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A CROSS-LINGUISTIC STUDY OF CERTAIN TEMPORAL FEATURES
OF SPEECH IN STUTTERING AND NONSTUTTERING CHILDREN

by

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ABSTRACT

Four experiments were performed to measure temporal coarticulatory speech features in the perceptually fluent speech of 120 South African children. The aim was to test, in a limited way, the postulate that stuttering may be essentially a disorder of speech timing. Comparisons were made between English- and Afrikaans-speakers, between younger (mean age 4.1 years) and older (mean age 6.7 years) children, and between stutterers and nonstutterers.

Experiment one investigated voice onset time (VOT) of word-initial voiced and voiceless bilabial and apical stop plosives in isolated CVC nonsense syllables. The VOTs were measured from oscilloscopic displays. Nonparametric statistical treatment identified certain trends in the data. English-speakers used short- and long-lag categories to express voiced and voiceless initial stops respectively. They showed a developmental trend in the direction of lengthening of VOT for voiceless stops. Afrikaans-speakers used two sets of short-lag VOT without aspiration to produce voiced and voiceless stops. Voicing lead occurred randomly as a stylistic variant. The stuttering children demonstrated longer VOTs than did nonstutterers. In addition, English-speaking stutterers failed to lengthen VOT for voiceless stops in the normal manner. This was attributed to difficulty with the physiological demands of long-lag VOT. Afrikaans speakers, who did not have to contend with the long-lag category, clearly distinguished between voiced and voiceless stops by means of VOT.

Experiment two dealt with the categorical labelling of nonsense syllables employing the voicing contrast. In younger nonstuttering subjects, English-speakers performed better than did Afrikaans-speakers, owing to the greater number of perceptual cues available to them. All younger subjects needed a lot of training in order to label correctly, whereas older subjects needed little training. English stutterers performed slightly poorer than did nonstutterers, while even older Afrikaans stutterers performed very poorly. It was postulated that stutterers might be dependent on perceptual cues which become redundant for nonstuttering listeners. Afrikaans stutterers were additionally handicapped by the paucity of perceptual cues in their language.

In experiments three and four, medial stop closure duration in VCV nonsense syllables and medial vowel durations in CVC nonsense syllables were measured. English and Afrikaans nonstutterers had longer stop closure durations on voiceless than on voiced stops and in high vowel compared with low vowel environments. A developmental trend was identified in the direction of differential stop closure lengthening. Medial vowel durations were also lengthened in voiced and voiced sibilant consonant environments. Subjects showed increasing vowel differential durations with age. Stutterers showed the normal trends towards differential medial stop closure and vowel durations but appeared to have a developmental lag in this respect relative to nonstutterers. Since stutterers did not differ from nonstutterers on measures of whole syllable duration or medial VOT it did not appear as if they were simply moving their articulators slowly. Experiments three and four probably tapped neurally programmed coarticulatory effects, whereas the VOT measure might reflect a lower aerodynamic-neuromuscular level of speech functioning, the voicing feature being primarily involved at both levels. The possibility exists, and is strengthened by the results of the categorical labelling task, that a central timing disorder, manifest as a developmental lag, may have been operating in the stuttering subjects.

TABLE OF CONTENTS

<u>Chapter One: Introduction.</u>	<u>Page</u>
Scope of the thesis	1
The nature of stuttering	2
Stuttering as a manifestation of psychopathology.....	4
Stuttering as a learned phenomenon.....	4
Stuttering as a sign of disturbed physiology.....	6
Genetics.....	6
Cerebral hemispheric specialization.....	6
Linguistic-motor coordination.....	8
Aerodynamic coordination.....	9
Stuttering as a disorder of timing.....	12
Elements of fluent speech timing	15
Stress patterning (rhythm).....	15
Normal pauses and hesitations in adult speech.....	16
Repeats.....	16
False starts.....	16
Filled pauses.....	16
Unfilled pauses.....	17
Transition smoothness.....	17
Dysfluencies in adult stutterers	20
Normal and abnormal development of speech timing control	21
Hesitation phenomena: normal and stuttering.....	22
Segmental durations.....	24
VOT developmental data.....	25
Rationale for the present study	27
Hypotheses	28
Subject selection	29
Selection of stuttering subjects.....	29
Selection of nonstuttering subjects.....	30
Hearing.....	30
Intelligence.....	30
Known pathologies.....	31
Experimental groups.....	31
 <u>Chapter Two: Experiment one.</u>	
<u>Production of voice onset time of voiced and voiceless</u>	
<u>bilabial and apical singleton stop plosives in initial</u>	
<u>positions in CVC nonsense syllables.</u>	
Aims of the experiment	32
Outline of the experimental design	33
Instrumentation	34
Material	34
Procedures for data collection	34

Data analysis	36
Preparation of audio tapes for analysis.....	36
Judges.....	36
Judgment criteria.....	36
Results	37
Distributions of MM2.....	38
Distributions of maximum scores.....	40
Distributions of minimum scores.....	42
Distributions of the range.....	44
Relative VOT distributions for cognate pairs.....	46
Spearman's correlations.....	46
Discussion	47
Cross-language comparisons.....	47
Age-related trends.....	50
Comparisons between stutterers and nonstutterers.....	51
Conclusions	52
Cross-language data.....	52
Normal developmental data.....	52
Comparisons between stutterers and nonstutterers.....	53

Chapter Three: Experiment two.

The acquisition of categorical labelling involving the voicing distinction.

Aims of the experiment	54
Hypothesis	55
Outline of the experimental design	56
Material	57
Procedures for data collection	57
Data analysis	59
Results	60
Contingency tables.....	60
Fisher 2-tail exact probabilities test.....	61
Discussion	63
Cross-language findings.....	63
Age-related data.....	63
Comparisons between stutterers and nonstutteres.....	63
Conclusions	64

Chapter Four: Experiment three.

An examination of the closure duration of medial stop plosives in /a/ and /i/ vowel environments in VCV nonsense syllables.

Aims of the experiment	65
Outline of the experimental design	66
Hypotheses	67
Material	68
Procedures	68
Older speakers.....	68
Younger speakers.....	69
Data analysis	69
Statistical treatment	70

Results	71
Interjudge reliability.....	71
Spearman's correlations.....	71
Whole syllable durations.....	74
Stop closure durations.....	75
Percentage of whole syllable occupied by stop closure...	76
Comparison between voiced and voiceless stop closure durations.....	78
Comparison between the influence of vowel environments on medial stop closure durations.....	80
Discussion	81
Whole syllable duration measures.....	81
Stop closure durations.....	81
Comparisons between voiced and voiceless stops.....	84
Influence of vowel environments on medial stop closure duration.....	87
Conclusions	89
Cross-language findings.....	89
Age-related findings.....	89
Comparisons between stutterers and nonstutterers.....	90

Chapter Five: Experiment four.

An investigation into the duration of medial vowels in voiced and voiceless sibilant and stop plosive environments in CVC nonsense syllables.

Aims of the experiment	91
Outline of the experimental design	92
Hypotheses	93
Material	94
Procedures	94
Data analysis	94
Statistical treatment	95
Results	98
Vowel duration.....	98
Whole syllable duration.....	99
Percentage of whole syllable occupied by vowel duration.	101
Vowel durations in voiced and voiceless consonant environments.....	102
Influence of manner-of-articulation of the consonant environment on medial vowel duration.....	103
Discussion.....	103
Vowel duration.....	103
Whole syllable duration.....	104
Effect on vowel duration of voicing and manner-of- articulation of the consonant environment.....	105
Conclusions.....	108
Summary of results and conclusions.....	109

Chapter Six: General discussion.

Summary of normative data obtained from the study.....	110
Voice onset time.....	110
Categorical labelling.....	110
Medial stop closure duration in VCV syllables.....	111
Medial vowel duration in CVC syllables.....	111
Summary of results obtained for the stuttering children.....	111
Voice onset time.....	111
Categorical labelling.....	111
Medial stop plosive closure and vowel durations.....	112
Speculations regarding the level of the difficulty underlying the results on stutterers in the present investigation	113
Research implications	117
Concluding remarks	118

<u>References</u>	119

Appendix

CHAPTER ONE

INTRODUCTION

- I Scope of the thesis
- II The nature of stuttering
- III Elements of fluent speech timing
- IV Dysfluencies in adult stutterers
- V Normal and abnormal development of speech timing control
- VI Rationale for the present study
- VII Hypotheses
- VIII Subject selection

I SCOPE OF THE THESIS

It has been proposed that the core of stuttering may be "...reduced ability to generate temporal patterns [for speech] whether for sensory or motor purposes, but especially the latter" (Kent 1983 p252). This report represents a limited attempt to test this proposition. It describes four experimental procedures designed to measure the following temporal and coarticulatory features in the fluent speech of nonstuttering and stuttering white South African children.

1. Voice Onset Time (VOT) of voiced and voiceless bilabial and apical singleton stop plosives in initial positions in CVC nonsense syllables.
2. Acquisition of categorical perceptual labelling of the same phonological contrasts as for (1).
3. Duration of the closure phase of voiced and voiceless bilabial and apical singleton stop plosives in medial positions in VCV nonsense syllables.
4. Vowel duration in CVC nonsense syllables in relation to the features of voicing and manner-of-articulation (plosive and sibilant) of the consonant environments.

These temporal and coarticulatory speech features (1, 3 and 4) appear to behave systematically within given languages and provide a way of tapping speech production control at the phoneme and syllable levels.

In the present study, normally fluent children were compared with their stuttering peers. Two further comparisons were made:

- * Between younger (3.1 - 5.0 years) and older (6.3 - 8.3 years)

children within each group. The aim was to discern age-related trends which might be interpreted as developmental patterns.

- * Between English- and Afrikans-speaking South African children. Since the speech timing demands of the two languages differ, a finding of similar trends in the two groups would indicate a need to investigate the same aspects of other languages. Experimental findings which are used to support hypotheses regarding the essential nature of stuttering must be validated by examining the patterns of speech behaviour in speakers of different languages.

Since stutterers may not comprise a homogeneous population, within-group variability was also examined.

II THE NATURE OF STUTTERING

"Stuttering is the enigma of speech pathology." (Perkins 1971 p.302)

Questions regarding the nature and causes of stuttering have received attention from speech pathologists, psychologists and medical practitioners for over half a century but have not yet been satisfactorily answered (Bloodstein 1977).

There is, as yet, no universally accepted definition of stuttering. Definitions abound, but reflect the theoretical biases of their authors. For the purposes of this study stuttering is defined according to those observable features which appear to be minimal requirements in order for a diagnosis to be made. These were identified by Wingate (1964c, 1969), who described the disorder as being an essentially involuntary disturbance in the flow of articulate speech, at the centre of which are:

1. Unitary repetitions, and
2. silent or audible sound prolongations

Most workers concede that there are small groups of stutterers whose speech dysfunction is clearly either neurological in origin and is associated with a definite history and medical diagnosis of brain dysfunction, or those whose stuttering is simply part of a personality maladjustment with a high ongoing level of nonverbal anxiety. Blood and Seider (cited by Andrews et al 1983) surveyed public school speech therapists who reported that only 2% of their stuttering caseloads appeared to have emotional disturbances. It is the origins of stuttering in the largest group of stutterers, those who are 'speech phobic', which continues to stimulate research and controversy. It is this group with which the present report is concerned. The term 'speech phobic' is merely a convenient label for that group of stutterers who are often regarded as being 'idiopathic' (Reis 1975).

Speech phobic stutterers are typically male, the sex ratio being 3 males to 1 female (Andrews and Harris 1964) and start stuttering in the preschool years, the median age of onset being 3-4 years (for reviews of studies see van Riper 1971; Andrews et al, 1983). Two developmental patterns may then be

distinguished, which van Riper (1971) has identified as Tracks 1 and 11, both of which may be considered as falling into the speech phobic category as defined in this thesis.

Track 1 stutterers have an initial period of a year or more of fluency followed by cyclical periods of dysfluency consisting mainly of easy syllabic repetitions. Prolongations of sounds gradually develop, with tension and struggle behaviours and the growth of secondary symptoms and fear of speaking. Track 11 stutterers never have much fluency and demonstrate poor articulation. Their dysfluency initially consists of syllable and word repetitions, pauses and revisions (perhaps indicating linguistic uncertainty). Gradually, the syllabic repetitions and durations of nonfluencies increase. While they do not develop the same tension and struggle reactions as do Track 1 stutterers, Track 11 stutterers do learn to fear various speaking situations. While they may need to be treated as a separate group, they are considered as speech phobic stutterers for the purposes of this report. Under the section dealing with subject selection note that about a third of the subjects were reported to have had histories of early developmental articulation or language difficulties. Furthermore, the dysfluency criteria for subject selection did not permit the elimination of Track 11 stutterers, provided the frequency count of their syllabic repetitions was sufficiently high.

As adults, speech phobic stutterers show the core features of stuttering. Their speech is effortful and there is accompanying physical tension. Verbal anxiety is typically at high levels and is related to stuttering frequency whereas nonverbal anxiety is low (Reis 1975).

Much has been learned about the phenomenology of the stuttering behaviour of speech phobic stutterers, such as the adaptation effect, the rhythm effect and the effect on the dysfluency of changes in audition. Stuttering adaptation occurs on repeated oral readings of the same material and the decrease in stuttering is accompanied by anxiety reduction (Frank et al 1971; Silverman and Williams 1971; Andrews and Harris 1964). The introduction of novel stimuli, such as delayed auditory feedback and masking, results in a decrement of the core features of stuttering (Sutton and Chase 1961; Cherry and Soderberg 1968, 1969; Wingate 1970). The secondary features may or may not decrease. The use of novel voicing characteristics decreases stuttering (Healey et al 1976). These effects are not observed to the same degree in organic stutterers (Rosenfield 1983). While these phenomena have been well documented, there is lack of agreement as to how they might be explained. Some authors claim that fewer laryngeal adjustments are required under fluency enhancing conditions, while others attribute the effects to diminished communicative responsibility.

In contrast to that stuttering which is clearly organic in origin and usually acquired (Helm et al 1978; Rosenbek et al 1978) speech phobic stuttering varies according to the communicative stress inherent in a given situation and may even be absent in some situations. The stutterer often tends to avoid difficult communicative situations which he has learned to fear because of his unique history of conditioning and generalisation (van Riper 1971).

