _Kate_ to 17/32 of an inch. The amount of mouth opening for the four words starts to decrease at 1.5 seconds. The mouth opening for _cane_ at this point is 14/32, _gain_ 17/32, and Kate 18/32 of an inch. At 2 seconds _cane_ and _gate_ have declined to 8/32, _gain_ to 11/32, and _Kate_ to 12/32 of an inch. There appear to be great differences beyond 2.0 seconds due in part to the decrease in the number of subjects to be averaged at any one time plot.

Whine, Wide, Wine. Figure 10 is a comparison of only three words because during the photography of white an error was made on one subject; hence the measurements for that word were discarded. The mouth opening at .25 second for wine and whine is 9/32; for wide, 11/32 of an inch. At 1 second the mouth opening for wine has decreased to 1/32 of an inch and for wide to 4/32 of an inch. The curve for whine has ascended at 1 second to a peak at 10/32 of an inch. At 1.5 seconds, the mouth openings for wide and wine are increasing; for wide the mouth opening is 6/32 and for wine, 10/32 of an inch. At 2 seconds, curves of wide and wine have reached peaks of 17 and 16/32 of an inch. The mouth opening for wine is increasing at 2 seconds; however, the mean is now based on three speakers and does not permit valid comparisons. The mouth openings for the other two words decrease in similar form to 8/32 of an inch at 2.75 seconds.

Boon, Mood, Moon, Boot. Figure 11 reveals mouth openings for the four words between 6 and 8/32 of an inch at .25 seconds. At 1 second the mouth openings for two words have increased; for the other two words they have decreased. The mouth opening for mood is 8/32, for boot it is 7/32 of an inch. Mouth openings for boon and moon are 4/32 of an inch. It is difficult to make an accurate comparison from this point on because certain speaker subjects closed and reopened their mouths in uttering the words; this continually changes the mean.

Bubble, Bumble, Mumble, Pommel. Figure 12 charts paths that are extremely difficult to compare since the four subjects closed their mouths after uttering the initial b's, m's, and p's. Due to speaker variance the mouths do not close at the same time, remain closed for the same period, nor reopen simultaneously. This produces continuous changes in the means and renders comparisons invalid. The only reliable comparison is at .25 second where the mouth openings range from 9 to 11/32 of an inch.

Dice, Dies, Ties, Nice. Figure 13 reveals similar mouth openings at .25 second for dies and ties -- 7 and 8/32 of an inch. The mouth opening is 11/32 of an inch for dice and nice. At 1 second the curve for ties has reached a peak at 18/32 of an inch; the curve for nice has moved down from a peak of 17/32 to 16/32 of an inch. The mouth opening for dies increases to 15/32 of an inch, but for dice it has decreased from its peak of 15/32 to 12/32 of an inch.