Response-contingent punishment of the 'moment of stuttering' in speech phobic stutterers often results in no reduction or even an increase in the core features. However if such reduction does take place, it is accompanied by an

increase in the secondary features (Martin and Siegal 1966, reanalyzed by Brutten, according to Reis 1975; Haroldson and Hasbrouck 1975; Quist and Martin 1967; Martin et al 1975). This resistance of the core features of stuttering to response-contingent manipulation argues against a causal explanation of stuttering which relies on behaviouristic principles (van Riper 1971). However, it is generally accepted that the secondary features of stuttering, such as avoidance responses, are learned. Accessory behaviours such as postponements, starters, avoidance and escape devices, in other words the myriad of struggle activities which the stutterer increasingly adopts and elaborates in an attempt to elude moments of core stuttering, become incorporated into his behavioural repertoire (van Riper 1971; Bloodstein 1975). While these strategies are not always successful they are probably retained by the stutterer since they seem to be intermittently reinforced. The theoretical difficulties lie in the search for a satisfactory explanation for the origins and development of the core features of stuttering.

The disorder of movement sequences in the speech of stutterers defined by Wingate is regarded by van Riper (1971) to be a function of aberrant neuromotor timing, affecting the sound, syllable and word production levels. While the core features of stuttering are manifestly disrupted speech in terms of temporal coarticulation, it is not clear whether disordered timing is primary, as suggested by Van Riper, or whether it is a function of tension and fragmentation, as proposed by Bloodstein (1974). There is clearly a need for research into the temporal coordination of both the fluent and stuttered speech of stutterers.

The various categories of stuttering theories are briefly reviewed in the following sections with emphasis on those with a constitutional bias.

A Stuttering as a manifestation of psychopathology

Psychoanalytic explanations for stuttering were common in the 1940's and '50's. Some regarded stuttering as satisfying neurotic oral (Coriat cited by van Riper 1971) or anal (Fenichel cited by van Riper 1971) needs. Glauber attributed fluency breakdown in stuttering to anxiety generated by conflict between pleasurable and aggressive impulses underlying speech. According to Barbara (1954), stutterers developed characteristic personality patterns stemming from anxiety relating to parent-child conflict. The stuttering child had ambivalent feelings regarding compliance with and aggressive reactions to the parents, with a consequent breakdown in the speech function since it is a primary means of relating to others. However, apart from social maladjustment resulting directly from the speech disorder, research and clinical experience have failed to demonstrate any characteristic personality traits or psychopathology in adult speech phobic stutterers or in stuttering children and their parents, and psychotherapy has generally proved to be unsuccessful in the treatment of stuttering (Prins 1972; Bloodstein 1975; Wingate 1983; and comprehensive surveys of the literature by Goodstein 1958; Sheehan 1958; and Andrews et al 1983).

B Stuttering as a learned phenomenon

Various theorists have postulated that the stutterer is basically a normal speaker who has learned to produce excessive dysfluencies because these behaviours are reinforced, either by environmental factors or by internal

mechanisms, such as drive reduction (Johnson 1959; Wischner 1951; Sheehan 1958; Bloodstein et al 1965; Goldiamond 1965; Shames and Sherrick 1963; Brutten and Shoemaker 1967.) Various types of learning have been suggested as operating.

Shames and Sherrick (1963) postulated that dysfluencies (whether normal or abnormal) which were emitted by a child came under operant control from environmental contingencies. Reinforcement, in the form of increased parental attention, for example, initially increased the dysfluency while punishment in the form of frustration or rejection led to the development of secondary stuttering behaviours. This explanation, in keeping with the traditional viewpoint of operant theorists, explains the maintenance of core features of stuttering and the development of secondary behaviours but does not concern itself with the etiology of the core features.

Brutten and Shoemaker (1967) proposed that both classical and operant conditioning principles were active in the development of stuttering. The initial fluency breakdown ie. the involuntary core features, whether normal or abnormal, occurred under conditions of negative emotion which became classically conditioned by means of the contiguity of previously neutral stimuli. Operant conditioning was then invoked to account for the development of secondary instrumental stuttering behaviours.

Sheehan (1958) considered that the stutterer was caught up within a double approach-avoidance conflict - the desire to speak opposing a desire to avoid speech and, concurrently, a tug-of-war between a wish to remain silent and a fear of silence. When these rivalling needs were almost equally strong, oscillatory speech, ie. stuttering, resulted.

Johnson's 'semantogenic' theory (Johnson 1959) was the most influential to emerge from this group. He believed that there were no actual speech differences between children who were labelled as 'stutterers' by their parents and those who were not, but that some dysfluency was a normal stage of development. The adverse reaction to these 'normal nonfluencies' on the part of overanxious parents created uncertainty in the children regarding speech and led to the development of struggle reactions which Johnson felt to constitute stuttering proper. While the role of parental reactions in the development of secondary features of stuttering is generally accepted as being an important factor (van Riper 1971; Bloodstein 1975), some research findings have contradicted Johnson's concept of normal nonfluency in stutterers, upon which his theory rests (McDearmon 1968; Andrews et al 1983). Furthermore, if some children are more 'normally nonfluent' than their siblings, the reason for the difference must be explained. It seems necessary to try and identify elements in the fluent speech of dysfluent children which might indicate a pervasive difficulty with some aspect of speech, such as timing control, which might not be perceptually apparent to the normal listener yet could be detected by means of fine measurement. Johnson made use of only gross measures of dysfluency.

While learning theorists have not concerned themselves with antecedent events, and however acceptable their theories may be as explanations for the maintenance of core features of stuttering and the development of accessory behaviours, many investigators have felt the need to probe for constitutional

etiological factors.

C Stuttering as a sign of disturbed physiology

Many attempts have been made to identify organic aberrations in stutterers who have no clearcut neurological signs. These have, inter alia, included notions of stuttering as a form of epilepsy (West 1958), as a perseverative phenomenon (Eisenson 1958), as a delay in myelinization of cortical speech areas (Karlin 1947), and as an outgrowth of an organic language dysfunction called cluttering (Weiss 1964).

The most promising directions arising out of the constitutional theories, and which are not necessarily mutually exclusive, are the following:

1 Genetics

Andrews and Harris (1964) found that 38% of their stuttering subjects had family histories of stuttering compared with 1.4% of the nonstuttering controls. Kidd (1980) has supported the claim of a threefold risk of stuttering in first-degree relatives of stutterers compared with the general population and further showed that the risk of the relative stuttering varies by sex of both proband and relative. Kidd et al (1978) and Kidd (1977) developed a preliminary genetic model which appears to match the facts about familial distribution of stuttering as well as the sex ratio. Their data negated an alternative explanation for the sex ratio ie. that stuttering is a learned behaviour based on sex role models. To many speech pathologists who have long suspected an inherited predisposition for the disorder, this will come as no surprise. Nevertheless, evidence in favour of an inherited tendency to acquire stuttering does not fully explain its nature and mechanism.

2 Cerebral hemispheric specialization

The earliest theory to suggest that stuttering might be a disorder of neurophysiological integration was proposed by Orton in 1927 and developed by Travis in 1931 (Travis 1978). Travis proposed that there was a failure to develop a cortical 'dominant gradient' of functioning in stutterers so that transient mutual inhibition from the two cerebral hemispheres resulted in tonic and clonic 'blocks' in speech.

Travis's concept of a continuum of cerebral dominance amongst individuals is in line with current ideas (Hardyck 1977). While his theory had much heuristic value, earlier studies were restricted to demonstrating a higher incidence of left handedness and ambidexterity in stutterers compared with nonstutterers (van Riper 1971). This phenomenon may be found to be linked to hormonal factors. More recently, technical advances have allowed for better controlled investigations of hemispheric asymmetries for speech and language functions, viz. the WADA test, dichotic studies and studies using evoked auditory potentials.

a) WADA test

Travis (1978) claimed support for his interhemispheric competition notion from a report by Jones (1966) who, using the WADA Test, demonstrated transient dysphasia in both cerebral hemispheres in four adult stutterers prior to neurosurgery. Following unilateral surgery to one or the other hemisphere, stuttering ceased in all the patients and the improvement appeared to be long term. Unfortunately, Jones did not supply details regarding the type of stuttering demonstrated by his patients but the implication is that they were typical stutterers. Implicit, but not clearly stated in his report, was equivalency of dysphasia severity between the two hemispheres. Since three of Jones's subjects were familial left-handers and the remaining right-hander came from a family of left-handers and ambidextrous people, the finding of bilateral speech/language representation is not remarkable. The cessation of stuttering after surgery, however, is of great interest.

It is not clear whether the linguistic or motor programming levels of speech encoding would be affected by interhemispheric competition. Travis seemed to implicate disturbed timing of motor planning or execution.

Travis's theory failed to explain how many ambidextrous or familial left-handed normal speakers, with presumed bilateral cortical representation for speech/language (Hardyck 1977), differ from stutterers with their postulated lack of hemispheric specialization.

b) Dichotic studies

Perceptual studies of dichotic listening in stutterers (which have employed various methodologies) have produced conflicting results and have failed to conclusively differentiate this group from normals. Curry and Gregory (1967) found that fewer stutterers showed right ear advantage compared with normal controls as well as smaller differences in scores between right and left ears in the stutterers. Sommers et al (1975) also reported atypical ear-preference scores for stutterers. McNeil and Aten (1976), on the other hand, found that stutterers showed normal right ear preference. Slorach and Noehr (1973) also failed to support Curry and Gregory's findings. The discrepancy between these experimental results may be attributed to the variable levels of linguistic loading in the stimuli employed.

Nondichotic listening tests have revealed 'soft' findings indicating possible inferior central auditory functioning at brainstem level in stutterers (Hall and Jerger 1978; Toscher and Rupp 1978). However, Manning and Riensche (1976) were unable to differentiate stuttering from nonstuttering children on an auditory assembly task. The notion of differences between stutterers and normals in terms of neurophysiological organization of audition cannot be discounted but is not necessarily linked with cerebral dominance.

A more promising area of investigation seems to be that of sensori-motor skills in relation to hemispheric specialization. Sussman (1971) found that, in normals, if the right ear and jaw or tongue were used together to track a target zone according to a tone, fewer errors were made than if the left ear and speech structures were used interactively. Stutterers showed no ear advantage on tongue-tracking tasks. They may thus be more dependent than

normals on the right hemisphere for sensori-motor functioning of the speech structures. Berlin (1971) has suggested a possible explanation for the right-ear advantage for listening tasks in normals to be the link between audition and vocal tract gesture coding.

c) EEG studies

Van Riper (1971) has reviewed twenty-two studies on EEG patterns in stutterers from 1936 to 1967 and concluded that, while there was not consensus regarding the findings and various methodologies had been used, most studies pointed toward the presence of atypical EEGs in a statistically significant number of stutterers. Zimmermann and Knott (1974) measured the contingent negative variation (CNV) prior to speech in adult stutterers and nonstutterers. The CNV reflects cortical arousal as much as a full second prior to the release of a motor programme (Symposium on Motor Behavior 1974). No CNV differences were found between the groups from vertex recordings prior to fluent speech or when no speech was required. Prior to stuttered speech, however, stutterers showed inter- and intra-hemispheric variability in terms of polarity or the presence or absence of the CNV, as measured from the inferior frontal lobes. Thus, it would appear that the cortical motor areas of the stutterers behaved differently to those of normals during stuttering. The nature of the observed difference is unexplained.

It is easier to interpret the results of an EEG study which measured alpha asymmetries in the left and right hemispheres of stutterers and normals during exposure to spoken word lists of high and low imagery (Moore and Lorendo 1980). Stuttering males, in contrast to nonstuttering males, demonstrated significantly less right hemisphere alpha, suggesting right hemisphere processing during presentation of both high and low imagery words. These results were interpreted as implying that stutterers may be more reliant than normals on the right hemisphere for perception of language.

One may conclude that the evidence in support of Travis's theory is, as yet, too sporadic to be decisive, but there are sufficient positive findings to indicate that is an area worthy of further investigation.

3 Linguistic-motor coordination

Perkins (1971) suggested that stuttering represents a linguistic-motor incoordination which arises if a child experiences difficulty in converting semantic, syntactic and morphemic decisions into a phonetic sequence. Speech flow is disrupted, but the mechanism underlying this faulty timing is unknown. Uncertainty on the part of the child regarding linguistic decision-making would add to the dysfluency. While this is a provocative idea, it needs to be substantiated with empirical data and fully explained. Several studies have indicated that stutterers frequently have delayed early language development and later perform poorer than do nonstuttering controls on various standardised language tests (Andrews et al 1983). However, no characteristic pattern of language delay or dysfunction has been identified for stutterers and their relatively poor performance on language tests in later childhood may, at least in part, be the result of inexperience with language as a result of the stuttering.

Certainly, there is a close link between linguistic planning and the

aerodynamics of speech. Flege (1983) emphasized the relationship between linguistic and respiratory preplanning of utterances by demonstrating that the supraglottal air pressure of stops in utterance-initial words increased as a function of utterance length. This suggested aerodynamic preplanning at the respiratory level to accommodate the requirements of utterance length, so that speech is not interrupted in linguistically and prosodically inappropriate places. Anticipatory coarticulation is further evidence of motor speech preplanning within relatively short time domains.

4 Aerodynamic coordination

In recent years, renewed attention has been focused on the aerodynamic aspects of stuttered speech. Adams (1974) suggested that the stutterer may show any one or combination of the following factors during speech:

- (i) Poor breathing patterns resulting in inadequate build-up of subglottal air pressure.
- (ii) Faulty control of the laryngeal mechanisms, producing increased glottal resistance and poor timing of vocal fold movements.
- (iii) Increased tension in supraglottic articulatory-resonatory structures, resulting in hard articulatory contacts and excessive impounding of supraglottic air pressure. This in turn, makes the onset of phonation difficult or impossible, since the stutterer does not have the necessary subglottal expiratory force in order to initiate airflow across the glottis.

As a result of poor temporal coordination of respiration, phonation and articulation-resonance, possibly in conjunction with increased muscle tension, the stutterer is thought to experience difficulty with the onset and maintenance of phonation.

The patterns of aerodynamic dysfunction in stutterers described by Adams may be observed clinically and have been described on roentgenoscopic examinations of fifty adult subjects by Handzel et al (1974). Only four of their subjects failed to show abnormal respiratory, phonatory and articulatory movements during speech and nonspeech conditions. Those four subjects were mild, clonic stutterers. The authors described a common finding of spasmodic movements in the muscles of respiration, phonation and articulation and discoordination between these three processes. The report implied that these signs were noted in all conditions but failed to supply a detailed description of the relative findings in the fluent speech, stuttered speech, and nonspeech conditions. It was further marred by a lack of quantification owing to limitations in the available equipment.

Adams speculated that, in stuttering children, the incoordination is mainly at the laryngeal level, but offered no evidence to support this idea. Stromsta (1965) in a spectrographic analysis of the dysfluencies of thirty-eight stuttering children, found a lack of formant transitions; abrupt phonatory stoppages and lack of glottal airflow associated with prolongations and clonic dysfluencies in twenty-four of the subjects. Those subjects were also found to still be stuttering ten years later. The remaining eleven subjects did show formant transitions and had no abrupt phonatory stoppages.

Ten of these eleven subjects were fluent at follow-up a decade later. In addition, in eight of the eleven subjects who were fluent on follow-up, the original measures revealed airflow through the vocal tract during the momentary pauses between syllable and word repetitions. Airflow characteristics during dysfluent speech in children may well have prognostic value.

Much attention has been devoted to the search for a primary laryngeal factor in stuttering. Starkweather (1982) distinguished between 'weak' and 'strong' hypotheses relating to the laryngeal factor. The weak hypothesis proposes that the larynx is involved during stuttering but that the whole vocal tract is also affected. The 'strong' hypothesis suggests that a laryngeal dysfunction is primary and causative in stuttering. This approach is exemplified by Schwartz (1976) who claimed that stuttering is basically a failure in inhibition of an airway dilation reflex. Gradually, excessive tensing of the vocal folds during speech becomes learned as a habit pattern. In another publication Schwartz (1974) took his localization proposals to extreme lengths when he attributed the cause of stuttering to a lack of central nervous system controls on the posterior cricoarytenoid muscle, a prime glottal adductor which supposedly overreacts to subglottal air pressures. Unfortunately Schwartz offered no experimental data to directly substantiate his ideas. Apart from various objections regarding his interpretation of anatomical and physiological research reports concerning the larynx and his failure to adequately account for all the core features of stuttering (Adams 1975; Freeman and Hirose 1975; Zimmermann and Allen 1975), there is growing evidence, which includes the results of the present study, that stuttering is unlikely to hinge upon so isolated a dysfunction.

More worthy of attention are several carefully controlled studies which, while of a pilot nature and not sufficiently comprehensive, have yielded positive findings implicating abnormal laryngeal functioning in stutterers. Freeman and Ushijima (1975), studying the stuttered and fluent (under novel stimuli) speech of four adult stutterers, concluded that their moments of stuttering were characterized by patterns of laryngeal muscle activity which deviated from those of normal speakers. Using a combined EMG and fiberoptic technique to measure intrinsic laryngeal muscle dynamics they found in general:

- (i) lack of normal reciprocity between adductors and abductors.
- (ii) lack of normal synchrony between adductors.
- (iii) generally higher levels of EMG activity than is normal in the posterior cricoarytenoid, lateral cricoarytenoid, interarytenoid and vocalis muscles.

The finding of asynchrony between adductors was particularly suggestive of an organic disorder, although this finding applied to only one of the subjects.

Shapiro (1980) while substantially replicating the findings of Freeman and Ushijima, differed by finding indications of abnormal laryngeal muscle activity and timing in the nonstuttered speech of adult stutterers. Overall, EMG activity was higher for stuttered than for fluent readings.

In another fiberoptic study by Conture et al (1974), lack of smooth

reciprocity between agonistic and antagonistic intrinsic laryngeal muscles was observed in stutterers.

Wyke (1967, 1974a) demonstrated the existence of three sets of mechanoreceptors in the intrinsic muscles and interarticular joints of the larynx which provide afferent stimulation to the brainstem as part of reflexes which regulate the precise laryngeal activity required for normal phonation. The intrinsic laryngeal muscles are preset, ie. adjusted to the required tension, prior to phonation. This presetting, which is probably coordinated with presetting of the rest of the respiratory muscles and supraglottic articulators, is a function of learning and takes place at a voluntary level. Further evidence of laryngeal presetting is proffered by Flanagan et al (1976) who demonstrated that interarytenoid muscle energy is correlated with voicing onset and anticipatory to it by approximately 40-50 msec. Wyke proposed that after presetting, the laryngeal reflexes then serve to regulate phonation in an automatic way.

Although he did not conduct any investigations into stutterers, Wyke (1974b) speculated that there might be two different types of stuttering involving laryngeal malfunctioning:

- (i) "Voluntary or Cortical Stammering" which represents a failure in the accurate timing of the voluntary presetting of the laryngeal musculature for the utterance of particular sounds. The wrong sound emerges, which is monitored by the speaker who changes the tension distribution or subglottal air pressures in an attempt at correction and brings about reflex spasm of the vocal tract muscles, interrupting the speech flow with a tonic stuttering symptom.

Wyke suggested that a cerebral dysfunction might operate which disrupts the timing coordination of voice onset with airflow from the lungs. The origins of the cerebral dysfunction might be genetic, acquired or psychogenic.

- (ii) "Reflexogenic stammering" in which presetting of the muscles is intact but the intrinsic laryngeal reflexes fail to maintain the muscles in the desired preset posture so that the tension and position of the vocal folds randomly deviate during air expiration. The speaker uses stress-provoking voluntary efforts to override the reflex dysfunction, with rapidly repeated presetting, bringing about clonic stuttering symptoms.

In general, the physiological studies of stuttering are limited by the small number of subjects used and because they have only been conducted on adults. It is not known whether stuttering children demonstrate similar problems or whether, indeed, such differences are typical of most stutterers.

Behavioural studies have claimed to support the idea of a primary laryngeal component in stuttering by showing less stuttering or more stuttering adaptation when the phonatory demands of the speech task were reduced (Adams and Reis 1971, 1974; Brenner et al 1971; Adams et al 1974).

Starkweather (1982) correctly warned of the dangers of overinterpretation of results of studies of the laryngeal component, since difficulties may not be confined to the larynx but may be part of a generalized dysfunction. He noted that reaction time studies have in general, revealed slow reaction times (RTs) in both oral and laryngeal structures in stutterers irrespective of mode of sensory input. Auditory dysfunction is unlikely to be a factor influencing slower vocalization times (Starkweather et al 1976). Studies which have included manual RTs have indicated that there may be a generalized neuromotor timing disturbance extending beyond the speech organs, although the larynx often seems to be most severely affected.

In a pilot study of one adult stutterer Yoshioka and Lofqvist (1981), using acoustic measurements in conjunction with fiberoptic monitoring of glottal movements in temporal relation to visual stimuli, found that during stuttering there was poor timing coordination between oral articulators and laryngeal movements, and between breathing and phonation. Thus, the entire vocal tract was involved. Even in the perceptually fluent speech of the subject, timing incoordination between respiration and phonation were observed.

Starkweather and Myers (1979) studied the duration of subsegments within an intervocalic interval in a VCV segment taken from the fluent speech of stuttering and nonstuttering adults. The stutterers were found to be slower than controls in transitional subsegments, which corresponded to tongue and laryngeal movements. This indicated an inability on the part of stutterers to move these muscles as quickly as nonstutterers. No difference was found between the groups in terms of steady-state subsegments. Although the study was limited in that only a very limited sampling of speech was analyzed, the results suggested that the vocal tract as a whole may function less than optimally during stuttering.

While it seems to be frequently affected, it is not clear whether laryngeal involvement is an essential part of stuttering. Evidence in support of this idea comes from Freeman and Rosenfield, cited by Rosenfield (1983), who reported several cases of cessation of stuttering after laryngectomy. In contrast, Tuck (1979) reported a case of a mild clonic stutterer who, after total laryngectomy, continued to exhibit whole-and part-word repetitions in his alaryngeal speech. However the late onset (13 years) and history given by the patient suggest that he may have been a maladjusted rather than 'speech phobic' individual and thus not representative of the group under consideration. Perhaps a laryngeal component will prove to be one of the signs differentiating the diagnostic categories of stuttering.

5 Stuttering as a disorder of timing

Van Riper (1971) suggested that stuttering be considered a disorder of timing. He proposed that a core stuttering behaviour is emitted whenever there is temporal disruption of the simultaneous and successive programming of muscular movements required for speech production. The underlying reason for the timing disruption is not clear but he considered the possibility of a hemispheric specialization disturbance as well as abnormal auditory feedback, which has been noted in stutterers (Stromsta 1956 cited by van Riper). The postulated mistiming may affect the balance between agonistic and antagonistic vocal tract muscle activity, or it may disrupt the temporal

coordination of respiration, phonation and articulation at the level of speech programming. Having reviewed the relevant literature, van Riper concluded that the proposed timing disorder seems to affect nonspeech muscles as well.

Support for the timing disorder theory comes from cinefluorographic studies by Zimmermann (1980 a,b,c,) in which movements underlying the perceptually fluent speech of adult stutterers were measured. The most critical measures were those pertaining to temporal articulatory features such as transitions, steady state durations, total syllable duration, and duration between movement onset and peak velocity. The stutterers demonstrated longer durations for these measures than did normal controls. Additional spatial measures involving displacement of the articulators were taken but these aspects of the study may not have been adequately controlled (Goldsmith 1983). Zimmermann's findings are interesting in that they suggest the presence of a pervasive motor control breakdown for speech timing. However the possibility exists that the stutterers may have adopted an overall slow speech rate in order to achieve fluency. If similar results could be obtained in young stuttering children, who may not yet have adopted such strategies, it would lend further credibility to Zimmermann's proposals.

Somewhat at variance with Wyke's implication of the cortical level, Zimmermann further proposed a theoretical model which suggested that variable articulatory movement patterns and timing operate via the peripheral sensory afferents to alter the level of excitability of motoneurone pools for speech musculature in the brainstem. This may interfere with subcortical coordination of reflex interactions and lead to clonic and tonic symptoms of stuttering. Despite these postulates there is no evidence to indicate on what level of speech encoding or decoding the primary breakdown in timing control might occur. Nor is it clear precisely how the speech timing deviates from normal, ie. whether there is an overall slowness in the system, such as is suggested by reaction time studies, or whether there is asynchrony of activity of bilateral speech structures, as observed in physiological studies.

Apart from studies of hemispheric specialization in stutterers, this group has been shown to differ from nonstutterers in terms of central auditory integration (Wynne and Boehler 1982; Hall and Jerger 1978). Furthermore Mirabile et al (1978) found that central auditory temporal processing was correlated with degree of fluency in stutterers. These studies have led Kent (1983) to suggest that central auditory dysfunction might be a contributing etiological factor in stuttering.

A theory of stuttering must account for the established phenomenology, including:

- * The universality of the disorder - stuttering appears to occur in all cultures (van Riper 1971).
- * The sex ratio of 3:1 males to females, increasing with age (Andrews and Harris 1964; Bloodstein 1981).
- * Loci of stuttering - stuttering tends to occur most often on long words, content words, at the beginning of utterances, on word-initial consonants

timing reflects an inherent constitutional dysfunction. While present to some degree in even young children, these factors are less prevalent or weaker, enabling the experimenter to partially eliminate those variables. Further information on the fluent speech of stutterers is also needed to clarify whether or not there is a pervasive ongoing timing control difficulty which is simply exacerbated during the moment of stuttering, or whether moments of stuttering and fluency differ qualitatively. Evidence to support the latter viewpoint comes from studies by Shapiro (1980), Handzel et al (1974), Love and Jeffress (1971); Zimmermann (1980); Yoshioka and Lovqvist (1981) but are contradicted by Few and Lingwall (1971) and Freeman and Ushijima (1975).

III ELEMENTS OF FLUENT SPEECH TIMING

Fluency, in its narrow sense, incorporates temporal, sequential speech features such as stress patterning, normal pauses and hesitations, and transition smoothness (Dalton and Hardcastle 1977). It implies intact central nervous system preprogramming of phonemes so as to provide the necessary coarticulation as well as precise sensorimotor coordination of respiratory phonatory and articulatory systems in relation to linguistic demands.

A Stress patterning (rhythm)

Rhythm comprises segmental durational variations, accompanied by changes in the intensity of syllables and changes in vocal fundamental frequency. Stress patterning is governed by phonological rules, eg. the duration of a stressed syllable is shortened when it is immediately followed by an unstressed syllable. This 'trochaic shortening rule' operates across word boundaries but is blocked by the presence of certain 'strong' syntactic boundaries, such as NP-Prep. Phrase (Cooper et al 1971).

Kent and Minifie (1977) proposed that there must be a level of speech motor control which plans the rhythmic grouping of syllables into suprasegmental patterns. Anderson (1975) also argues in favour of a central timing control mechanism which organizes speech rhythm and to which coarticulatory timing effects are subordinate. This notion is supported by Flege's demonstration of respiratory preplanning according to the demands of utterance length (Flege 1983).

In addition to changes in duration, stressed syllables are accompanied by an increase in voice fundamental frequency and intensity, with a corresponding rise in subglottal air pressure (Netsell 1973). Netsell points out that there are two important kinds of temporal structure which contribute to the rhythm of a language:

1. The time programme, ie. temporal grouping of syllables extending over phrases. This is easily perceived by the listener.
2. Segmental timing: shorter rhythmic groupings comprising the durations of individual segments making up each syllable. This is not easily perceived at conscious level by the ordinary listener. It is this level which is of particular interest in the present thesis.

In most languages segmental timing is of phonemic importance since, for example, voice onset time (VOT) can differentiate a voiced from a voiceless phoneme. VOT is the time taken from release of a stop plosive closure to the onset of voicing for the following vowel. Segmental timing is thought to operate with units larger than the single phoneme. Allen (1970) proposed that, in English, vowels are grouped with the following consonant or consonants to form higher-order time units. In Russian, vowels are thought to form temporal units with preceding consonants (Kozhevnikov and Chistovich cited by Gilbert and Johnson 1978). Fischer-Jorgensen (cited by Cooper 1977), on the other hand, found no consistent compensation in consonant length in relation to the length of the following vowel in Danish CV syllables produced by adult speakers. However, stop closure plus burst (the 'open interval') was longer before high than before low vowels. CV syllables with voiceless stops had longer open intervals, shorter closure durations and shorter following vowels than did syllables with voiced stops.

B Normal pauses and hesitations in adult speech

Goldman-Eisler (1958) points out that pauses occur at clause junctions as well as within the boundaries of syntactic units. These hesitation pauses are distinguished from deliberate pauses for the sake of emphasis or phrasing. In discourse, hesitation pauses are longer than in reading or in the recitation of prepared material. These pauses vary widely in frequency and duration from utterance to utterance and amongst speakers. Goldman-Eisler found that they account for most of the overall variance in speech rate. Articulation rate was relatively invariant. Since most hesitation pauses occurred at points in the speech flow where there is great freedom of choice for the following words, with little predicability and automaticity of word choice, she concluded that they function in relation to verbal planning. Goldman-Eisler (1972) later found that, in spontaneous discourse, pause measurements were lawfully related to syntactic structuring.

McClay and Osgood (1959) identified four normal hesitation types in spontaneously-encoded speech.