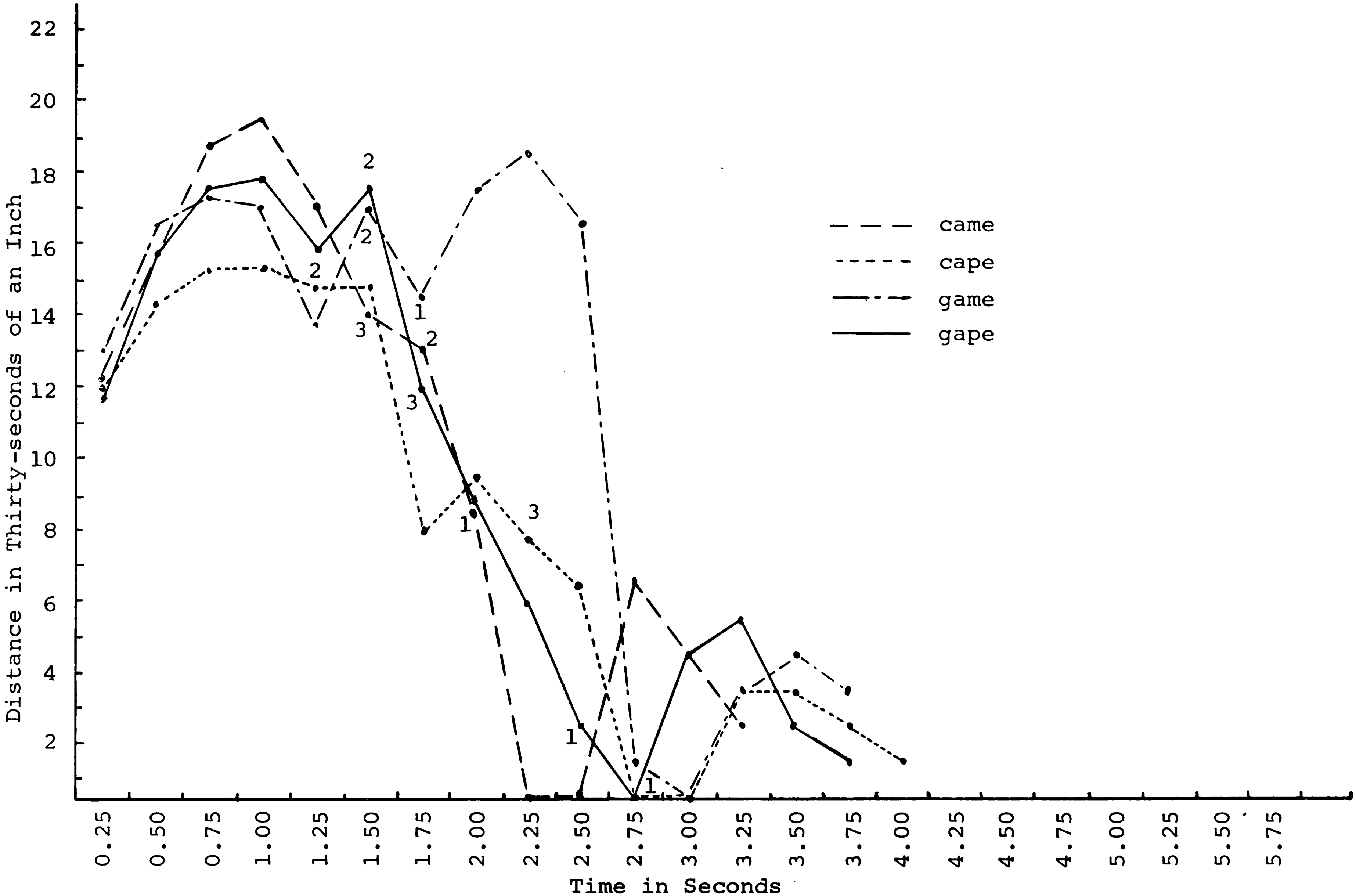

Figure 2--Mean mouth openings of four subjects saying came, cape, game, gape

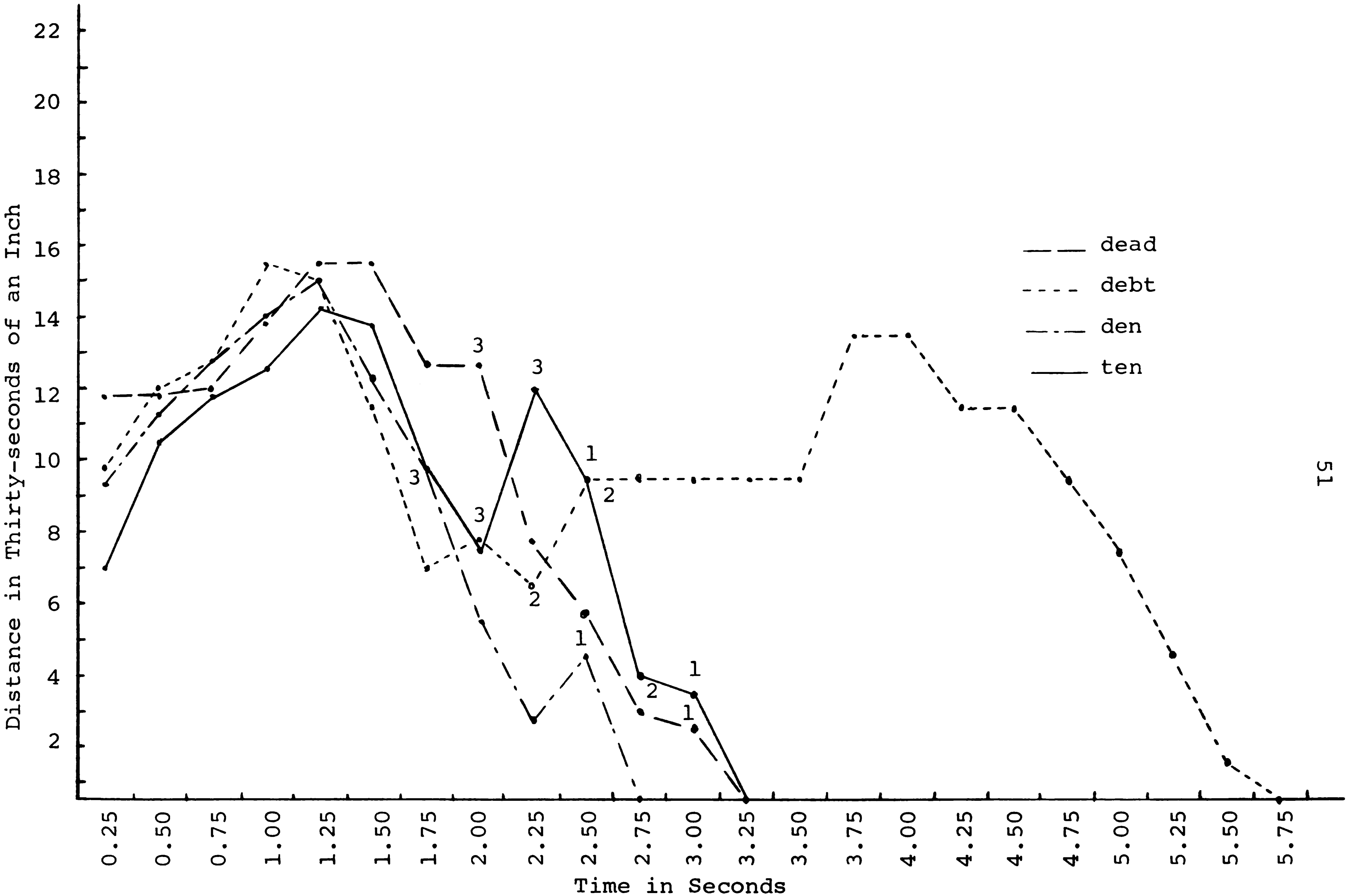

Figure 3--Mean mouth openings of four subjects saying dead, debt, den, ten

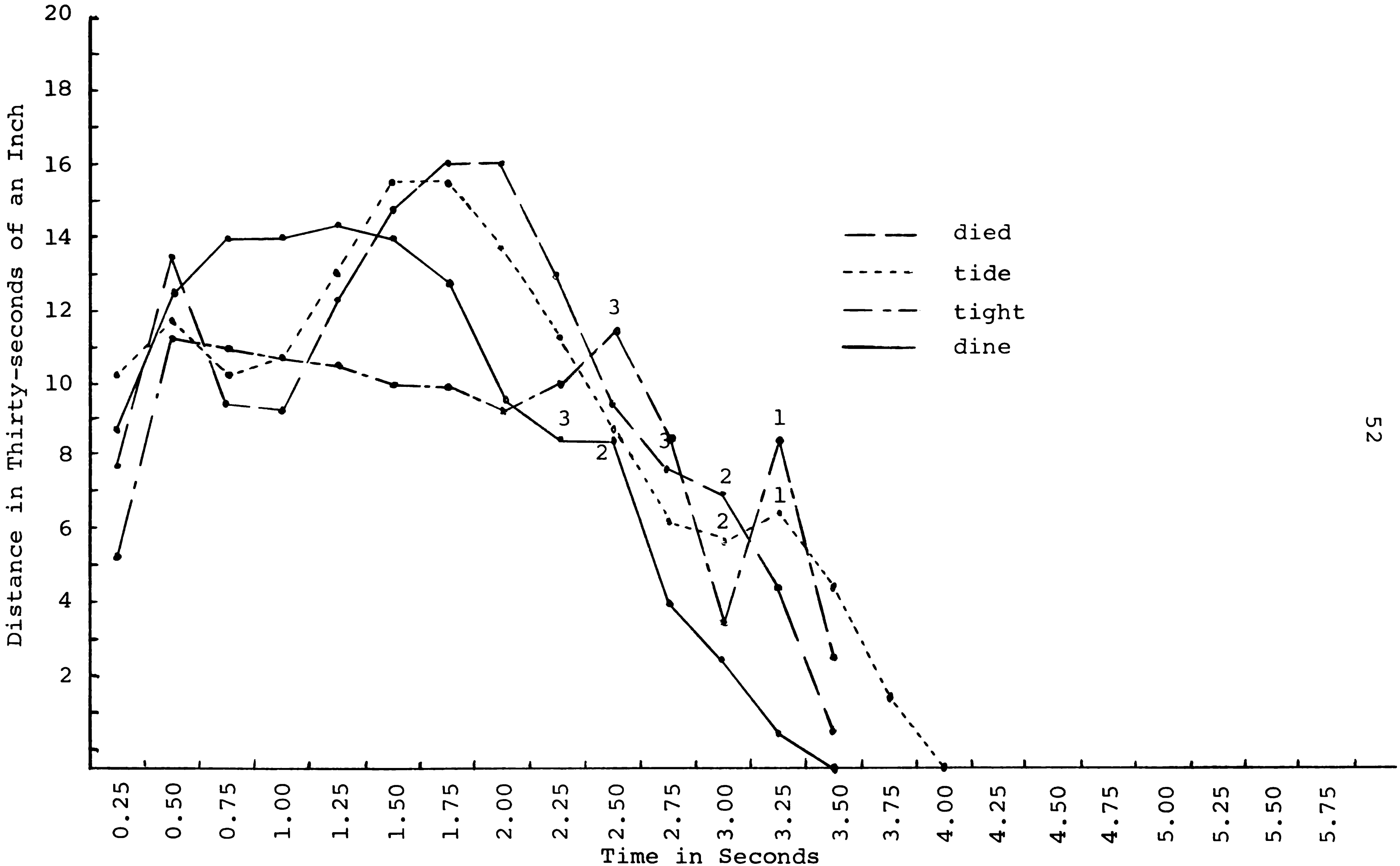

Figure 4--Mean mouth openings of four subjects saying died, tide, tight, dine

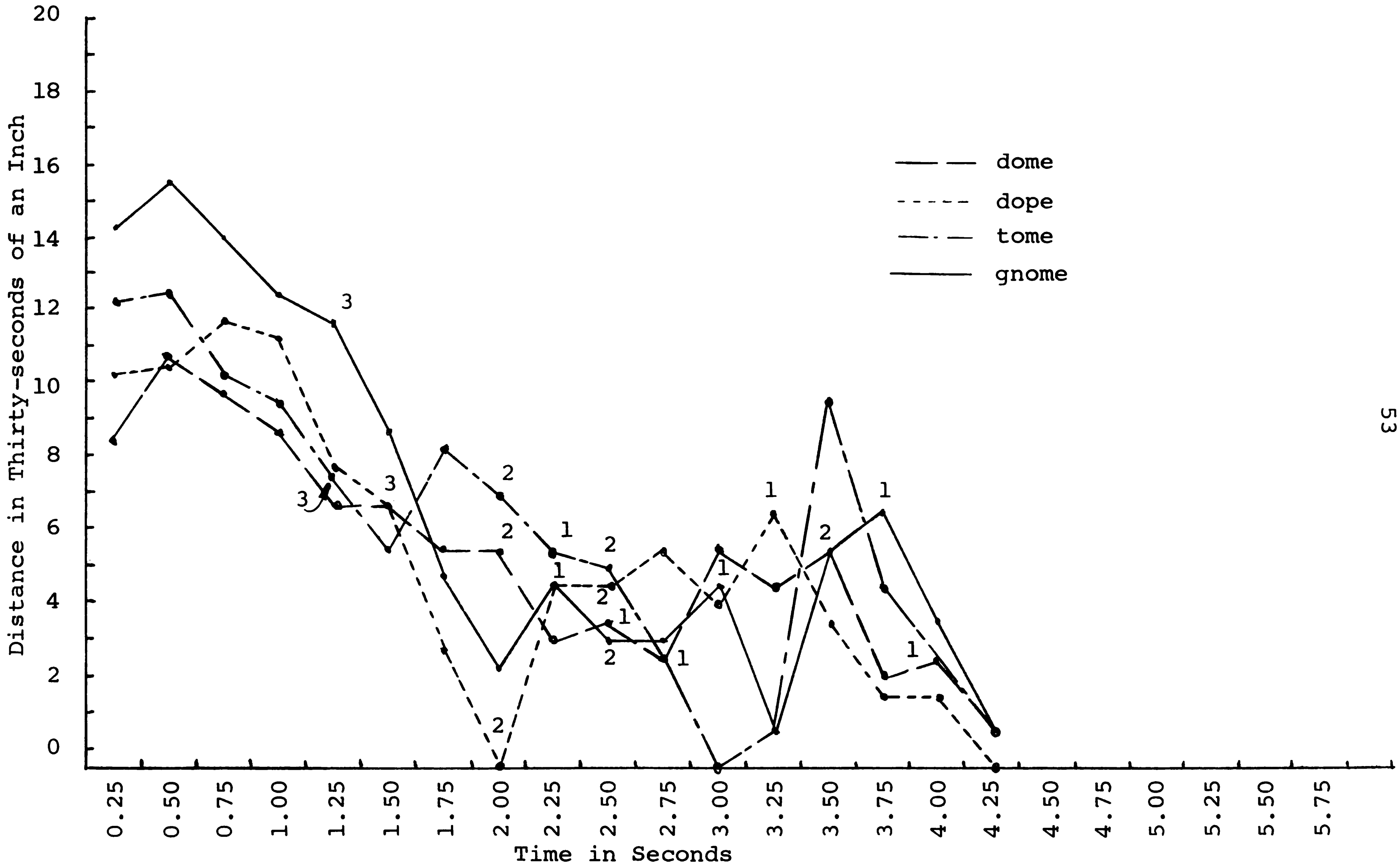

Figure 5--Mean mouth openings of four subjects saying dome, dope, tome, gnome

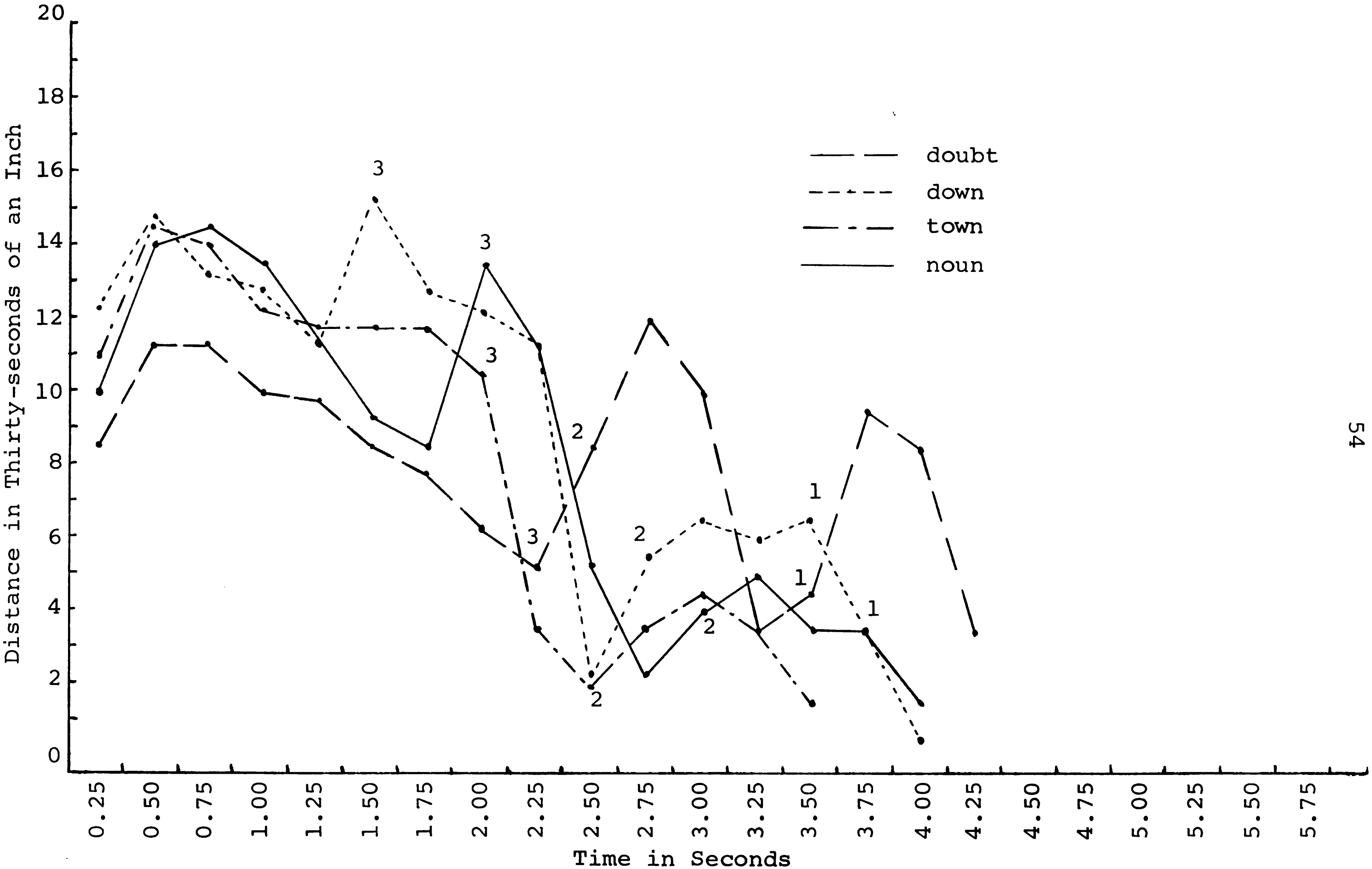

Figure 6--Mean mouth openings of four subjects saying doubt, down, town, noun

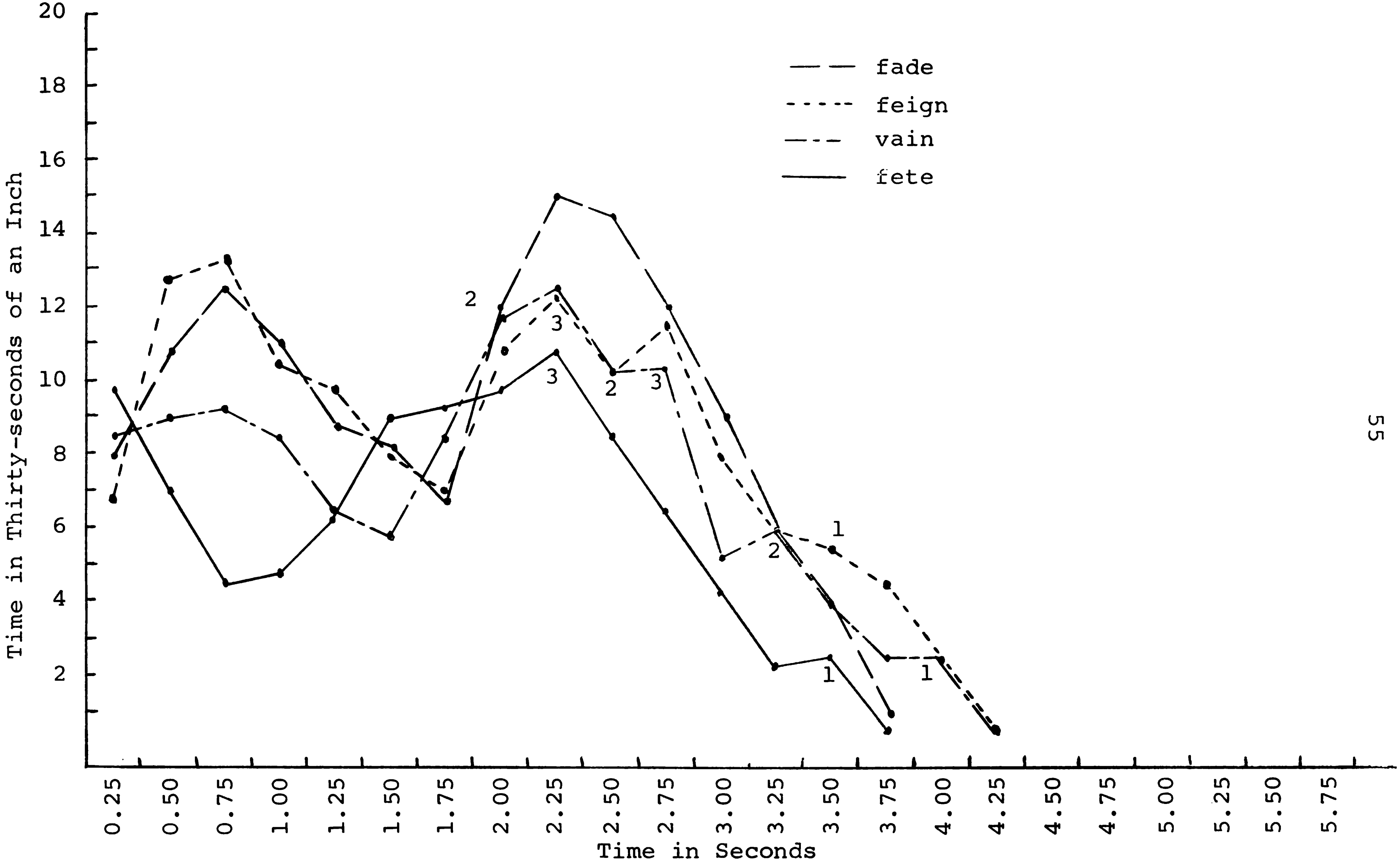

Figure 7--Mean mouth openings of four subjects saying fade, feign, vain, fete

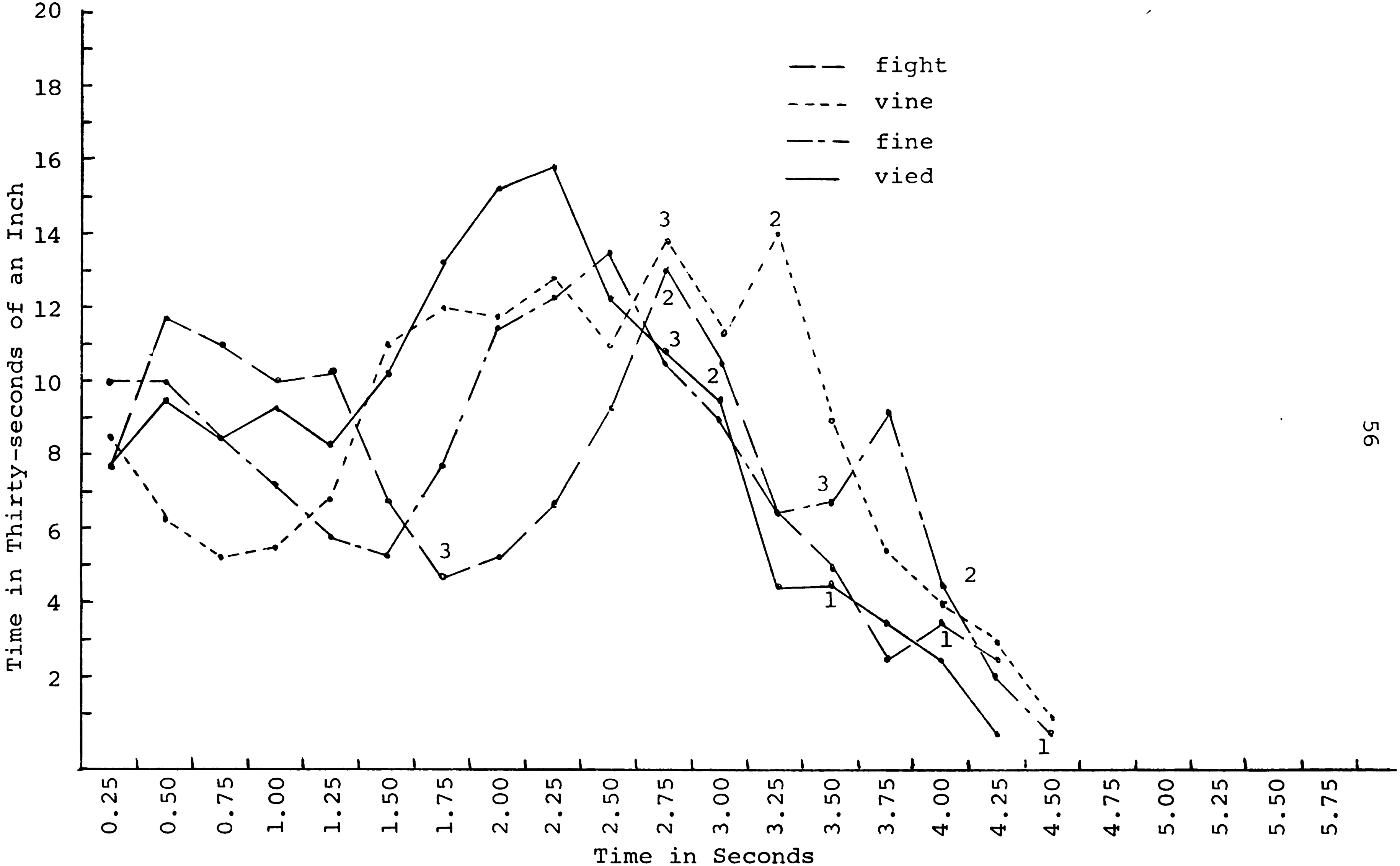

Figure 8--Mean mouth opening of four subjects saying fight, vine, fine, vied

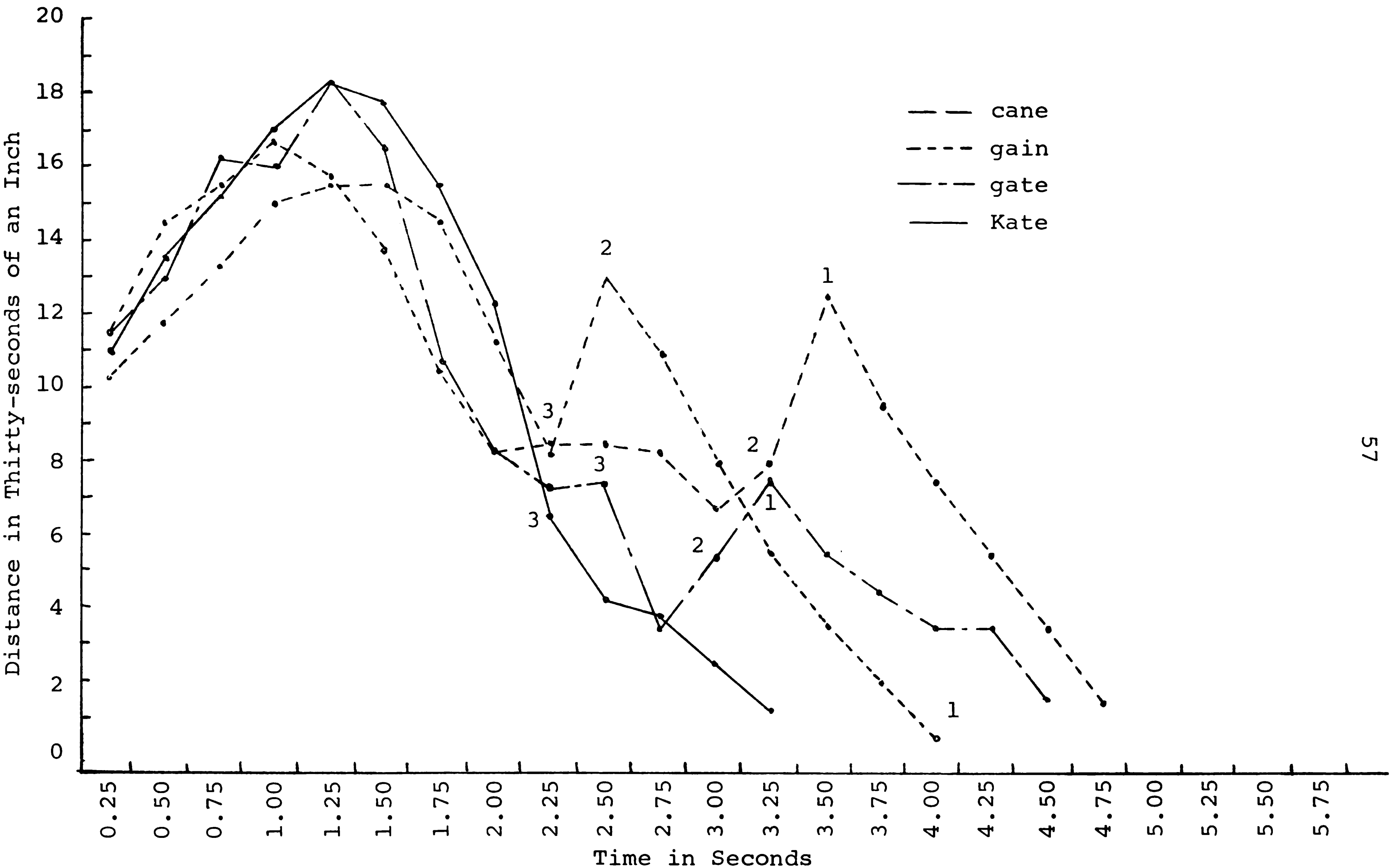

Figure 9--Mean mouth opening of four subjects saying cane, gain, gate, Kate

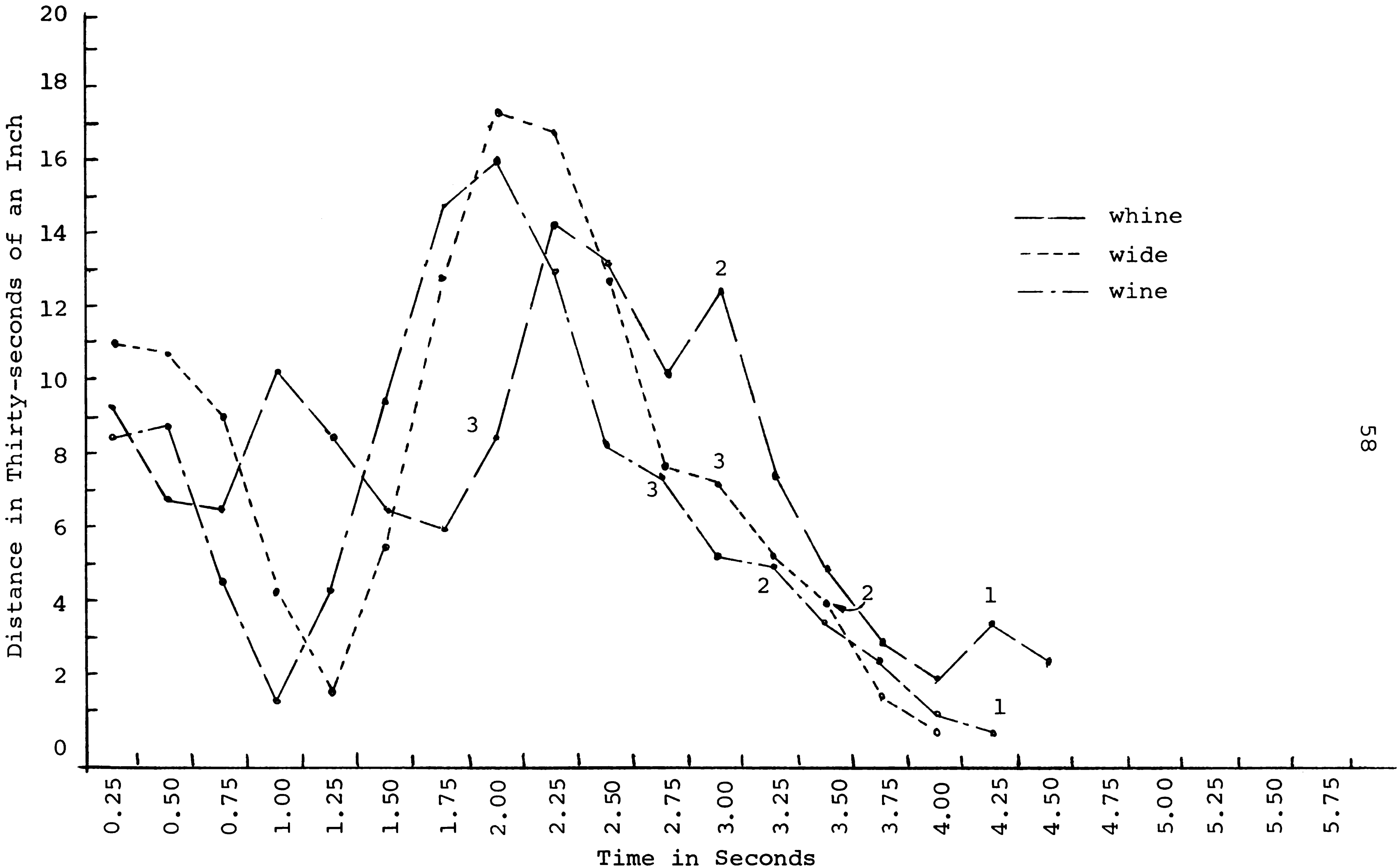

Figure 10--Mean mouth opening of four subjects saying whine, wide, wine

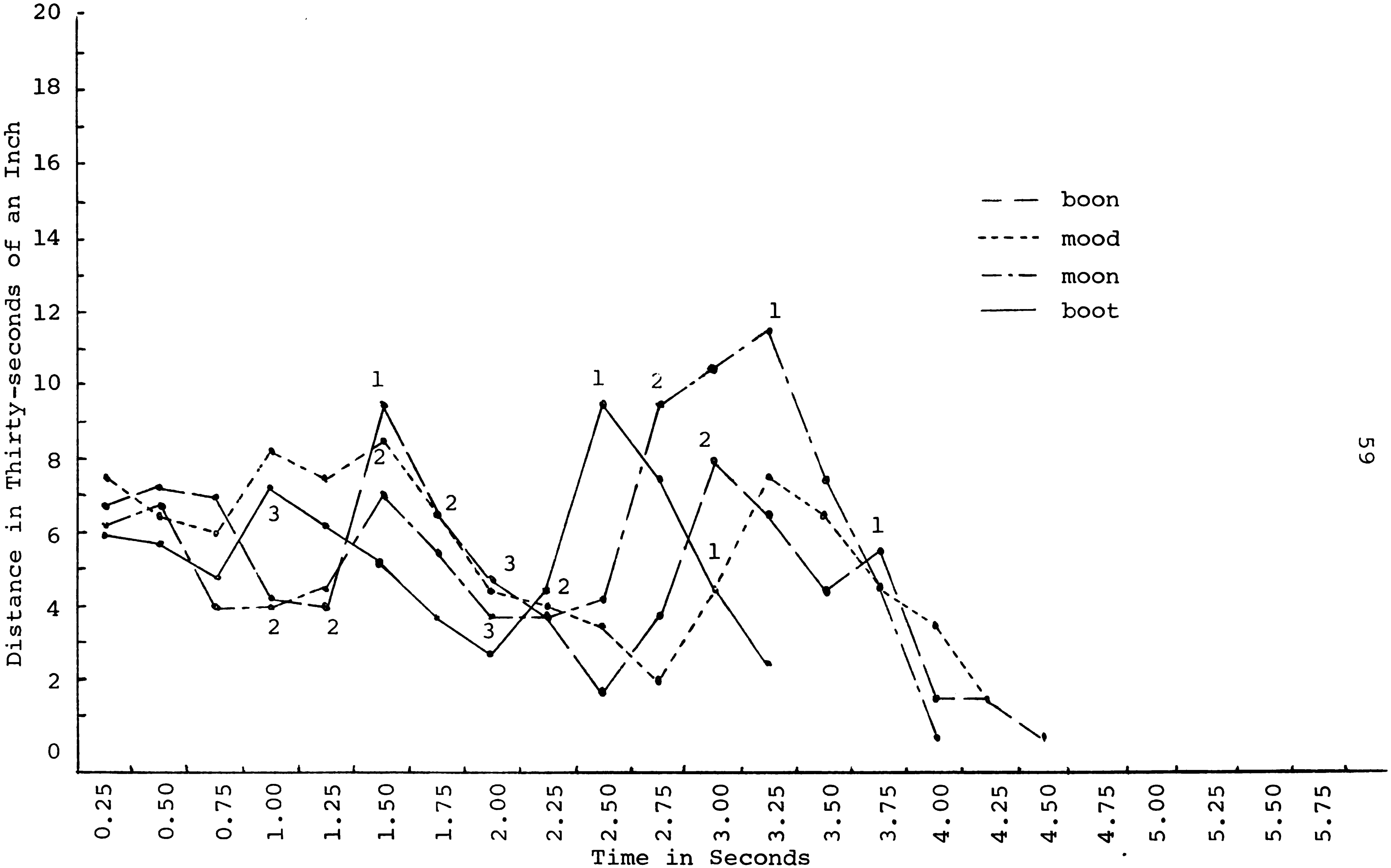

Figure 11--Mean mouth opening of four speakers saying boon, mood, moon, boot

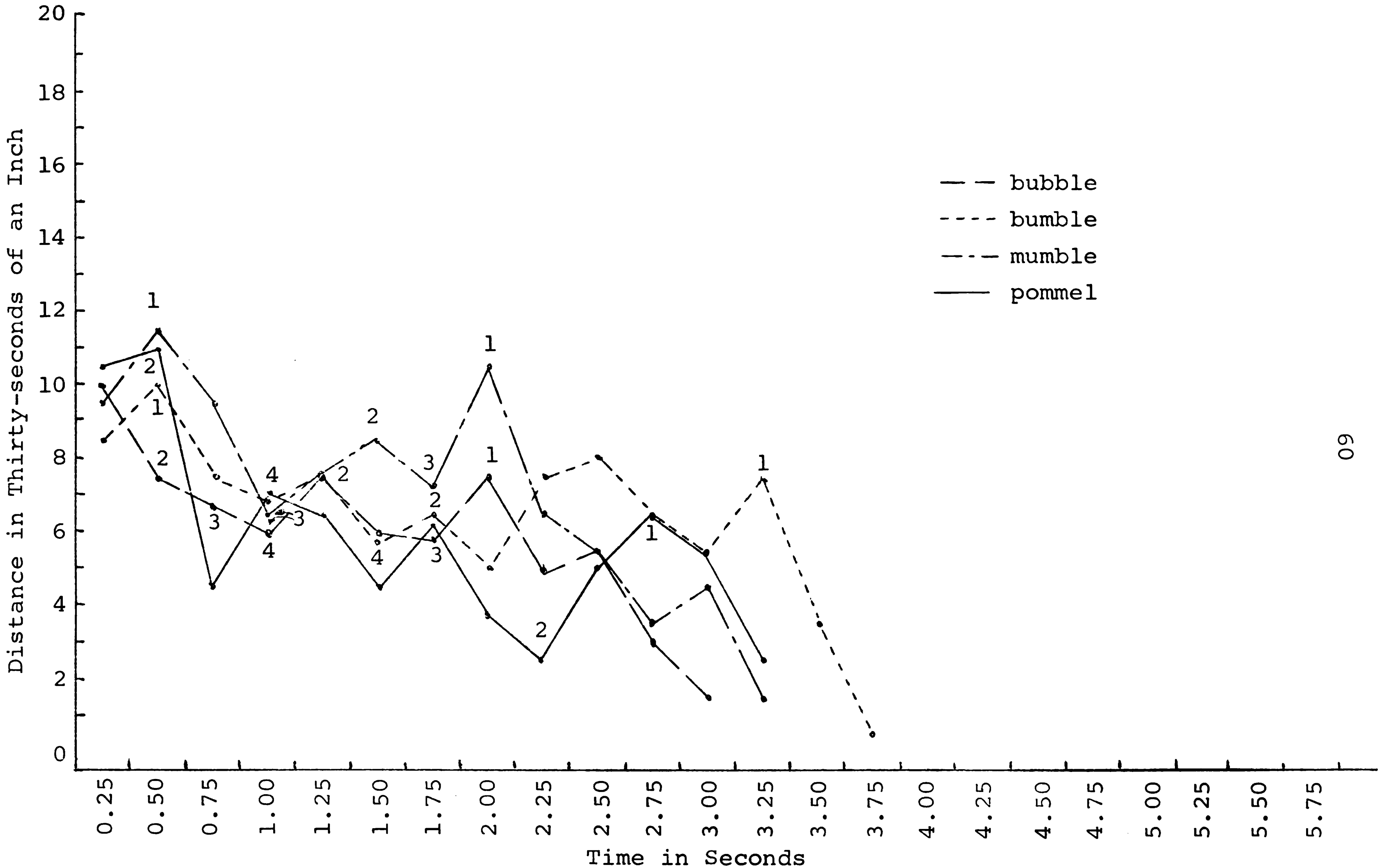

Figure 12--Mean mouth opening of four speakers saying bubble, bumble, mumble, pommel