1 Repeats

Repetitions of sounds, words or phrases which have no semantic significance (such as intensification). These mostly occur on functors preceding a lexical item. 9% of repetitions were of single phonemes, 4% of single syllables, 1% of single morphemes, 71% of single words and 17% of two or more words. Thus, in normal English speech, repetitions of units smaller than a word are rare.

2 False starts

Incomplete or self-interrupted utterances. Typically, these involve lexical items - nouns, verbs, adjectives and adverbs.

3 Filled pauses

These include /ə:/ and /m:/. The low schwa is the most frequently used filler. Filled pauses tend to occur before function words, especially at phrase boundaries, and seem to be a device which the speaker uses for keeping

his conversational 'turn'. The extent to which filled pauses are related to syntactic planning has not yet been unequivocally established (Cook et al 1974).

4 Unfilled pauses

These include silences of unusual length and non-phonetic lengthening of phonemes. They occur most often at word boundaries within phrases, especially before lexical words.

Fast speakers were found to make fewer hesitation errors, while individual speakers showed a relative 'preference' for certain hesitation types, which formed part of their speech style.

While normal hesitation phenomena seem to be related to the dynamics of grammatical and lexical selection, they are also influenced by the motivational and emotional states of the speakers (Mahl 1957 cited by McClay and Osgood). Apart from hesitations the latency of speech initiation has also been related to lexical retrieval complexity and syntactic planning (Lindsay 1975, 1976).

Elderly speakers (69-78 years) without known pathology are only slightly less dysfluent than are normal preschoolers. However, the pattern of dysfluency differs, interjections of sounds, syllables, words or phrases being the predominant dysfluency type in the elderly. Elderly speakers are significantly more dysfluent than are senior high school students (Yairi and Clifton 1972). The dysfluency patterns of the elderly also differ from those of stutterers, which are discussed in a later section.

Normal adults are most dysfluent in those situations which they regard as least important, ie. conversation. They monitor their speech more carefully and are consequently more fluent in more important situations, such as public oratory (Broen and Siegel 1971). Further evidence of the control exerted over their speech by normal speakers comes from findings by Siegel and Martin (1966) and Boone and Dittman (1964), viz. that the rate of dysfluencies decreased when adult subjects were instructed to be less dysfluent. At a more automatic level, normal adult speakers were found by Silverman and Goodban (1972) to behave like stutterers by showing dysfluency reduction when reading aloud under conditions of bilateral white noise masking (94dB SPL). However, normals reduced their dysfluencies by about 27%, while in the case of stutterers the reduction is much larger (75%).

C Transition smoothness

Transition smoothness, an integral part of fluency, can take place on several levels (Dalton and Hardcastle 1977):

1. Segmental phonetic level between sounds and syllables.
2. Grammatical level, between phrases, clauses and sentences.
3. Prosodic level, between intonation units.

4. Semantic level between thematic elements.

Dalton and Hardcastle regard fluency breakdown as synonymous with breakdown in transition smoothness. They see pathological speakers as differing from normals quantitatively rather than qualitatively.

The present report is aimed at measuring aspects of transition smoothness at the segmental phonetic level which, according to Dalton and Hardcastle, is dependent on aerodynamic coordination. These include voice onset time, and consonant and vowel durations in VCV and CVC syllables respectively. These temporal speech features seem to be lawfully governed by phonological rules of the speakers language. However, Allen (1973) noted that there is no simple 1-to-1 relationship between underlying phonological segmental length specification and the observable phonetic duration. Sources of variation are speech tempo and biological restraints such as jaw mass, muscle elasticity, and aerodynamic factors. Lisker (1971) and Lehiste (1970) found that interaction between biological restraints and phonological rules influence VOT and vowel duration respectively. Thus, in measuring the phonetic output, it is only possible to make assumptions about the phonological input.

The segmental phonetic level of speech timing control comprises coarticulatory as well as segmental timing effects. Coarticulation is "...that process which occurs when two or more sounds overlap in such a way that their articulatory gestures intermingle..." (Daniloff 1973 p201). Coarticulation is a major source of allophonic variation, the articulatory gestures of a given sound being spread over several adjacent sounds. It results in sensitivity of spectral and durational phonetic properties to the phonological context.

Daniloff distinguished between two types of coarticulation.

1. Left-to-right effects which are due to mechano-inertial timing. During fast speech, in particular, the longer articulators move a little too slowly and overlap with movements for other sounds.
2. Neurally-programmed right-to-left effects in which there are anticipatory movements occurring on one sound in preparation for the following one. This makes the smooth flow of normal speech tempo possible.

Patterns of neurally-programmed coarticulation indicate the speaker's articulatory planning strategies. Anderson (1975) has identified several coarticulatory speech timing effects. Those affecting consonants include:

1. Shortening of a consonant when combined with other consonants in a cluster.
2. Lengthening of consonants as well as vowels in stressed syllables.

Vowel effects include:

1. Relative lengthening of vowels before voiced consonants.

2. Vowel lengthening of up to 50% in stressed compared with unstressed syllables.
3. Shortening of vowels in unstressed syllables when speech rate is increased. The result is a reduction of vowel transitions so that the vowel is neutralized to schwa or even disappears.

VOT is an important dimension of segmental timing, since it is a valid measure by means of which voicing categories in many languages can be differentiated. In their seminal study of native adult speakers of eleven languages, Lisker and Abramson (1964) used wide-band spectrographic analysis to study stop plosives in a variety of positions in words and sentences.

Three categories of VOT values were identified:

1. Prevoicing, ie. -125 to +25 msec (median -100)
2. Short-lag, ie. Zero to +25 msec (median +10)
3. Long-lag ie. +60 to +100 msec (median +75)

It is now generally accepted that a VOT boundary of approximately +35 msec separates the short and long lag categories in English (Cooper 1977), a figure which corresponds with the perceptual boundary. Inter alia, Lisker and Abramson found English to be a two category language employing short-lag and long-lag VOT to differentiate voiced and voiceless stops respectively. Occasional prevoicing would be categorized with short-lag. Prevoicing was much more common in Dutch, also a two-category language. Generally, VOT increased as the place-of-articulation of stops moved posteriorly in the mouth. Sentence data was found to be very similar to data for isolated words, although some embedding effects were observed.

Bailey and Haggard (1973), using an oscilloscopic analysis to measure VOT of word-initial singleton stops in adult English speakers, confirmed that this parameter is a stable aspect of performance separating voiced from voiceless sounds. Fundamental frequency at voicing onset was not a very reliable measure.

VOT attains adult stability at approximately 8 years of age (Kent 1976), however it appears to be resistant to change in the elderly. Neiman et al (1983) found no significant differences in VOTs between 20-30 year old and 70-80 year old females. This was an unexpected finding, since other investigations have shown that measures such as motor reaction time and diadochokinesis slow down with age. The authors speculated that the elderly might use compensatory patterns, such as keeping the vocal folds more adducted, so as to achieve the short lag interval, to negate the influence of neuromuscular changes in the larynx.

Lisker and Abramson showed that subjects discriminated VOT values in synthetic stimuli in a categorical manner that reflected the phonological contrasts of their native languages. VOT was found to be the most important perceptual cue for judging the voicing distinction in English. Other cues

have been found to operate to a lesser degree:

1. F1 'cutback' (Liberman et al 1958).
2. Fundamental frequency (Fijima 1971; Haggard et al 1970).
3. F1 transition duration (Stevens and Klatt 1974). However, there is contrasting evidence that the transition itself is of lesser importance than is its frequency at the onset of voicing (Lisker 1975; Summerfield and Haggard 1977).

Stevens and Klatt found that the VOT perceptual boundary, while not fixed, has a limited range of approximately 18-48 msec following burst onset.

IV DYSFLUENCIES IN ADULT STUTTERERS

What is known regarding the syndrome of stuttering has been well described elsewhere (van Riper 1971; Dalton and Hardcastle 1977; Bloodstein 1975).

Table I illustrates the rates of occurrence of dysfluency types which include core features, and are thought to differentiate stuttering from normal dysfluencies (Bloodstein 1970; Johnson 1961).

TABLE I Rates of occurrence of dysfluency types of adult stutterers and nonstutterers during a three-minute speech sample

<u>Dysfluency type</u>	<u>Nonstutterers</u>	<u>Stutterers</u>
Interjections	0 - 13.7	0 - 80
Part-word Repetitions	0 - 15.5	0 - 59.5
Whole-word repetitions	0 - 2.9	0 - 15.5
Phrase repetitions	0 - 2.2	0 - 8.5
Revisions	0 - 4.3	0 - 5.5
Broken words	0 - 0.5	0 - 28.2
Prolongations	0 - 1.7	0 - 21.8

It can be seen that whole-word repetitions, part-word repetitions, audible prolongations and silent prolongations (broken words), ie. Wingate's core features, characterize the dysfluencies of stutterers.

Studies of the segmental speech level in adult stutterers have highlighted the ways in which this group differs from normals. Wingate (1971) found adult stutterers to perform poorly on tasks requiring manipulation of language at the phonological level, as measured by the Backward Speech Test and Phonetic Anagrams Test. Segmental timing aberrations have also been noted for stutterers. Starkweather and Myers (1979) demonstrated longer-than-normal transitional subsegment durations. Steady state durations were normal. Longer-than-normal vowel durations have been observed in the fluent speech of stutterers under conditions of masking, rhythmic stimulation, whispering and delayed auditory feedback (Brayton 1976 cited by Freeman 1979; Lehiste 1964 cited by Freeman 1979; Wingate 1970; Borden et al 1977). This has been interpreted as an attempt by the stutterer to simplify the phonatory requirements of the speech task. However, bearing in mind that voice reaction time and oral articulation studies have suggested an overall slowness in the speech movements of stutterers, increased phonation time under conditions of artificially-induced fluency may simply be another manifestation of this sluggishness. Agnello et al (1974 cited by Starkweather 1982) reported longer VOTs and, to a lesser extent, voice termination times in the fluent speech of adult stutterers compared with nonstutterers. These findings have been confirmed by other studies (Hillman and Gilbert 1977; Kerr and Cooper 1976 cited by Starkweather 1982). DiSimoni (1974c) measured vowel duration in relation to the following consonant as well as consonant duration in relation to the following vowel in the fluent speech of adult stutterers. While the essential vowel durations in relation to the following consonant were retained, the durations were longer than those reported elsewhere for normals. Consonant durations were longer than those of normal controls and the stutterers showed more intra-subject variability for consonant durations.

V NORMAL AND ABNORMAL DEVELOPMENT OF SPEECH TIMING CONTROL

Cooper (1977) identified three levels on which children learn control of speech timing:

1. The phonetic-phonemic level, such as VOT.
2. The syllable level, comprising rules for the timing of sounds within the syllable depending on contextual influences, eg. the child learns that vowels need to be lengthened when they are followed by a voiced consonant. It is also likely that rules for temporal compensation for segment duration within each syllable may need to be learned. Such a rule would specify, eg. that a longer-than-average vowel must be accompanied by a shorter-than-average consonant.
3. The sentence level. Both children and adults seem to preplan the timing of segments within utterances, eg. the longer the utterances, the shorter the individual segments. This preplanning probably allows for coordination of breathing with language. Morpheme selection or

syntactical difficulties would disrupt speech timing at this level.

Dalton and Hardcastle (1977) included:

4. The prosodic level, ie. transition smoothness between intonation units.
5. The semantic level: smoothness between thematic elements.

It is the phonetic-phonemic and syllable levels of programming which are of interest in the present study.

A Hesitation phenomena: normal and stuttering

Little work has been done on both the temporal patterning of and hesitations in the speech of children. Unfilled pauses decrease as language proficiency in children improves, as reflected in reading and story-retelling tasks (O'Connell and Kowal 1970). Kowal et al (1975) found age-related trends in vocal hesitations in children 5.10 to 18.1 years of age on picture sequence description tasks.

Yairi and Clifton (1972) found the following percentages of dysfluency types in the spontaneous speech of preschool and senior high-school children.

TABLE 11 Rates of occurrence of dysfluency types in nonstuttering children based on Yairi and Clifton (1972)

Dysfluency type	Preschool children	High school Seniors
Revision-incomplete phrase	32.55	28.65
Interjection (sound, syllable, word)	24.84	43.23
Word repetition	16.21	10.68
Part-word repetition	7.84	4.70
Phrase repetition	7.71	7.81
Dysrhythmic phonation	9.67	7.81
Tense pause	1.18	1.04

Preschoolers were significantly more dysfluent overall than were high school students. Note that tense pauses, which are characteristic features of stuttering, have a low rate of occurrence in normals.

Nonstuttering boys and girls (76-99 months) do not differ significantly in terms of overall number of dysfluencies exhibited, however boys show more incomplete phrases than do girls (Kools and Berryman 1971). This study also found a low rate of occurrence of those dysfluency types characteristic of stuttering.

Johnson's (1961) and Bloodstein's (1970) data, based on three-minute speech samples, have been pooled to provide the following rates of occurrence of dysfluency types in stuttering and nonstuttering children.

TABLE III Comparative rates of occurrence of dysfluency types in stuttering and nonstuttering children based on data from Johnson (1961) and Bloodstein (1970)

Type	Nonstutterers	Stutterers
Interjections	-	-
Part-word repetitions	0-60/1000 wds	0-366/1000 wds
Whole-word repetitions	0-46/1000 wds	0-148/1000 wds
Phrase repetitions.	-	-
Revisions	-	-
Prolongations	0-19/1000 wds	0-196/1000 wds

Adams (1977), reviewing the literature on fluency failure in children, pointed out that children who have been labelled as stutterers are at least twice as nonfluent as those considered to be normal. The stutterers' total number of dysfluencies is, on average, 10 or more per 100 words. Qualitative differences are also observed between the groups, as has been noted, i.e. stutterers display many more sound prolongations and part-word repetitions than do normals. The part-word repetitions may consist of one to five unitary repetitions in even incipient stutterers, whereas normals never show more than three unitary repetitions on a given word. In further contrast to normals, the repetitions and prolongations of stutterers may be masked by abrupt, abnormal cessation of voice or airflow through the vocal tract. Within part-word repetitions, stutterers may substitute the schwa vowel for the vowel they are attempting to produce.

Bloodstein and Grossman (1981) noted that most stuttering in children's speech occurs at the beginnings of sentences, clauses and phrases. More stuttering occurs on functors than on content words.

One of the most puzzling features of stuttering is that, after onset, which is usually around three years of age, there is often a period of fluency, followed by alternating periods of exacerbation and remission of signs.

Bloodstein (1960) points out that, in most cases, no obvious environmental factors can be identified which might have triggered the recurrence of the dysfluency.