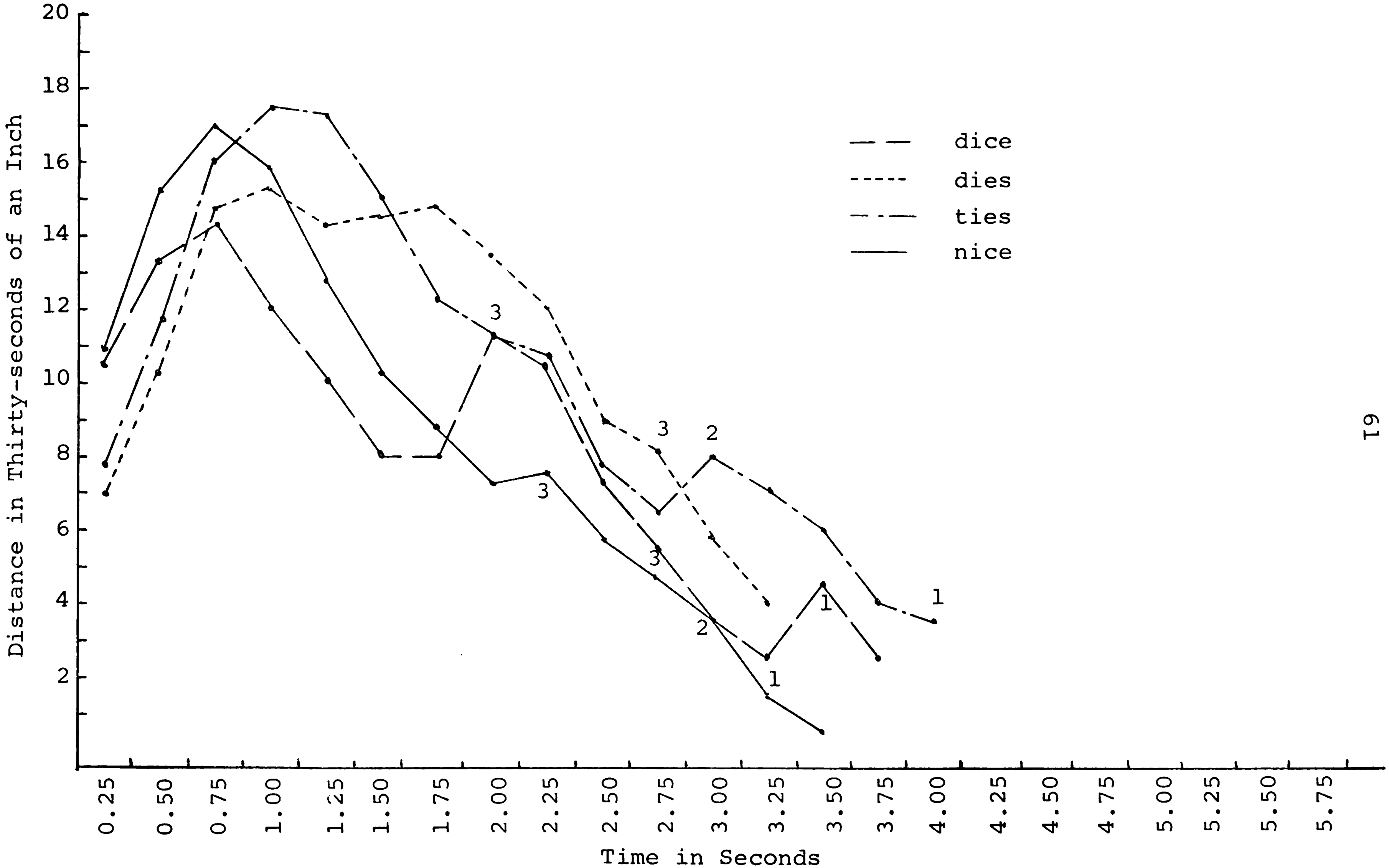

Figure 13--Mean mouth openings of four speakers saying dice, dies, ties, nice

At 2 seconds, the mouth openings are decreasing; nice is at 7/32, ties at 11/32, and dies 14/32 of an inch. The comparison of the fourth curve is not valid at this point because the number of speaker subjects has decreased.

Mouth width. Figures 14-25 plot the average amount of mouth width on the four subjects for each of the groups of homophenous words. The intervals along the ordinates represent distance measured in inches. The abscissas represent time measured in seconds.

With one exception it is felt that the variations displayed in the graphs that chart mouth width are not significant. Variations are given in tenths of seconds which would not seem to be visible, significant differences. There is very little distinguishing mouth movement from the beginning of the pronunciation of the words to the end.

The one exception that may be significant is the variation shown among the words charted on Figure 17. This group of words -- dome, dope, tome, gnome -- show the greatest deviation in our study and were also those that were identified correctly the greatest number of times in Roback's study.[1] Two of the four words in this group, tome

[1]See Chapter III, p. 27, Homophenous Word List.

and <u>gnome</u>, at 3 seconds show .22 of an inch difference in mouth width, the largest variance of the entire word list.

Figure 21 (charting <u>whine</u>, <u>wide</u>, <u>wine</u>, <u>white</u>) appears to be the only graph that reveals significant mouth width movement among the words. The four curves decrease as the lips pucker to say the initial w's and the lips resume a more normal position as the remainder of the word is uttered.

One of the speaker subjects closed his mouth slightly after the utterance of each word. This accounts for the sharp drop at the end of many of the words. This occurred with only one subject.

<u>Time</u>. Upon inspection of the data it is observed that there are differences in the amount of time required for each subject to utter the homophenous words. To determine if these differences are statistically significant, a <u>t</u> test for ascertaining significance was employed. The time values for the utterance of the words were computed on the total number of frames required for each subject to pronounce the words. Six <u>t</u>'s were run on each group of four homophenous words. Study of Table 11 reveals that the seventy-two <u>t</u>'s computed were all nonsignificant at .05 level of confidence.