The relationship between language development and stuttering in children is not clear. Many stuttering children have a history of late acquisition of articulation or language. But no convincing causative link has yet emerged from the literature. If stuttering children were simply uncertain regarding linguistic decision-making one would expect normal speech hesitations to occur. School-aged stuttering children do not have longer object-naming latencies than do nonstuttering children (Boysen and Cullinan 1971). Negative or equivocal findings have emerged from many studies exploring the link between language and stuttering (Bloodstein 1975) although older stuttering children have been found to perform poorer than nonstuttering controls on certain formal language tests (Andrews et al 1983). It is logical to suppose that uncertainty regarding language might contribute to hesitations and create aerodynamic difficulties in children who already have a tendency to stutter. Language-delayed children are also subject to communicative pressures, and tend to show more fluency-breakdown if they are receiving speech therapy than if they are not treated (Merits-Patterson and Reed 1981).

B Segmental durations

DiSimoni (1974a, 1974b) studied segmental durations, which are governed by phonological rules, in the speech of three-, six-, and nine-year-old children. He examined the influence of consonant environment on vowel duration as well as the effect of vowel environment on consonant duration. The influence of phonetic context on segmental durations was shown to appear between 3 and 6 years of age. The effect of vowel environment on consonant duration was approaching, but had not yet reached adult levels in the 9-year-olds. A developmental trend was noted in terms of decreasing variability of performance as a function of age. This trend has also been observed by other investigators (Forner 1983; Tingley and Allen 1975; Zlatin and Koenigsknecht 1976).

Kent (1976), reviewing the literature on the development of temporal aspects of speech production, called attention to the paucity of information on what may be "...the most critical factor in skilled motor performance" (p438). He regarded timing variables as providing a sensitive matrix of neuromuscular maturation of the speech mechanism. VOT studies have indicated that children do not have reliable temporal control over articulatory movements until about 10 years of age. It is interesting that stuttering onset after this age is rare and frequently apparently psychogenic in origin. Furthermore, Milisen and Johnson (cited by Andrews and Harris 1964), also reported recovery from stuttering by 11 or 12 years of age in 40% of the stutterers in their longitudinal study. Thus, refinement of speech motor skills continues after children have acquired the phonological system of their language in a way which satisfies the casual listener. In addition Kent suggested that the acquisition of motor programmes for speech was conditioned by learning phonological regularities.

Tingley and Allen (1975) found that 5-year-olds had developed strategies for preplanning of motor control, although precision of control continued to improve until 9-11 years. Rhythmic finger-tapping tasks were found to parallel the speech development data.

1 VOT developmental data

a) Production

In a longitudinal study of three American English children, Kewly-Port and Preston (1974) found that at 6 months of age infants are physiologically capable of producing long-lag VOT but do not have the necessary voluntary control (long-lag VOTs are generally considered to be physiologically more complex than short-lag VOTs). VOT lags appear randomly at this age. As voluntary control develops, short-lag VOTs predominate with a gradual increase in long-lag VOT. By 2 years of age 50% of /t/ productions had VOT values in the adult range. While the authors referred to 'voluntary control', the realization by children of the phonemic importance of the voicing contrast must also be an important factor in its emergence after the babbling stage. Eguchi and Hirsh (1969) reported that mean VOT does not change systematically with age after three years. By 7-8 years there is adult-like minimal within-subject variability of production in American English children.

Zlatin and Koenigsknecht (1976) reported the same VOT ranges for 2-year-olds, 6-year-olds and adults, although there was a less distinct voiced/voiceless boundary and more within-subject variability in the case of the children. The values were:

/p/: +50 to + 100 msec

/b/ and /d/: 0 to + 20 msec

/t/ and /k/: +60 to + 110 msec

In a longitudinal study of four American English children, Macken and Barton (1977) noted similar developmental trends to those of Kewley-Port and Preston. Three of their subjects reached adult contrast values by 1.9 years and the fourth child by 2.4 years. Some children were found to change more abruptly than others into the long-lag region. Most of their children tended to overlengthen the VOT stop values beyond the mean adult value at first and then to shorten them. Gilbert (1977), on the other hand, found that although three-year-old Canadian English children clearly differentiated between /d/ and /t/ in their speech, they did not yet have /t/ VOT values in the adult region.

Spanish-speaking children who were learning English were found by Williams (1974) to show evidence of merging of Spanish and English voicing characteristics.

VOT and voice termination times (VTT) in stuttering children has been compared in one study (Agnello et al cited by Starkweather 1983). Both values were longer in the stuttering children than in the controls. In general, children showed longer VOT and VTT values than did adults.

b) Perception of the voicing distinction

When all the perceptual cues of normal speech are available to American English children, they identify stop consonants in a way similar to adults by four or five years of age (Wolf 1973; Parnell and Amerman 1978). However, when only selected portions of the syllables are available for syllable identification, four-year-olds, in contrast with older children and adults, are unable to use only the aperiodic portions of the syllable, eg. the plosive burst, for identification (Parnell and Amerman 1978).

Shvachkin (1948, translation in Ferguson and Slobin 1973), studying Russian children, traced the development of perception of phonemic speech in a categorical labelling paradigm. The children had to learn the labels (monosyllabic nonsense words) for geometrical figures. Shvachkin established that perception of the voicing contrast occurred late in the developmental sequence but was acquired by all twelve subjects by 1.9 - 2.0 years of age. The perceptual data contrasted with the early appearance of /p/ and /b/ in prephonemic speech.

Shvachkin's experiment was replicated by Garnica (1971) using American English children. She found a similar developmental sequence of acquisition of phonetic contrasts to that of Shvachkin. The voicing distinction was again acquired late, although the age was not specified. She noted, however, that by 2.7 - 2.11 years of age, subjects were still having difficulty in discriminating certain classes of oppositions.

Simon and Fourcin (1978) compared perception of the voicing contrast in English-and French-speaking children using a categorical labelling paradigm. The VOT distributions of the two languages differ for cognated voiced-voiceless pairs. The following developmental trends were noted:

English children.

- (i) Two-year olds judged extreme VOT values consistently but gave random responses to mid-values. They made little use of the F1 transition cues.
- (ii) In the next stage they no longer gave random responses to mid-values but still failed to use the F1 transition cue. Labelling shifted gradually from one category to another in almost linear progression.
- (iii) Categorical labelling was shown by five-to six-year-olds, who also showed use of the F1 transition cues.

French children.

- (i) The same perceptual patterns as seen in two-year old English children were shown by French children up to four years of age.
- (ii) French children demonstrated categorical labelling one to two years later than did English children and never used the F1 cue.

The authors commented that the lack of F1 perceptual cue usage by French children was logical since, in spoken French, voiced-voiceless cognates have short VOT values (less than +30 msec with prevoicing common) in which F1 transitions do not change much. French children have a more difficult perceptual task than do the English since they have to rely on VOT cues alone and this explains the later age of acquisition of categorical labelling.

Simon and Fourcin's comment that there is a discrepancy between perception and production of the voicing contrast, since French children's age of production is comparable to that of English speakers, is in agreement with Schvachkin's observation that his subjects were able to repeat the names of objects, yet did not have categorical labelling.

From the above data, and taking into account the failure to demonstrate categorical perception in neonates (Molfese and Molfese 1979), it seems that categorical labelling for speech sounds is to some extent language-specific and a function of learning. The VOT boundary identification without phonemic correlates, on the other hand, appears to be innate and based on psychoacoustic capabilities, since it has been demonstrated in young babies and chinchillas (Kuhl and Miller 1978; Lasky et al 1975; Streeter 1976).

VI RATIONALE FOR THE PRESENT STUDY.

The development of an adequate theory to explain the cause(s), nature and development of stuttering is being hampered by a lack of empirical data. This has led to a trial-and-error approach in the development of diagnostic and therapeutic procedures for the disorder. Many theorists have suggested that the basis of stuttering is some kind of constitutionally based timing disorder. The nature of the proposed timing dysfunction is unexplained apart from indications that, while it might be more widespread than the speech structures, it affects coordination between respiration, phonation and articulation as well as possibly resulting in asynchrony of neural inputs to midline speech structures. The role of feedback mechanisms and cortical language programmes is unknown. In terms of motor speech production, a description of the ability of stutterers is required at every level of the hierarchy postulated by Kent and Minifie (1977), the basic components of which are:

1. Rhythmic grouping of syllables in a multisyllabic unit or phrase.
2. Syllable form (including intrasyllabic rules).
3. Phoneme or segments.
4. Set of phonetic features.
5. Pattern of articulatory transitions, including the relative timing of the articulatory movements within a sequence.
6. Sequence of neuromotor commands.

Since most of the studies conducted on motor timing control for speech in stutterers have used adult subjects, it remains to be established whether similar problems occur in stuttering children and, if so, their nature and extent. It seems to be advisable to investigate the perceptually fluent speech of stuttering children so as to ascertain whether a timing disorder exists which affects speech outside moments of stuttering, since moments of stuttering, by their very nature, contain aberrant timing which may be symptomatic and not causal. Any demonstrated disorder must further be found to cross language barriers, when the demands of the languages are comparable, if it is to be attributed to neuromotor factors.

While all levels of speech production merit investigation, it is the phonetic-phonemic and syllable levels which come under consideration in the present report.

VII HYPOTHESES

It was hypothesized that the stuttering subjects used in the present study would differ from the nonstuttering controls in terms of the production of the temporal features of VOT, stop plosive closure duration and vowel duration.

1. Experiments 1, 3 and 4: The stuttering group was expected to show more intrasubject variability in performance than controls, even in the older age groups.
2. Experiments 3 and 4: While they were expected to show normal contextual influences on vowel and stop closure durations, it was postulated that greater durational values would be found in the stutterers than in the nonstutterers.
3. Experiment 1: With respect to VOT, it was hypothesized that, despite the fact that long-lag VOTs are physiologically more complex to produce than are short-lag VOTs, the stuttering children would show longer VOT values overall than the controls. This finding was predicted on the basis of the voice reaction time studies and the one VOT and VTT study, all of which suggested slower speech movements in stutterers. The stuttering children were expected to maintain a VOT distinction between voiced-voiceless cognate pairs, however VOT value trends for place-of-articulation shifts were not expected to differentiate stutterers from normals.
4. Experiments 1, 3 and 4: Older stuttering subjects were expected to show shorter durational values than the younger stuttering subjects as well as less intrasubject variability, reflecting increased speech production skills with maturation.
5. Experiment 2: Since there is no convincing evidence, as yet, of auditory language dysfunction in stuttering, the experimental groups were expected to acquire categorical labelling on tasks employing the voicing contrast in a manner similar to that of controls. Afrikaans

children were expected to be slower than English children in acquiring categorical labelling, since the voicing contrast is less marked in Afrikaans and fewer perceptual cues may be available to them.

VIII SUBJECT SELECTION

The subjects were 120 white children, 116 from the Cape Peninsula and 4 from Johannesburg. 119 were of South African parentage, 1 child was from a British immigrant family but was included in the study since he spoke standard British English with Received Pronunciation, an accent comparable with Conservative South African English.

60 subjects had English and 60 had Afrikaans as the only home language. While the home environments were monolingual, the native language of one parent sometimes differed from the one used at home. Mixed English-Afrikaans parentage occurred in 3 cases, Afrikaans-Dutch in 2 cases and Portuguese-English in 1 case. If the subjects attended creches or schools, the language medium of the classroom matched that of the home. However 38 subjects played with children from the other language group on the playground or in the neighbourhood. Second-language influence on the subjects' own dialects could thus not be ruled out, nor could it be accurately measured or matched between experimental groups.

Subjects were matched for sex but as there were only 6 females sex-based comparisons could not be made.

10 of the stuttering subjects reportedly had close relatives (parents or siblings) who stuttered, while 17 had distant relatives who stuttered. None of the control subjects reported any stuttering relatives.

A Selection of stuttering subjects

University and hospital clinics, public school speech therapists and correctionists, and the principals of creches and preprimary schools for normal children were asked to identify monolingual stutterers of suitable ages amongst their patients and pupils. With parental permission, the experimenter interviewed the children at school or at home and obtained a 5-minute audio recording of the interview, containing both spontaneous and elicited speech samples. This sample was considered to be sufficient for analysis (Jaffe and Breskin 1970). The tapes were played to two qualified practising and experienced speech therapists who, together with the experimenter subjectively identified those children who were considered to be definite stutterers. No subject was included in the study if there was any clinical doubt as to whether or not he or she was a stutterer. The subjects then had to meet the following criteria for inclusion into the study:

1. Frequency of occurrence of dysfluencies was 4% or more of syllables spoken by the subject during the recorded part of the interview.
Dysfluency rates are contained in Table XXI in the Appendix.

2. These dysfluencies comprised the following types:

Silent prolongations 1 sec or more in duration
Audible prolongations 1 sec or more in duration
Part-word repetitions
Whole-word repetitions of functors only

The 4% dysfluency cut-off point was thought likely to exclude nonstutterers, who do not usually exhibit more than 2.5% dysfluent syllables (Floyd and Perkins 1974) and who tend to mostly exhibit phrase repetitions and repetitions of content words (van Riper 1971).

B Selection of nonstuttering subjects

Class teachers from the stuttering subjects' classes were asked to select nonstuttering controls who were regarded as asymptomatic speakers, who were of the same sex as the stutterers, and who were as close to them as possible in age. In the case of those stuttering subjects who were not attending creches or schools controls were found from the same residential areas so as to try to control for social class.

Control subjects were interviewed and recorded in a similar way to the stutterers. The judges were unanimous that they were normal, nonstuttering speakers. They did not exhibit more than 2.5% dysfluencies and those dysfluencies were not characteristic of stuttering.

C Hearing

All subjects were screened audiometrically at the Hearing and Speech Clinic of Tygerberg Hospital immediately prior to exposure to the experimental conditions. Younger subjects were given free-field screening tests in a sound-treated room. If behavioural responses were equivocal, impedance audiometry was performed. Older subjects were audiometrically screened at 15dB SPL using a pure-tone sweep through the frequencies 250-8000 Hz. This screening was performed in an acoustic booth using a Maico MA 24 audiometer. All of the subjects were regarded as having hearing acuity thresholds within normal limits at the time of testing.

D Intelligence

No formal intelligence testing was done for the purpose of inclusion into this study. School-going subjects were assumed to have normal intelligence since they were reported to be coping satisfactorily academically. Any child who was destined for transfer to a special class was excluded from the study.

In the case of those subjects who were not yet at schools, the speech therapists in charge of the cases were asked for their opinions regarding the childrens' intelligence. Only those regarded as intellectually normal were

included in the study.

E Known pathologies

Children with known neurogenic or other medical disorders, such as cleft palate, were excluded from the study. None of the subjects nor their parents were receiving or had received active psychotherapy. 20, ie. one third, of the stuttering subjects were reported to have had a developmental delay or dysfunction of articulation or language. None of the nonstuttering subjects had histories of speech or language difficulties.