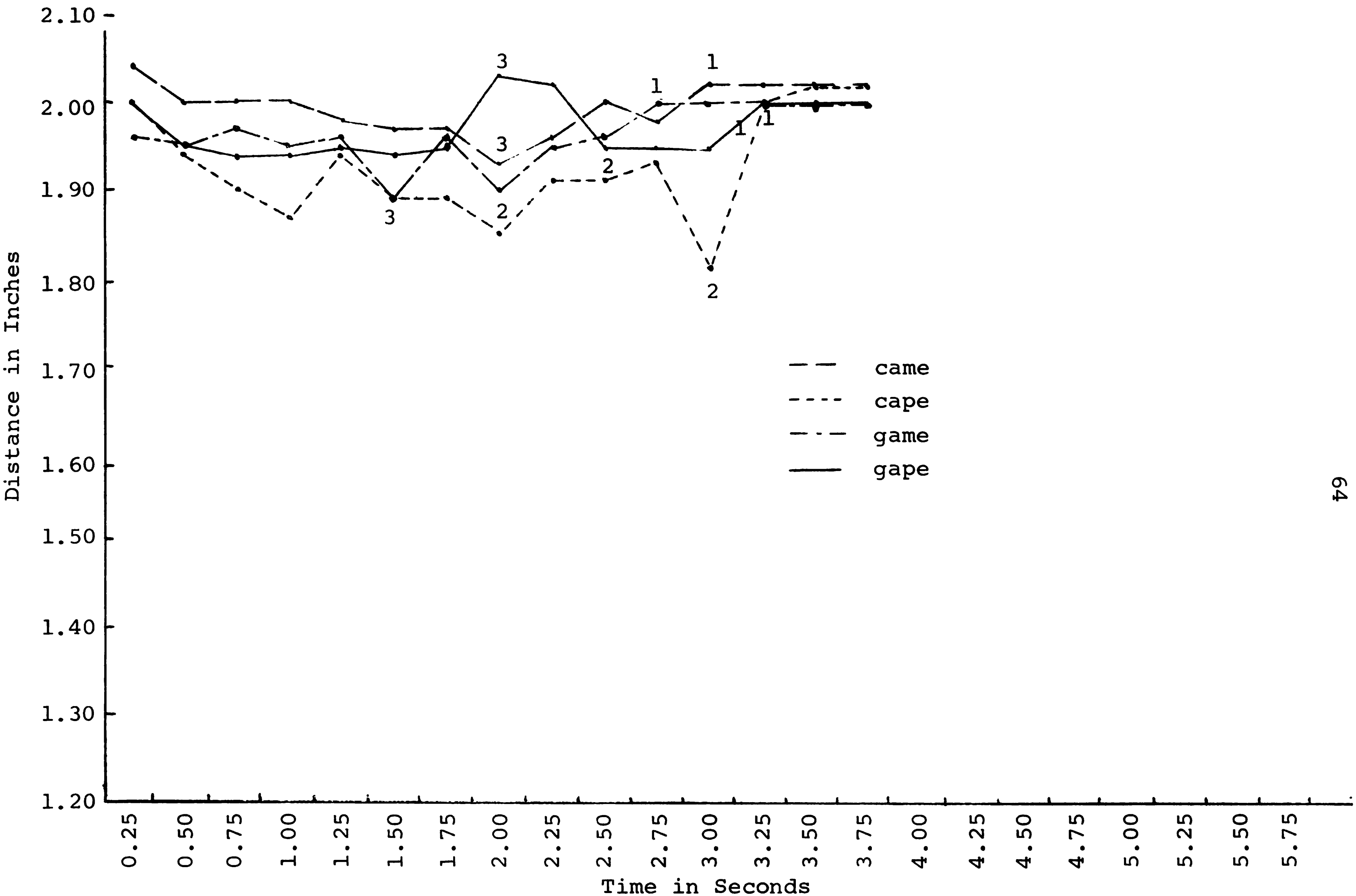

Figure 14--Mean mouth widths of four subjects saying came, cape, game, gape

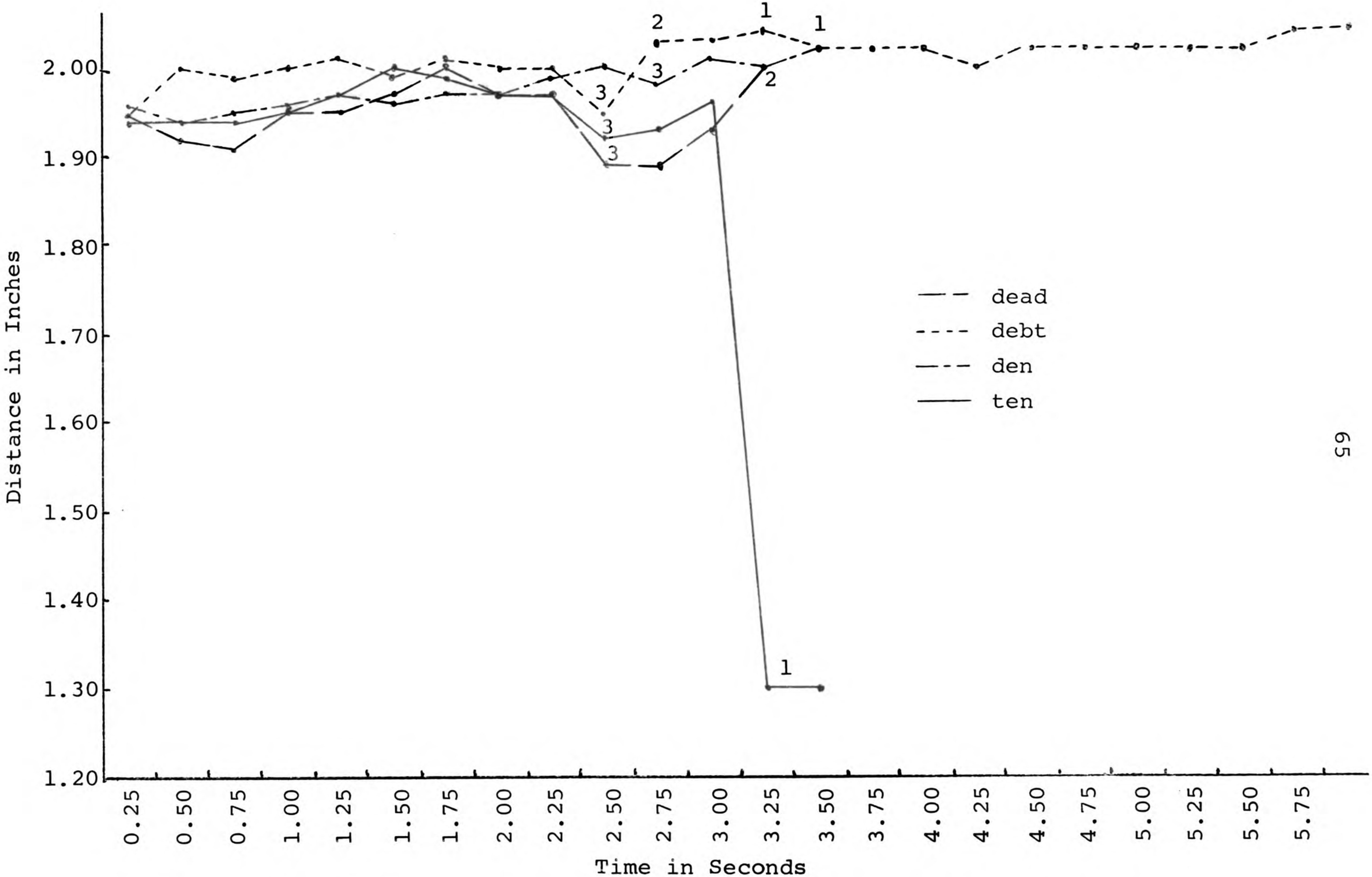

Figure 15--Mean mouth widths of four subjects saying dead, debt, den, ten

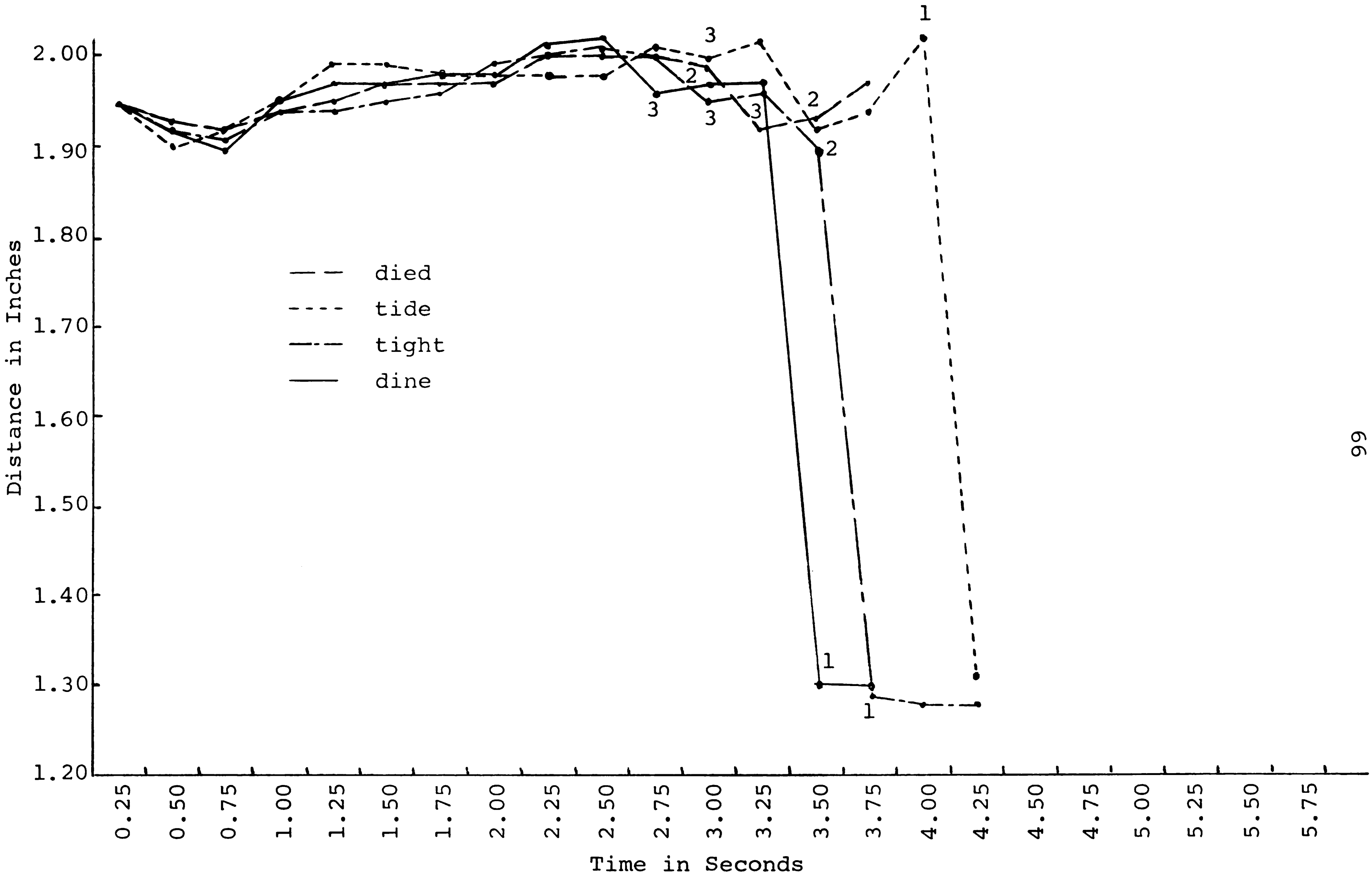

Figure 16--Mean mouth widths of four subjects saying died, tide, tight, dine

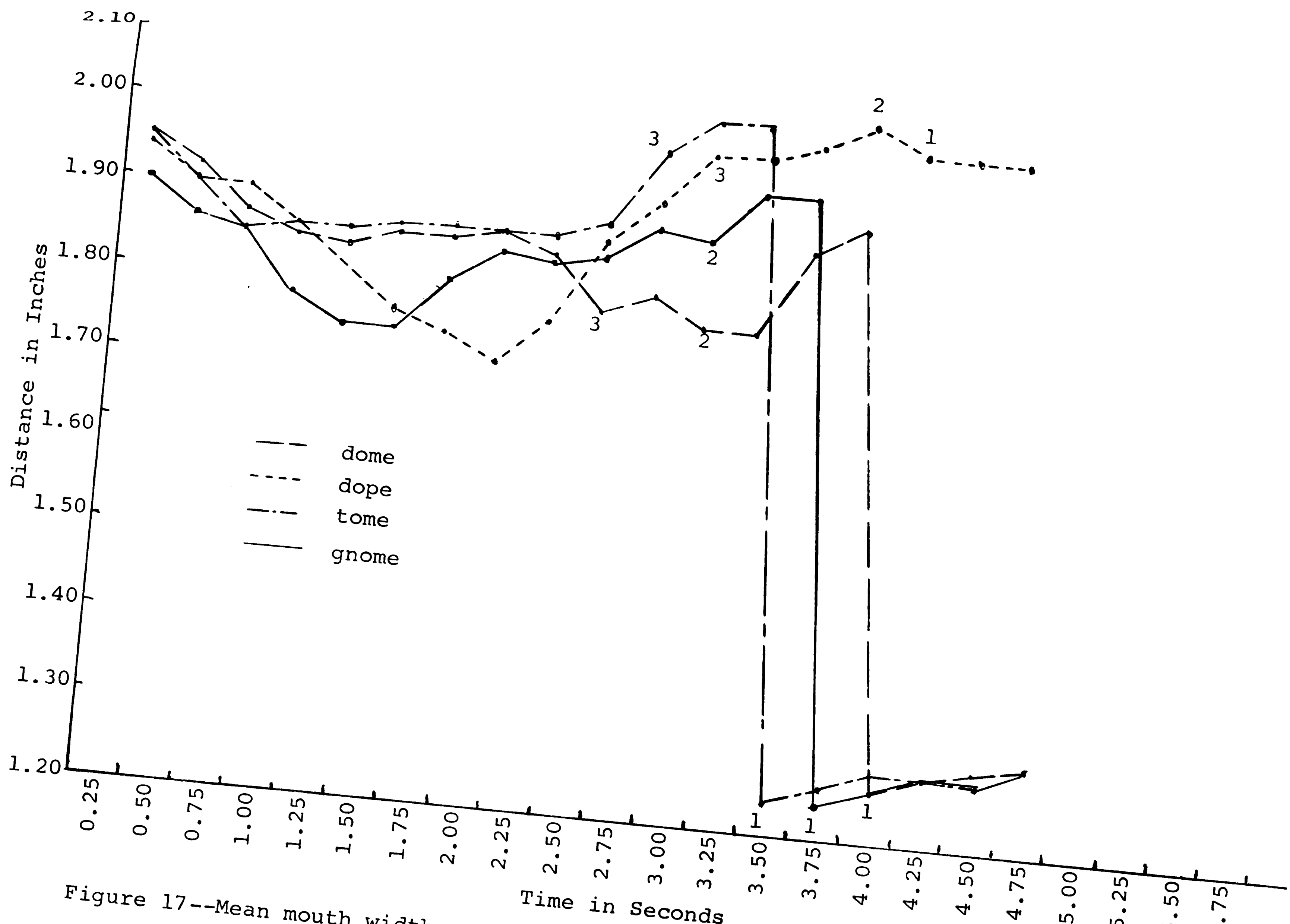

Figure 17--Mean mouth widths of four subjects saying dome, dope, tome, gnome