F Experimental groups

Subjects were assigned to one of eight experimental groups as outlined in Table IV. Each group consisted of 15 subjects.

TABLE IV The eight experimental groups used in this study with mean ages and ranges in years and months

Group	Mean age (in years and months)	Range
1. Older English nonstutterers	6.10	6.5 - 7.6
2. Older Afrikaans nonstutterers	6.9	6.4 - 7.10
3. Older English stutterers	6.0	5.11 - 8.1
4. Older Afrikaans stutterers	7.2	6.3 - 8.3
5. Younger English nonstutterers	4.4	4.0 - 5.0
6. Younger Afrikaans nonstutterers	4.1	3.1 - 4.8
7. Younger English stutterers	3.9	3.4 - 4.11
8. Younger Afrikaans stutterers	4.0	3.7 - 4.6

PRODUCTION OF VOICE ONSET TIME OF VOICED AND VOICELESS BILABIAL AND APICAL
SINGLETON STOP PLOSIVES IN INITIAL POSITIONS IN CVC NONSENSE SYLLABLES

- I Aims of the experiment
- II Outline of the experimental design
- III Instrumentation
- IV Material
- V Procedures for data collection
- VI Data analysis
- VII Results
- VIII Discussion
- IX Conclusions

I AIMS OF THE EXPERIMENT

The aims of this experiment were:

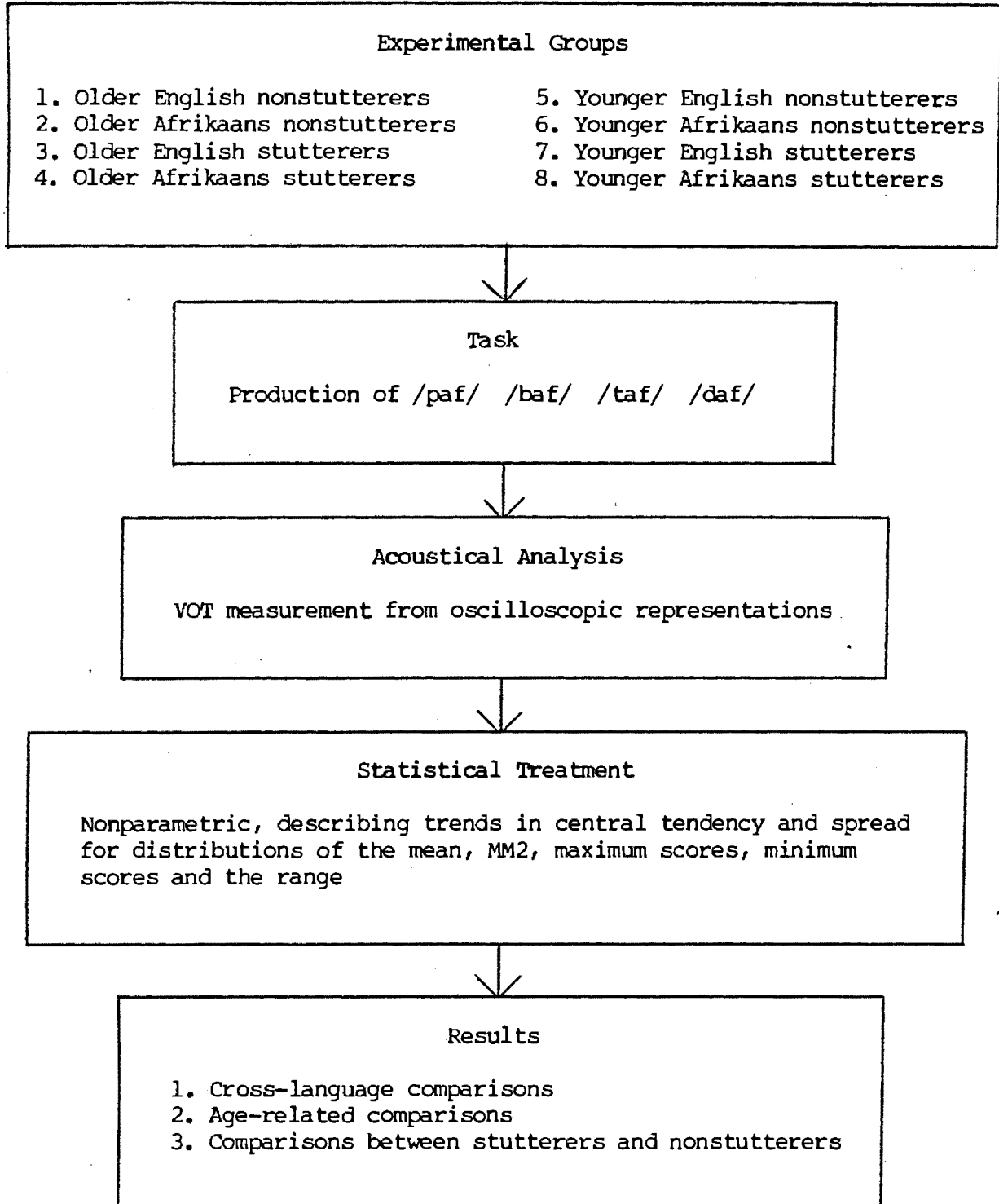
1. To establish normative trends for VOT production of syllable-initial singleton stop plosives in the nonstuttering English and Afrikaans groups (Experimental groups 1,2,5 and 6).
2. To determine whether or not there were differences between stuttering and nonstuttering children in terms of VOT production trends.
3. To investigate the age-related trends which may be present within each language group with regard to VOT production as well as to determine whether comparable age-related trends could be identified in the stuttering and nonstuttering groups.

It was hypothesized that English-speakers would use short- and long-lag VOTs to express voiced and voiceless stops respectively, the long-lag category being relatively poorly developed in younger subjects. Afrikaans-speakers were expected to use short-lag VOTs for both categories of stops. Stutterers were expected to show longer VOTs than were nonstutterers.

II OUTLINE OF THE EXPERIMENTAL DESIGN

A brief summary of the design for this experiment appears in Table V:

TABLE V Outline of research design for experiment one



III INSTRUMENTATION

The subjects' productions were recorded on Scotch 207 audio tapes using a Nagra reel-to-reel tape recorder (Model IV-L) and a Beyer microphone (M66). The Scotch 207 tape has a low signal-to-noise ratio and negligible tape stretching. The recording speed was 7.5 ips.

Storage oscilloscopic displays of the recorded material were obtained using an electronic memory (waveform recorder), Biomation Model 1015. The oscilloscope was a Tektronix Inc. Model 510 3 N. The time dimension display obtained from these instruments is generally regarded as accurate and reliable. The instruments were housed in an acoustics laboratory where they were maintained at an even temperature, thus reducing the risk of environmentally-produced instrument errors. Analysis of the acoustic waveform permits clear distinctions to be made between the speech burst, signifying release of stop closure and the quasiperiodic waveform characteristic of phonation (Shoup and Pfeifer 1976). This facilitates segmentation between sound features so that durational measures can be made with a high degree of accuracy.

IV MATERIAL

Four productions of each of the following CVC nonsense syllables was elicited from each subject:

/paf/ /baf/ /taf/ /daf/

Each monosyllable thus started with a singleton stop plosive representing voiced/voiceless contrasts at two places-of-articulation, viz. bilabial and alveolar. Velar stops were not investigated since Afrikaans does not use the stop plosive /g/. The CVC sound combinations selected are phonetically acceptable in both English and Afrikaans but were unlikely to have prior semantic significance for the subjects.

Isolated monosyllables were used in an attempt to eliminate variations in stress, since monosyllables must be stressed. The stress factor of a word has been shown to influence VOT (Lisker and Abramson 1967). Use of CVC syllables further facilitates accurate oscilloscopic measurement, as segmentation boundary points in such syllables are easier to identify than in vowel or consonant clusters.

V PROCEDURES FOR DATA COLLECTION

The subjects were individually tested at the Hearing and Speech Clinic, Tygerberg Hospital, Parowvallei. The audio recordings were made in an acoustic booth or in a sound-treated room with an ambient noise level of not more than 30 db SPL (A scale). Four of the subjects were tested in a similar sound-treated room at the University of the Witwatersrand, Johannesburg.

Two female experimenters interacted with the children. One was a native speaker of South African English, the other a native speaker of Afrikaans. Each subject was thus tested by an adult speaker of his/her home language. The English-speaking experimenter aspirated the syllable-initial singleton

stop plosives and used a high schwa vowel, eg. /p^h3f/. The Afrikaans experimenter, in keeping with the requirements of her language, used unaspirated initial plosives with a low schwa vowel, eg. /pəf/.

The experimenter and subject were seated side-by-side at a table of appropriate height for the subject. A chart with pictures illustrating the story to be read was placed in front of them. The tape recorder was placed unobtrusively but the microphone was positioned in front of the subject, who was aware that a recording was being made. Following a similar procedure to that of Hawkins (1973), the experimenter read short picture-stories containing the stimulus syllables. At certain points in the stories, the subject was asked a simple question relating to the story content and which elicited the production of one of the experimental syllables. In the present study, two sets of pictures and story content were employed, one for younger and one for older subjects. The syllables elicited were the same for each group however. Equivalent forms of each story were used for English and Afrikaans subjects (See Fig. 1 in the Appendix).

Prior to presentation of the stories containing the experimental syllables, each subject was given a practice trial with a non-experimental syllable, to ensure that he understood the task. The unfamiliar experimental syllables were then produced for the child to hear when the experimental stories were introduced and he was asked to repeat them once. The stories were then read to him. The questions pertaining to the experimental syllables were phrased in such a way as to elicit isolated productions from the subject rather than phrases or sentences. The requirement of a one-word production also enhanced the chances of fluent productions in the case of the stuttering subjects. Four nonconsecutive productions of each syllable were elicited at various points in each story. This had the advantage of preventing a rhythmic response and of ensuring that any one response did not influence its predecessor or successor by means of coarticulatory effects. Occasionally, a subject failed to respond to a question, in which case a direct imitation of the syllable was obtained, however these occurrences were too few in number to significantly influence the results. In addition, VOT production values for imitated and spontaneous productions have been reported to be comparable (Elman 1976).

The first three successful isolated productions of the four attempts at each syllable were selected for analysis. Unsuccessful productions, which were discarded, included those that were stuttered, whispered, were contained in phrases, or which coincided with significant ambient noise.

An uncontrolled factor was individual articulation rate which may have varied amongst subjects. This was not a serious consideration, though, since amongst adult subjects, at any rate, tempo only influences segmental duration by 0.5 - 1.0% per second during the first twenty repetitions of the same material (Allen 1978).

The knowledge that their speech was being recorded may have affected the naturalness of the subjects' productions. However it seemed as if the children became involved in the stories and to some extent distracted from the artificiality of the situation, since many of them made spontaneous comments regarding the story content.

VI DATA ANALYSIS

A Preparation of the audio tapes for analysis

The first three clear, isolated samples of each of the four experimental syllables uttered by each subject was edited out of context to form separate tapes. Each syllable was spliced inbetween 5-second strips of timed leader tape, so as to facilitate the capture of the images osciloscopically. There were 1,440 syllables available for analysis. However, on osciloscopic analysis, 72 productions were excluded since they were too low in intensity to show up on the display with the available instrumentation, or were masked by ambient noise which had not been detected at the time of tape-editing. Thus, 1368 productions were finally analyzed and taken into account in the results.

The subjects' recordings were arranged at random on the edited tapes so that the judges who rated them were given no information regarding the age, language or state of fluency of the speakers.

B Judges

A sample of 139 tokens was analyzed by two judges, one being the experimenter. A short training session was held to familiarize Judge 2 with the task and segmentation criteria. Both judges were qualified speech pathologists with training in acoustic phonetics.

For the purposes of judging, the experimental tokens were captured one at a time on osciloscopic display. The judges took it in turns to sit directly in front of the display and independent VOT measures were made and written down. No information was exchanged between the judges during the judging session. The display was read from directly in front so as to minimize observational errors.

Interjudge agreement was high, although observations for /taf/ were less close than for the other syllables (see Figs.2a to 2d). With such close agreement, it was felt that it was not necessary to use a second judge for the remaining observations.

C Judgment Criteria

Segmentation of the continuous osciloscopic recording necessitated a degree of subjective decision-making regarding the location of changes in the waveform signifying important events in the articulatory process. Shoup and Pfeifer (1976) note, however, that the initiation and termination of voicing is a relatively unambiguous cue on osciloscopic displays.

The segmental boundaries of interest in this experiment occurred where the burst of the syllable-initial stop plosive changed to the onset of voicing for the following vowel. Vocal fold vibrations are reflected in the quasiperiodic waveform (Shoup and Pfeifer 1976).

The closure phase of most voiced and voiceless stop plosives was seen on osciloscopic display as 'quiescent' waves, ie. waves of zero or near-zero amplitude. In the present study, the onset of voicing was taken to be that

point at which quasiperiodic waves were first observed following release of the stop plosive. The durational measures of interest were:

Long-Lag VOT. The release of voiceless stop plosives was seen as a burst of random waves. This was followed in some cases by a short transitional period of quasirandom activity as the vocal folds approximated for the onset of the vowel. A long-lag VOT is illustrated in the oscillograph in Fig.3.

Short-Lag VOT. The burst was absent following voiced stop plosive release and the VOT was shorter as is illustrated oscillographically in Fig.4.

Voicing lead (prevoicing). The waveform in voicing lead, indicating the presence of voicing during the closure phase of some voiced stops was easily distinguished from the quasiperiodic waveform of the vowel (Fig.5).

Note that the time scales in Figs.3 to 5 are not comparable.

VII RESULTS

Since each experimental group comprised only 15 subjects, descriptive nonparametric statistics were applied. Each individual provided three scores of each syllable. It was decided not to summarize the information contained in these three productions in one mean, but to utilize the statistical variation contained therein. By doing this, new variables were created such as the range of the three scores, the mean of the three scores, etc. A detailed rationale for the choice of statistical procedures is contained in the Appendix.

Summary distributions of the mean, MM2, minimum and maximum scores as well as the range of VOT scores for the eight experimental groups are illustrated in multiple box plots (Figs.6a to 6e). In a few instances extreme outlying values were scaled down, however this had no effect on the boxes themselves. Unless otherwise indicated, further comment on the distributions refers only to the interquartile distance, ie. $Q(.75) - Q(.25)$ portrayed by the tops and bottoms of the rectangles. The median was chosen as the appropriate measure of central tendency for the purpose of describing the results and is indicated on the box plots by asterisks linked by a horizontal dashed line. The interquartile distance was selected as the appropriate measure of spread since it is more stable than the range. The range of each individual was plotted against the MM2 of that individual in Figs.7a to 7d and each group was depicted by a different numerical value. From these figures a clear heteroschedastic pattern could be seen. In some instances particular groups clustered in certain positions in the plots.

MM2 was obtained by summing the maximum and minimum VOT scores for each subject and dividing by 2. In those few instances where MM2 differed from the mean, the former was selected as the preferred measure, since it is slightly more sensitive to outlying values.

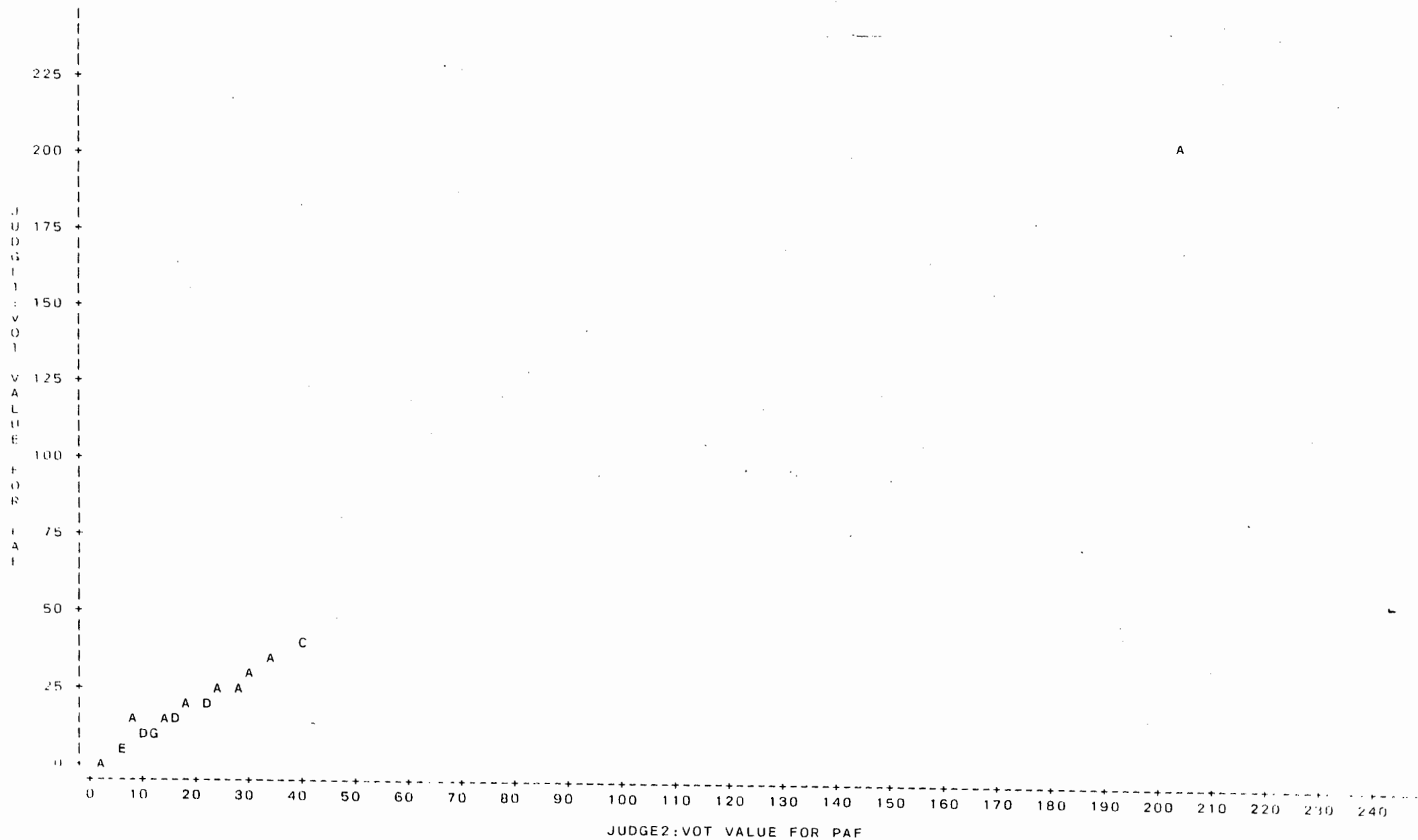


Fig. 2a Plot showing interjudge agreement for /paf/

Key: A = 1 observation, B = 2 observations, C = 3 observations etc

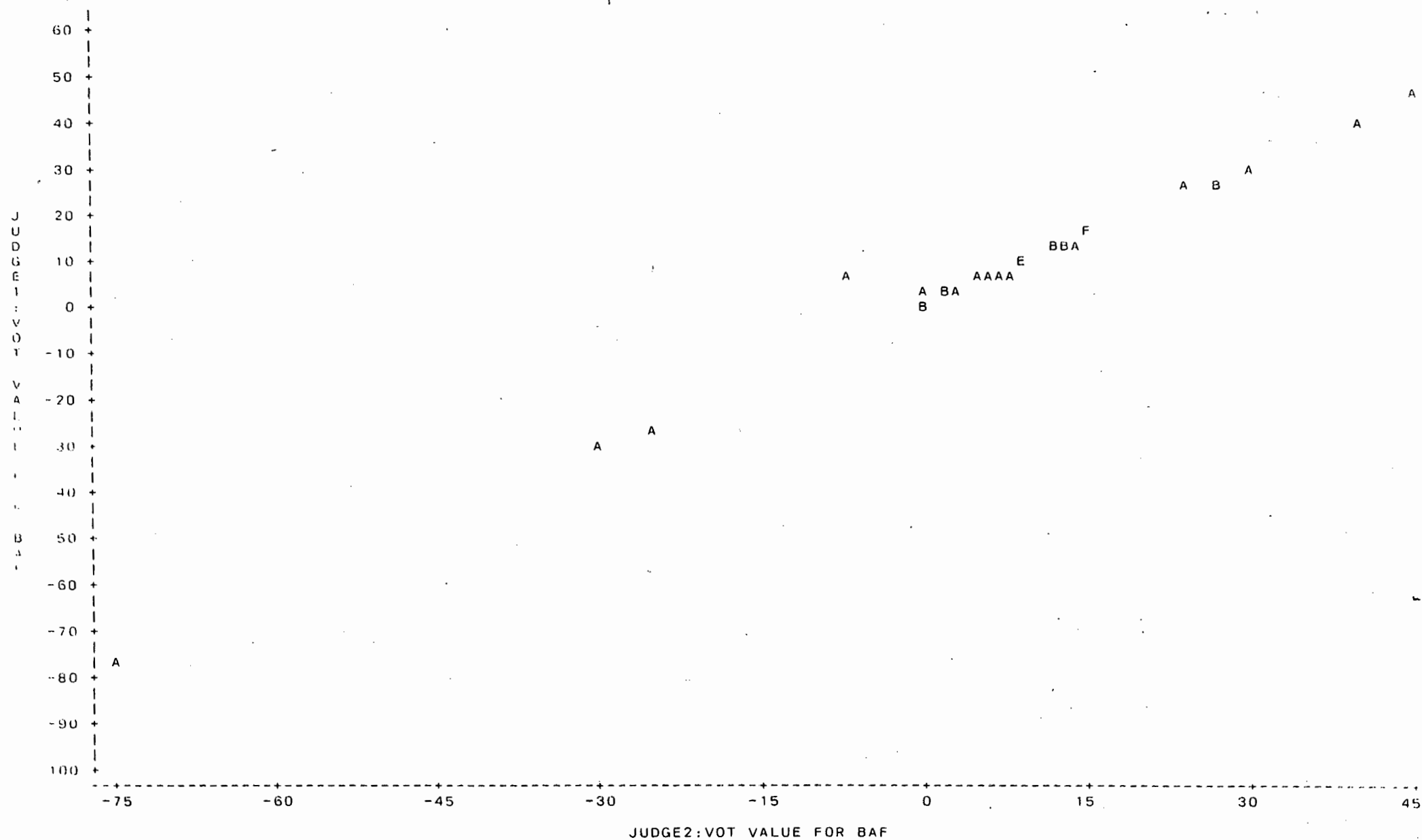


Fig. 2b Plot showing interjudge agreement of /baf/

Key: A = 1 observation, B = 2 observations, C = 3 observations, etc.

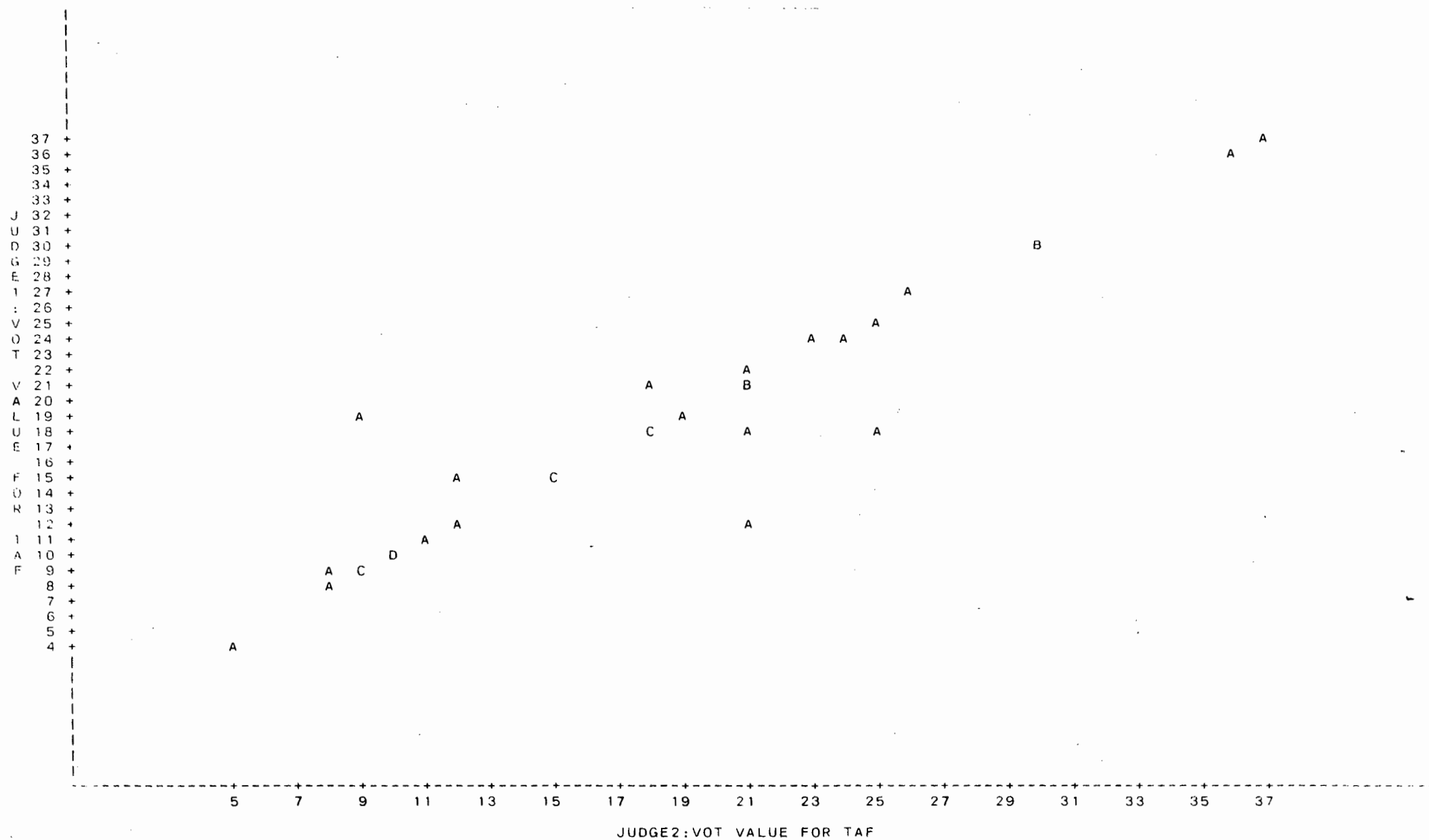


Fig. 2c Plot showing interjudge agreement for /taf/

Key: A = 1 observation, B = 2 observations, C = 3 observations, etc

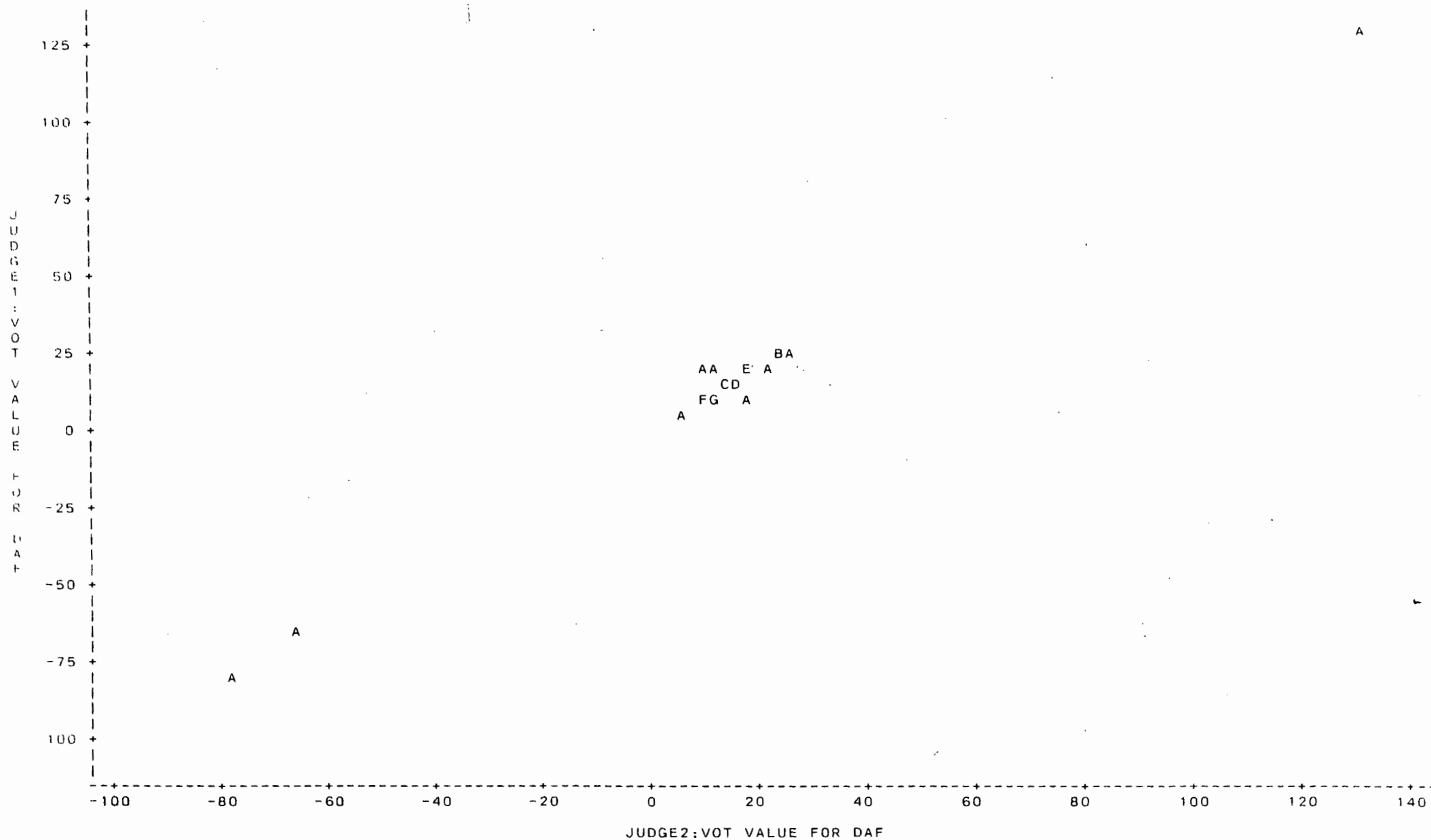


Fig. 2d Plot showing interjudge agreement for /daf/

Key: A = 1 observation, B = 2 observations, C = 3 observations, etc.