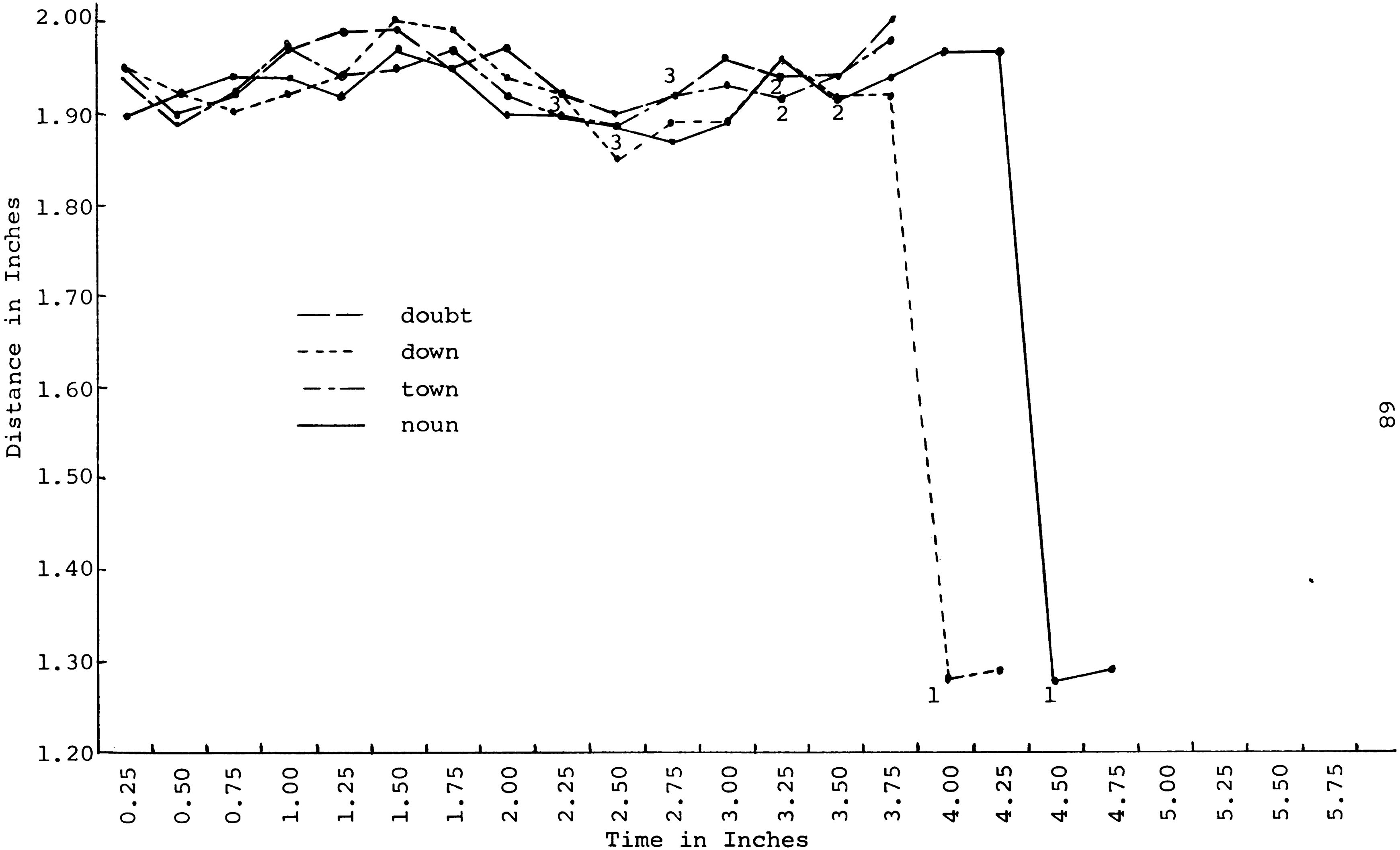

Figure 18--Mean mouth widths of four subjects saying doubt, down, town, noun

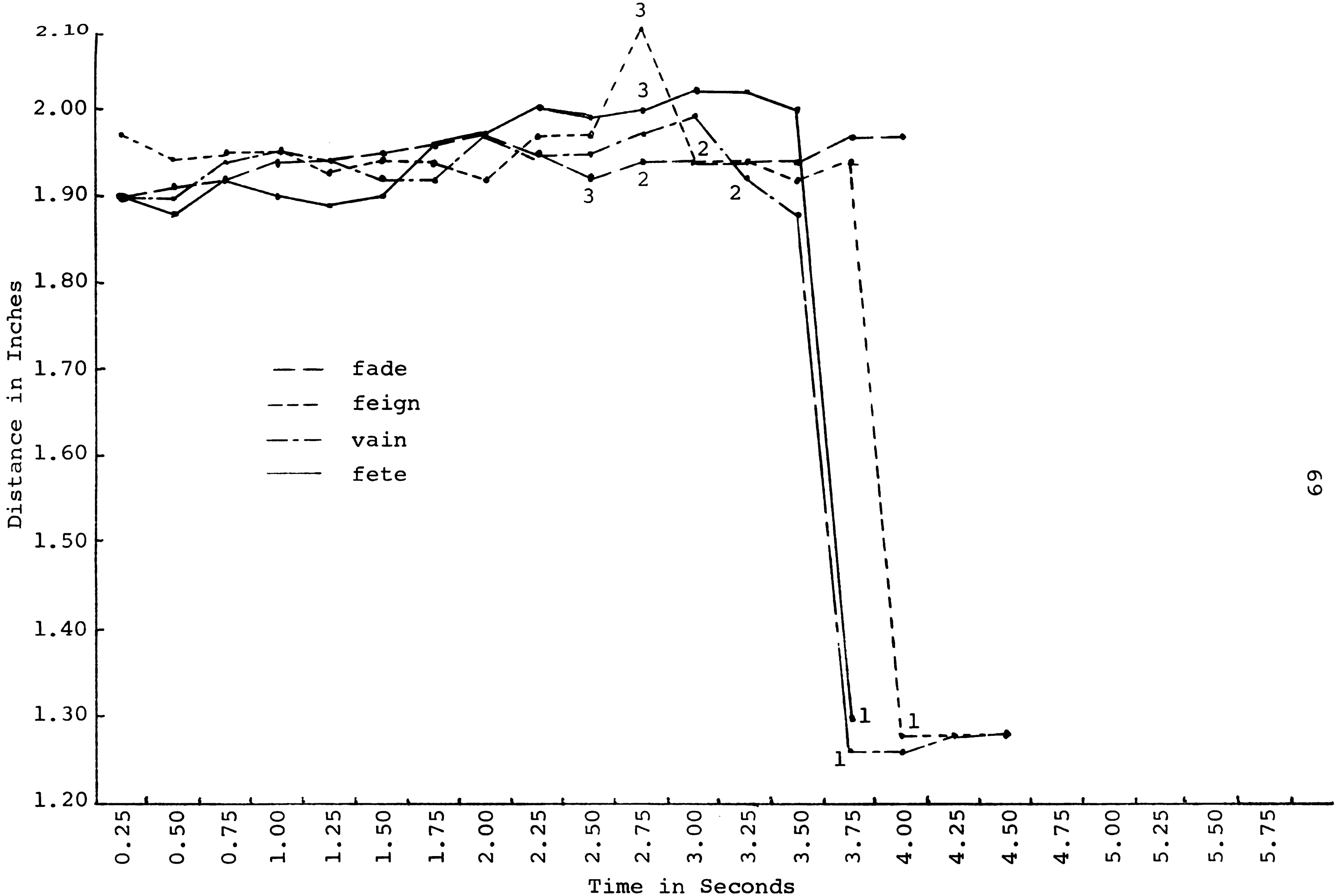

Figure 19--Mean mouth widths of four subjects saying fade, feign, vain, fete

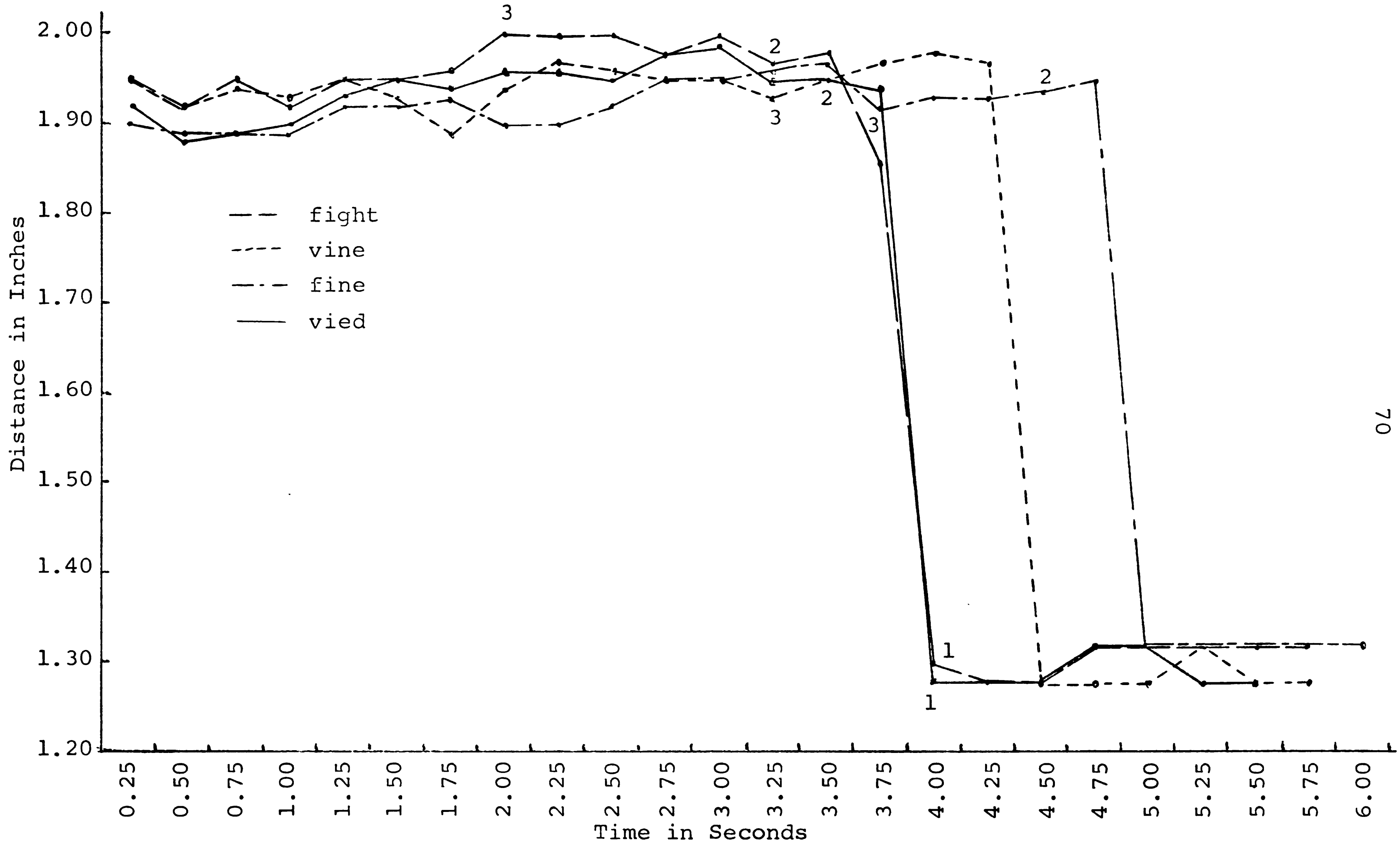

Figure 20--Mean mouth widths of four subjects saying fight, vine, fine, vied

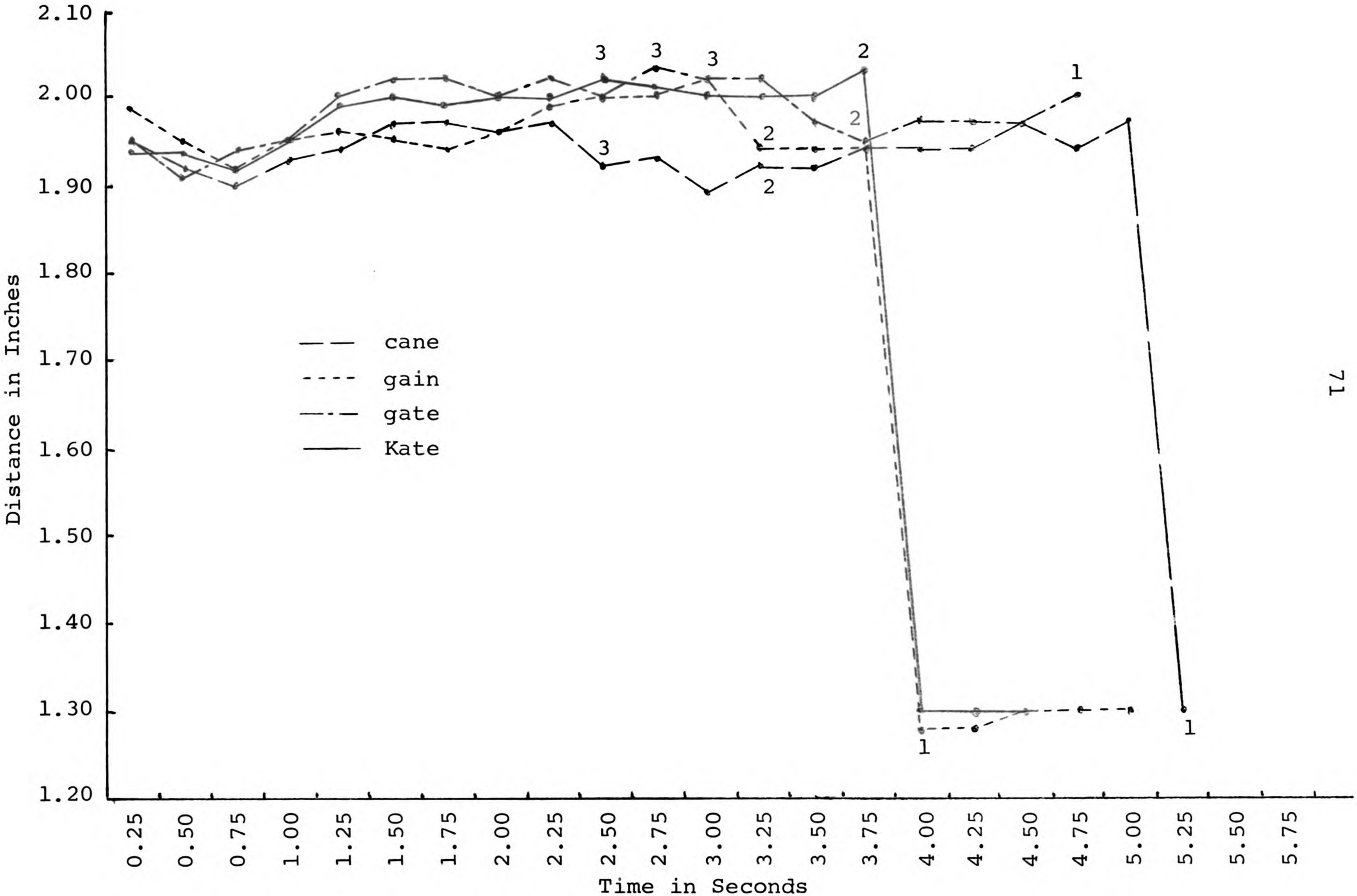

Figure 21--Mean mouth widths of four subjects saying cane, gain, gate, Kate

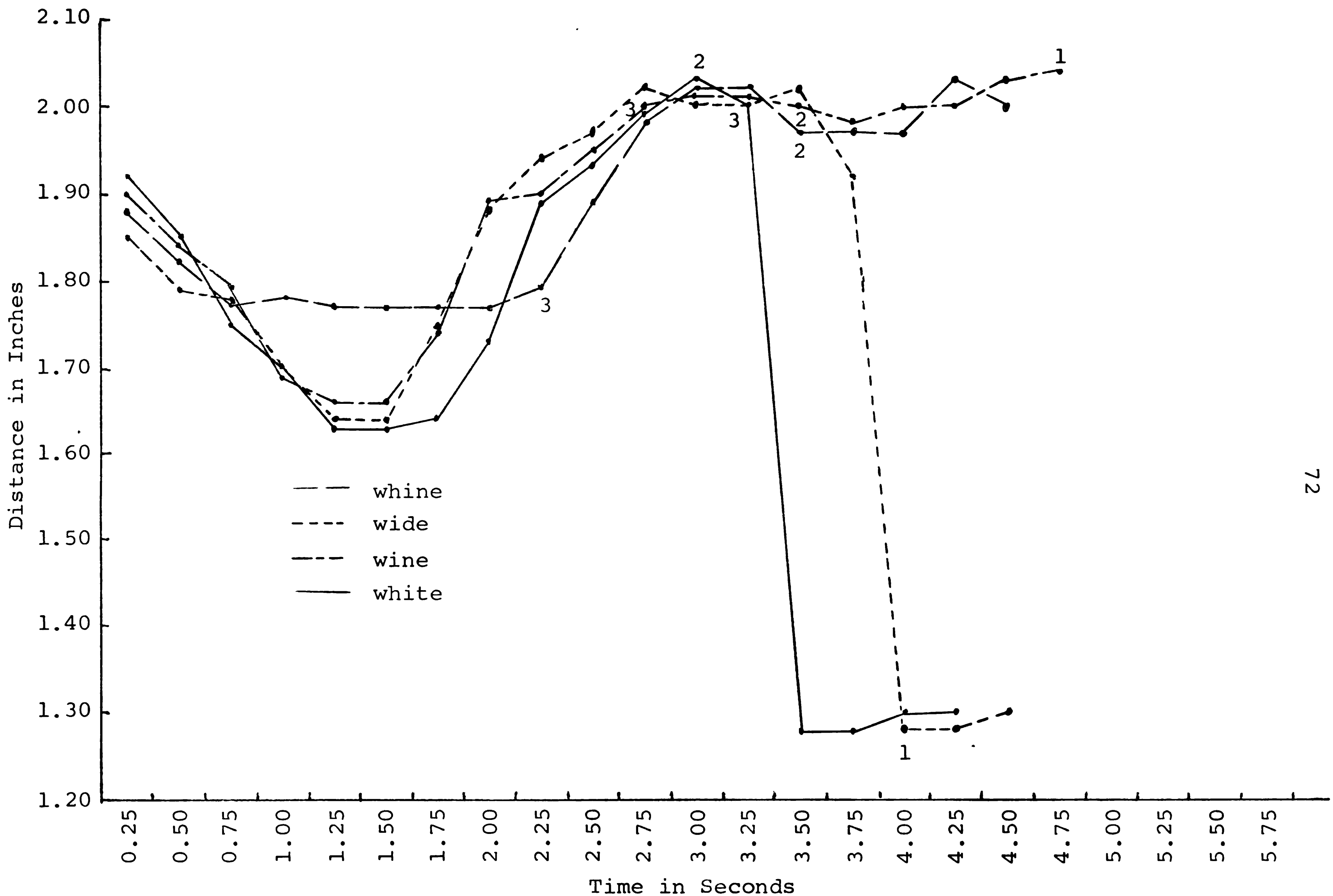

Figure 22--Mean mouth widths of four subjects saying whine, wide, wine, white

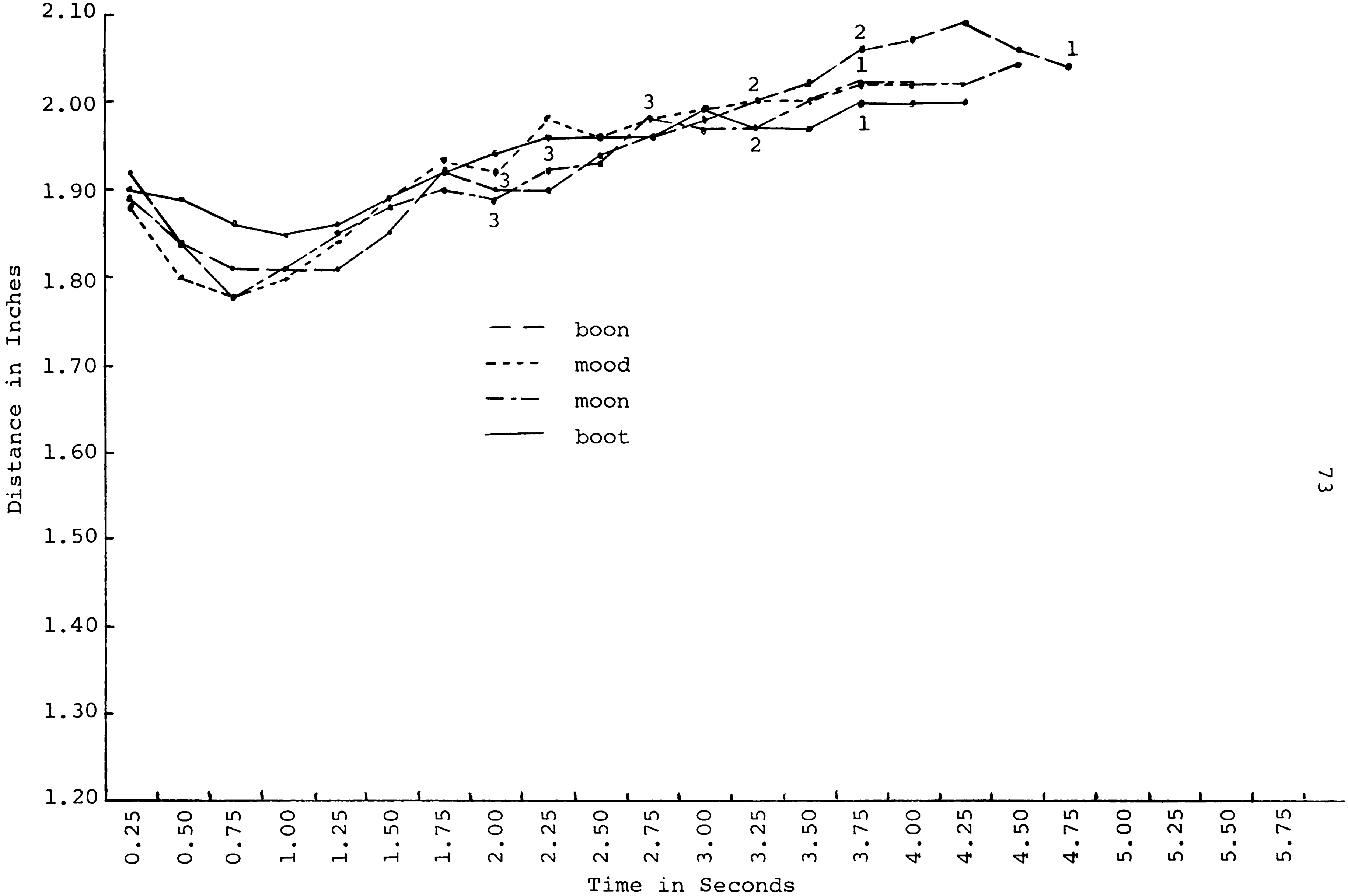

Figure 23--Mean mouth widths of four subjects saying boon, mood, moon, boot

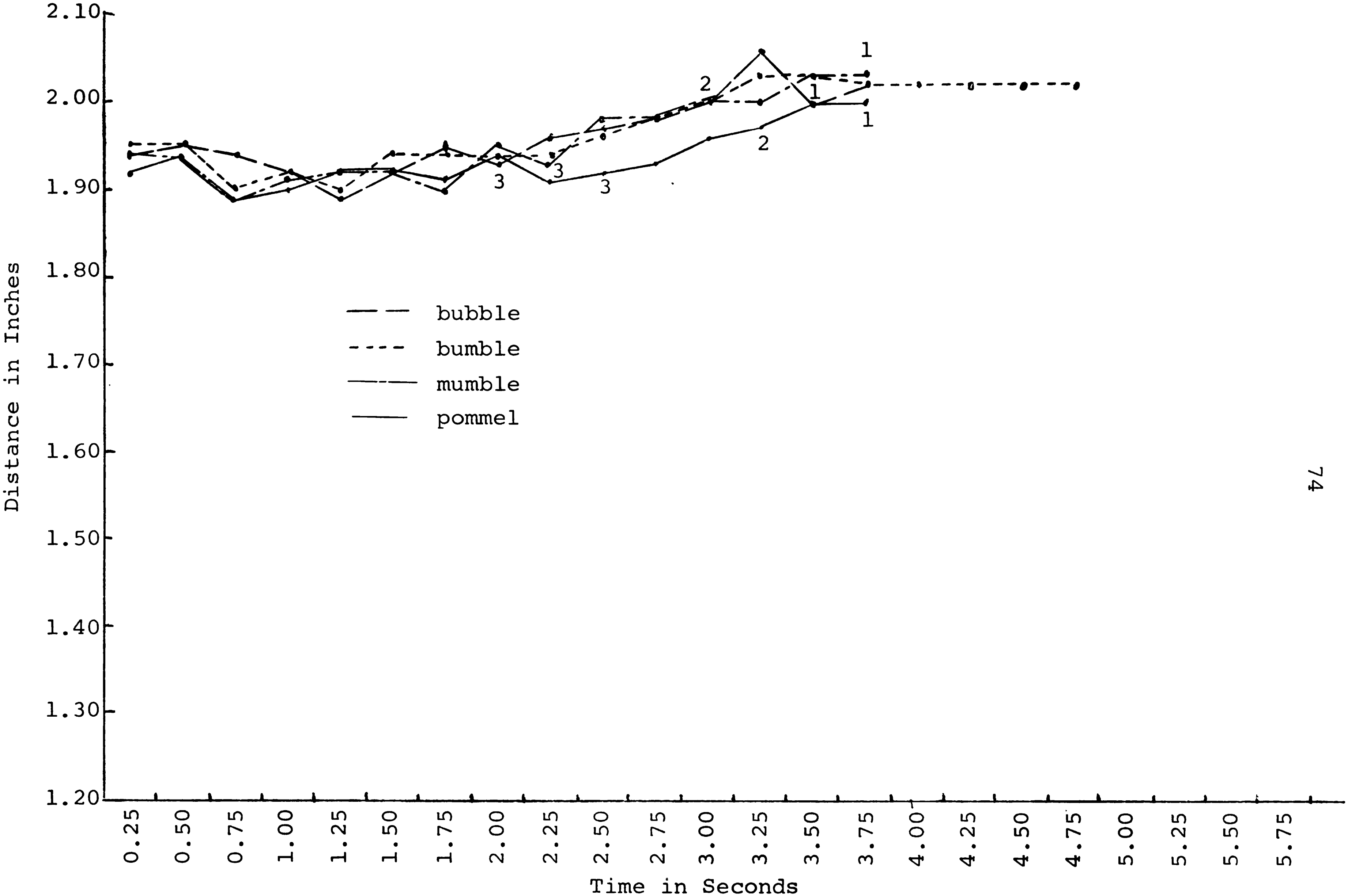

Figure 24--Mean mouth widths of four subjects saying bubble, bumble, mumble, pommel

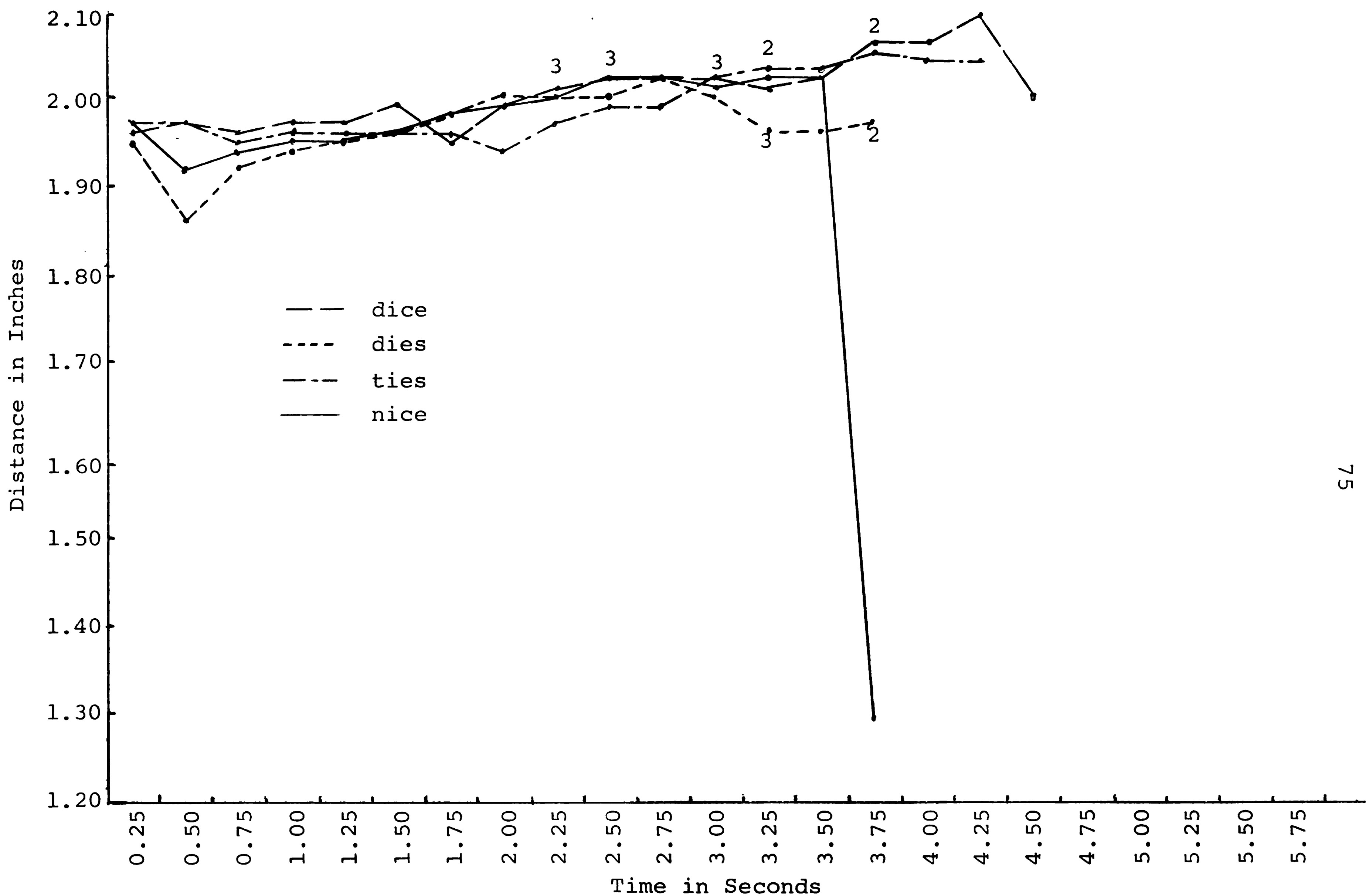

Figure 25--Mean mouth widths of four subjects saying dice, dies, ties, nice

The greatest time difference among the four subjects occurred between the words debt and den with the t = 1.86. The least time difference among the four subjects occurred between the words doubt and town. A t was impossible to compute because the differences were so minute.

The t formula used for this computation was:

$$t = \frac{M_1 - M_2}{\sqrt{\frac{\Sigma d^2}{N(N - 1)}}}$$

Teeth. The time that the teeth are visible or nonvisible during the pronunciation of one group of homophenous words was analyzed. The words selected for the comparison of teeth visibility were dome, dope, tome, and gnome -- the words most frequently identified in Roback's study.[2] The duration of time that the tooth was visible or not visible was computed in seconds. A plus represented the tooth as being one-half or more than one-half visible; a minus indicated the tooth as being less than one-half visible; NV indicated not visible.

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[2] Ibid.

TABLE 1

COMPARISONS OF AMOUNT OF TIME REQUIRED FOR UTTERANCE OF HOMOPHENOUS WORDS

Words	Comparisons	Means	t	Level
came - cape	1-2	68.00 - 71.00	.395	ns at .05
came - game	1-3	68.00 - 60.50	.717	ns at .05
came - gape	1-4	68.00 - 73.00	.891	ns at .05
cape - game	2-3	71.00 - 60.50	.570	ns at .05
cape - gape	2-4	71.00 - 73.00	.381	ns at .05
game - gape	3-4	60.50 - 73.00	.555	ns at .05
dead - debt	1-2	91.25 - 90.50	.402	ns at .05
dead - den	1-3	91.25 - 86.00	.452	ns at .05
dead - ten	1-4	91.25 - 77.75	.426	ns at .05
debt - den	2-3	90.50 - 86.00	1.86	ns at .05
debt - ten	2-4	90.50 - 77.75	.460	ns at .05
den - ten	3-4	86.00 - 77.75	.119	ns at .05
died - tide	1-2	80.00 - 85.25	.093	ns at .05
died - tight	1-3	80.00 - 87.50	.503	ns at .05
died - dine	1-4	80.00 - 82.25	.730	ns at .05
tide - tight	2-3	85.25 - 87.50	.547	ns at .05
tide - dine	2-4	85.25 - 82.25	.521	ns at .05
tight - dine	3-4	87.50 - 82.25	.462	ns at .05
dome - dope	1-2	83.75 - 90.50	.389	ns at .05
dome - tome	1-3	83.75 - 87.50	.469	ns at .05
dome - gnome	1-4	83.75 - 86.75	.594	ns at .05
dope - tome	2-3	90.50 - 87.50	.183	ns at .05
dope - gnome	2-4	90.50 - 86.75	.243	ns at .05
tome - gnome	3-4	87.50 - 86.75	.144	ns at .05
doubt - down	1-2	81.50 - 83.00	.235	ns at .05
doubt - town	1-3	81.50 - 80.00	.00	ns at .05
doubt - noun	1-4	81.50 - 89.75	.520	ns at .05
down - town	2-3	83.00 - 80.00	.439	ns at .05
down - noun	2-4	83.00 - 89.75	.750	ns at .05
town - noun	3-4	80.00 - 89.75	.547	ns at .05
fade - feign	1-2	80.00 - 85.25	.496	ns at .05
fade - vain	1-3	80.00 - 87.50	.425	ns at .05
fade - fete	1-4	80.00 - 82.25	.168	ns at .05
feign - vain	2-3	85.25 - 87.50	.247	ns at .05
feign - fete	2-4	85.25 - 82.25	.303	ns at .05
vain - fete	3-4	87.50 - 82.25	.382	ns at .05

TABLE 1.--Continued

Words	Comparisons	Means	t	Level
fight - vine	1-2	89.75 - 100.25	.648	ns at .05
fight - fine	1-3	89.75 - 113.00	.552	ns at .05
fight - vied	1-4	89.75 - 103.25	.527	ns at .05
vine - fine	2-3	100.25 - 113.00	.571	ns at .05
vine - vied	2-4	100.25 - 103.25	.413	ns at .05
fine - vied	3-4	113.00 - 103.25	.534	ns at .05
cane - gain	1-2	98.00 - 89.75	.485	ns at .05
cane - gate	1-3	98.00 - 93.50	.300	ns at .05
cane - Kate	1-4	98.00 - 89.00	.288	ns at .05
gain - gate	2-3	89.75 - 93.50	.420	ns at .05
gain - Kate	2-4	89.75 - 89.00	.700	ns at .05
gate - Kate	3-4	93.50 - 89.00	.410	ns at .05
whine - wide	1-2	89.75 - 92.75	.301	ns at .05
whine - wine	1-3	89.75 - 94.50	.313	ns at .05
whine - white	1-4			
wide - wine	2-3	92.75 - 94.50	.218	ns at .05
wide - white	2-4			
wine - white				
boon - mood	1-2	95.75 - 75.50	.740	ns at .05
boon - moon	1-3	95.75 - 80.75	.252	ns at .05
boon - boot	1-4	95.75 - 80.00	.716	ns at .05
mood - moon	2-3	75.50 - 80.75	.695	ns at .05
mood - boot	2-4	75.50 - 80.00	.382	ns at .05
moon - boot	3-4	80.75 - 80.00	.060	ns at .05
bubble - bumble	1-2	74.00 - 83.00	.717	ns at .05
bubble - mumble	1-3	74.00 - 77.00	.632	ns at .05
bubble - pommel	1-4	74.00 - 78.50	.495	ns at .05
bumble - mumble	2-3	83.00 - 77.00	.594	ns at .05
bumble - pommel	2-4	83.00 - 78.50	.381	ns at .05
mumble - pommel	3-4	77.00 - 78.50	.408	ns at .05
dice - dies	1-2	92.75 - 86.00	.450	ns at .05
dice - ties	1-3	92.75 - 84.00	.922	ns at .05
dice - nice	1-4	92.75 - 81.50	.810	ns at .05
dies - ties	2-3	86.00 - 84.00	.168	ns at .05
dies - nice	2-4	86.00 - 81.50	.415	ns at .05
ties - nice	3-4	84.00 - 81.50	.327	ns at .05

The values for the four subjects were totaled for each of the three categories (plus, minus, NV) and for the sixteen teeth under observation: first premolars, canines, lateral incisors, and central incisors. The means for every value were then computed and totaled, yielding three totals of means (pluses, minuses, NV's). The same procedure was followed for each of the four words.

Six *t*'s were run on the four words to determine if there was a significant difference in the total amount of time the teeth were visible and nonvisible. Table 2 reveals that the six *t*'s were nonsignificant at the .05 level of confidence.

TABLE 2

t TEST FOR VISIBILITY AND NONVISIBILITY OF TEETH

Words	Comparisons	Means	*t*	Level
dome - dope	1-2	4.06 - 4.61	.625	ns at .05
dome - tome	1-3	4.06 - 3.92	.476	ns at .05
dome - gnome	1-4	4.06 - 4.04	.175	ns at .05
dope - tome	2-3	4.61 - 3.92	.728	ns at .05
dope - gnome	2-4	4.61 - 4.04	.261	ns at .05
tome - gnome	3-4	3.92 - 4.04	.15	ns at .05

Discussion

Several findings resulting from the analysis of the data warrant discussion and evaluation. The subjective analysis on the first question regarding differences in mouth openings at the beginning of the utterance of many homophenous words may provide cues for the lipreader. There also appear to be some differences in total amount of mouth opening during the pronunciation of homophenous words.

Another variation that may be of assistance to the lipreader relates to the pattern of lip movement during actual pronunciation. For example (see Figure 7), four subjects, in uttering the words fade and feign, opened their mouths widely within the first 3/4 of a second. The lip pattern of the same four subjects in pronouncing fete was diametrically opposed so that at 3/4 of a second their mouths were almost closed. A review of Figures 2-13 reveals additional similar differences in the pronunciation of specific homophenous word groups. Further analysis is justified to determine more specifically what these variables are and how significant they may be.

The analysis designed to shed light on deviation in mouth widths was also subjective. Critical observation of the twelve graphs reveals very little lateral lip movement during the uttering of homophenous words. However, one interesting fact is apparent. The graph that shows the greatest amount of variability is the one that presents the mouth widths of the four words that were identified correctly the greatest number of times in Roback's study.[3] This indicates the need for precise analysis to ascertain what minute differences the eye can perceive.

Time differences in the utterance of homophenous words were analyzed by employing a *t* test. All seventy-two *t*'s computed were nonsignificant at a .05 level of confidence. This appears to be meaningful within the limits of this study, indicating that time is not a significant variable in the identification of homophenous words.

In an attempt to discover another clue for the detection of homophenous words, the visibility and nonvisibility of the teeth during the pronunciation of words was analyzed. The six *t*'s computed on a sample four words were nonsignificant at a .05 level of confidence. This seems to indicate that the amount of time the teeth were visible (more or less than half the tooth) and nonvisible

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[3] *Ibid*.

was not consequential in the four words sampled. This does not prove, however, that there would not be detectable differences in the amount of time the teeth were visible, or partially visible during the utterance of the words. There is need for closer analysis of the three visibility ratings in relationship to duration of the word as well as for complete statistical analyses of the forty-eight words employed in this study before any positive statements can be made regarding teeth as a clue in the identification of homophenous words.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR FURTHER STUDY

Summary

Research has shown that homophenous words can be correctly identified by untrained lipreading subjects a greater number of times than can be attributed to chance alone.[1] This finding suggested that there were visible, measurable differences in lip patterns during the utterance of homophenous words.

The purpose of this study was to make physical measurements of the mouths of four speakers as they uttered forty-eight homophenous words. This was accomplished by a frame-by-frame analysis of a moving picture film to determine the variables, if any, that existed in mouth openings, mouth widths, and visibility and nonvisibility of the teeth during the pronunciation of homophenous words.

The size of the mouth opening at the philtrum was first measured. Results were plotted on twelve graphs.

[1] Ila Mae Roback, "Homophenous Words" (unpublished Master's thesis, Dept. of Speech, Michigan State University, 1961) pp. 4-5.

In the second phase of the study measurements of mouth width were determined. Time required for utterance of homophenous words was computed. To determine if the time differences were significant t tests were employed.

Teeth visibility was measured in three ways: one-half or more of the tooth visible, less than one-half visible, and nonvisible. A t test for significant differences was computed on a sample of four words.

Conclusions

Within the confines of this study the following conclusions seem warranted:

1. There appear to be visible differences in mouth openings during the utterance of homophenous words.

2. There appear to be very minute differences in mouth widths during the utterance of homophenous words.

3. The difference in time required for saying the homophenous words in this study is not statistically significant.

4. The difference in time during which the teeth were visible or nonvisible was not statistically significant when the production of the words dome, dope, tome, and gnome was analyzed.

Implications for Further Study

The differences occurring in mouth openings during the utterance of homophenous words appeared to be an area of investigation that warrants complete and thorough analysis. The present study also points up a need for critical analysis of the visibility of the teeth in relation to all homophenous words uttered by speakers in this study.

APPENDIX

HOMOPHENOUS WORD LIST

1. came
2. cape
3. game
4. gape

5. dead
6. debt
7. den
8. ten

9. died
10. tide
11. tight
12. dine

13. dome
14. dope
15. tome
16. gnome

17. doubt
18. down
19. town
20. noun

21. fade
22. feign
23. vain
24. fete

25. fight
26. vine
27. fine
28. vied

29. cane
30. gain
31. gate
32. Kate

33. whine
34. wide
35. wine
36. white

37. boon
38. mood
39. moon
40. boot

41. bubble
42. bumble
43. mumble
44. pommel

45. dice
46. dies
47. ties
48. nice

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