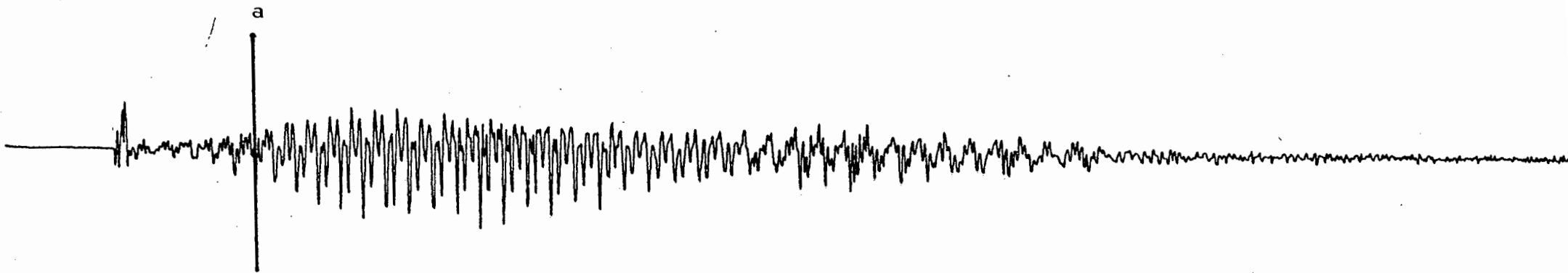


Fig. 3 Production of /paf/ by an English-speaker (Subject 109) illustrating a long-lag VOT (+52 msec). The initial brief plosive burst is followed by a transitional period of quasirandom activity prior to onset of quasiperiodic vowel activity, signified by line a. Since the segmentation boundary was a little ambiguous in this instance, with no clear boundary point, the cut-off was made at a midpoint in the boundary area, as recommended by Shoup and Pfeifer (1976).

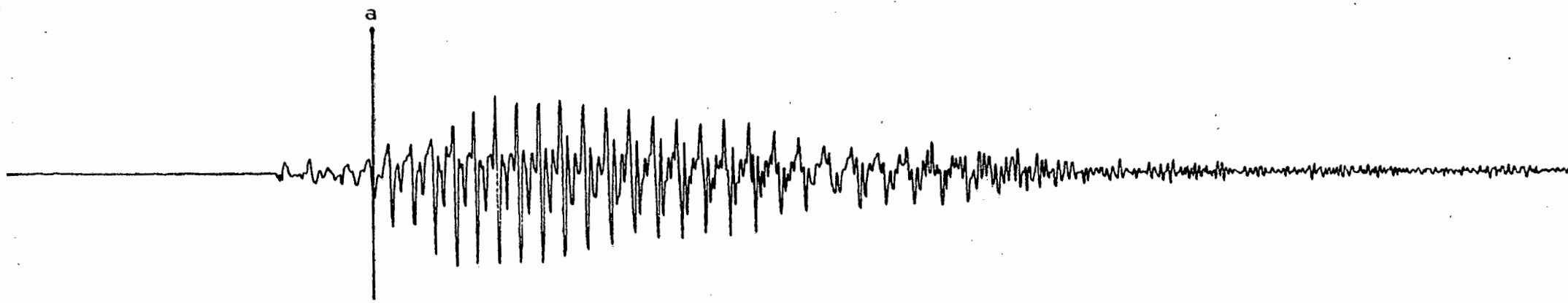


Fig. 4 Production of /paf/ by an Afrikaans-speaker (Subject 119) illustrating short-lag VOT (+ 15 msec). Note the absence of aspiration prior to the quasirandom activity of the transition period. Line a indicates the onset of the quasiperiodic vowel waveform.

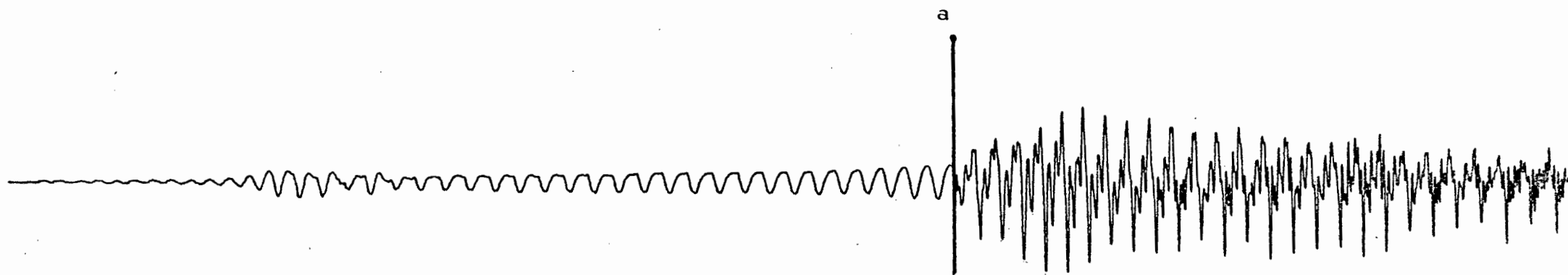


Fig. 5 Production of the first portion of /baf/ by an Afrikaans-speaker (Subject 119) showing voicing lead (- 132 msec) prior to abrupt onset of quasiperiodic activity signalling the vowel. The segmental boundary is indicated by line a.

Experimental Groups

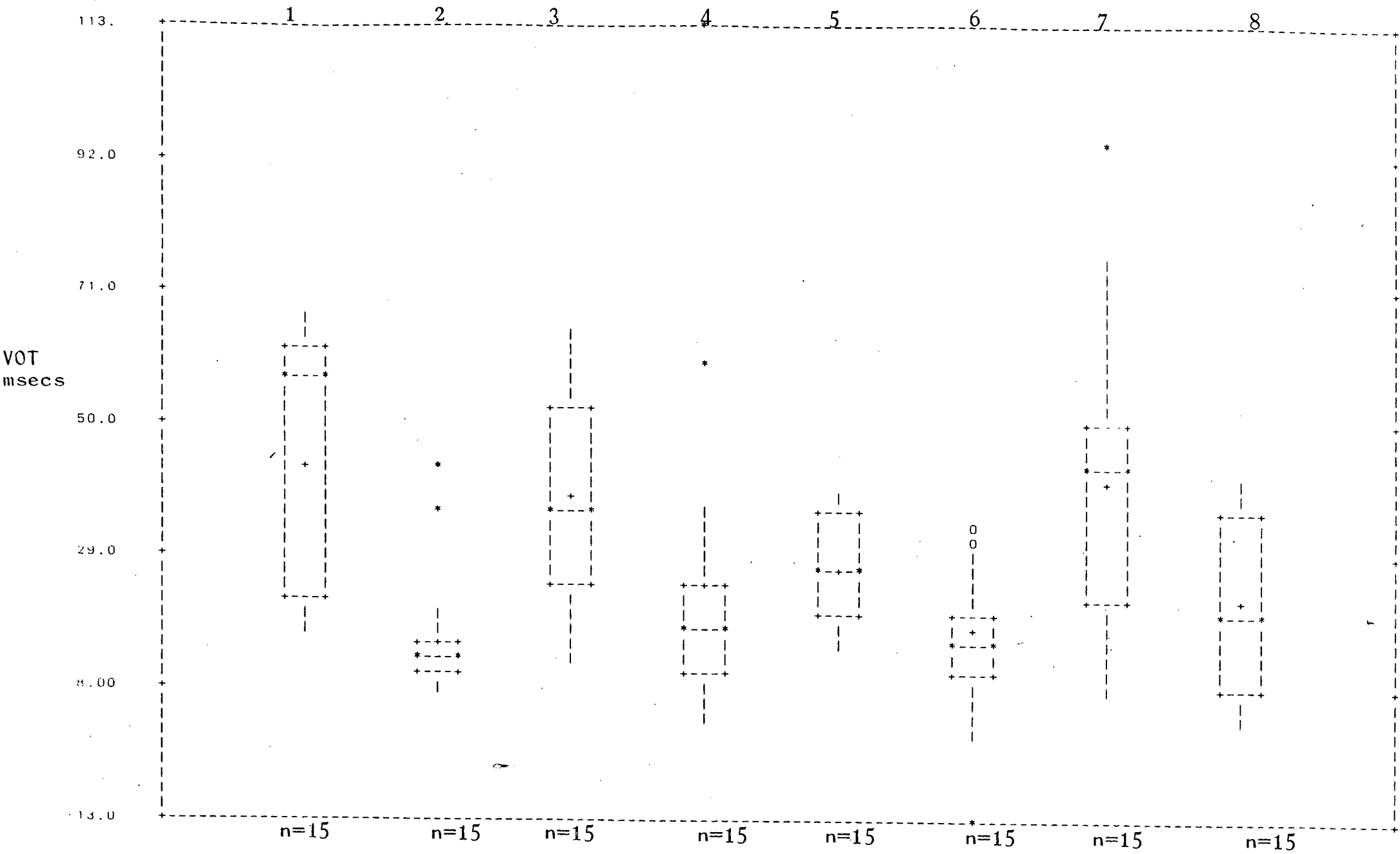


Fig. 6a(i) Multiple box plots illustrating distributions of mean VOT scores for /paf/

Experimental Groups

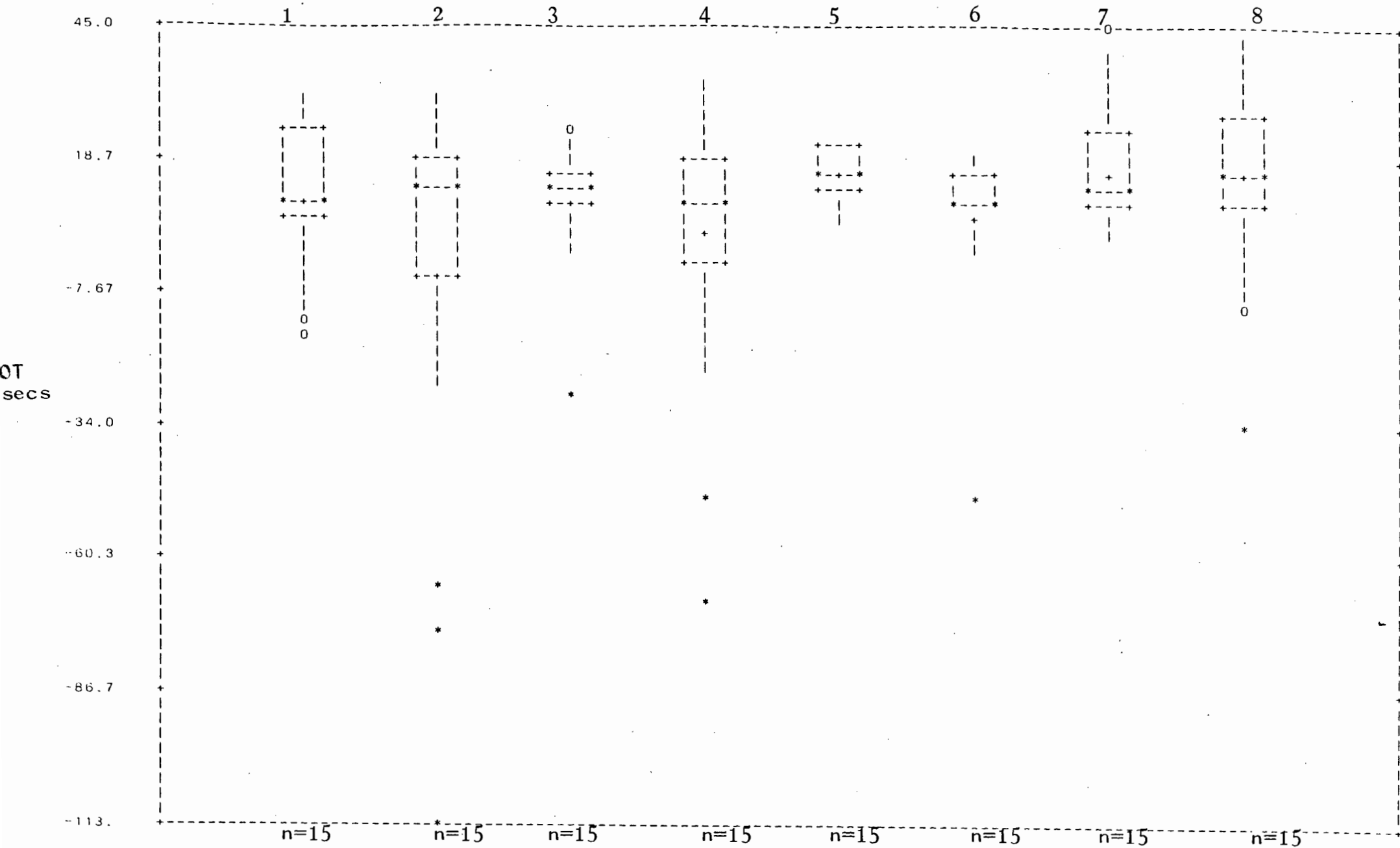


Fig. 6a(ii) Multiple boxs plots illustrating distributions of mean VOT scores for /baf/

Experimental Groups

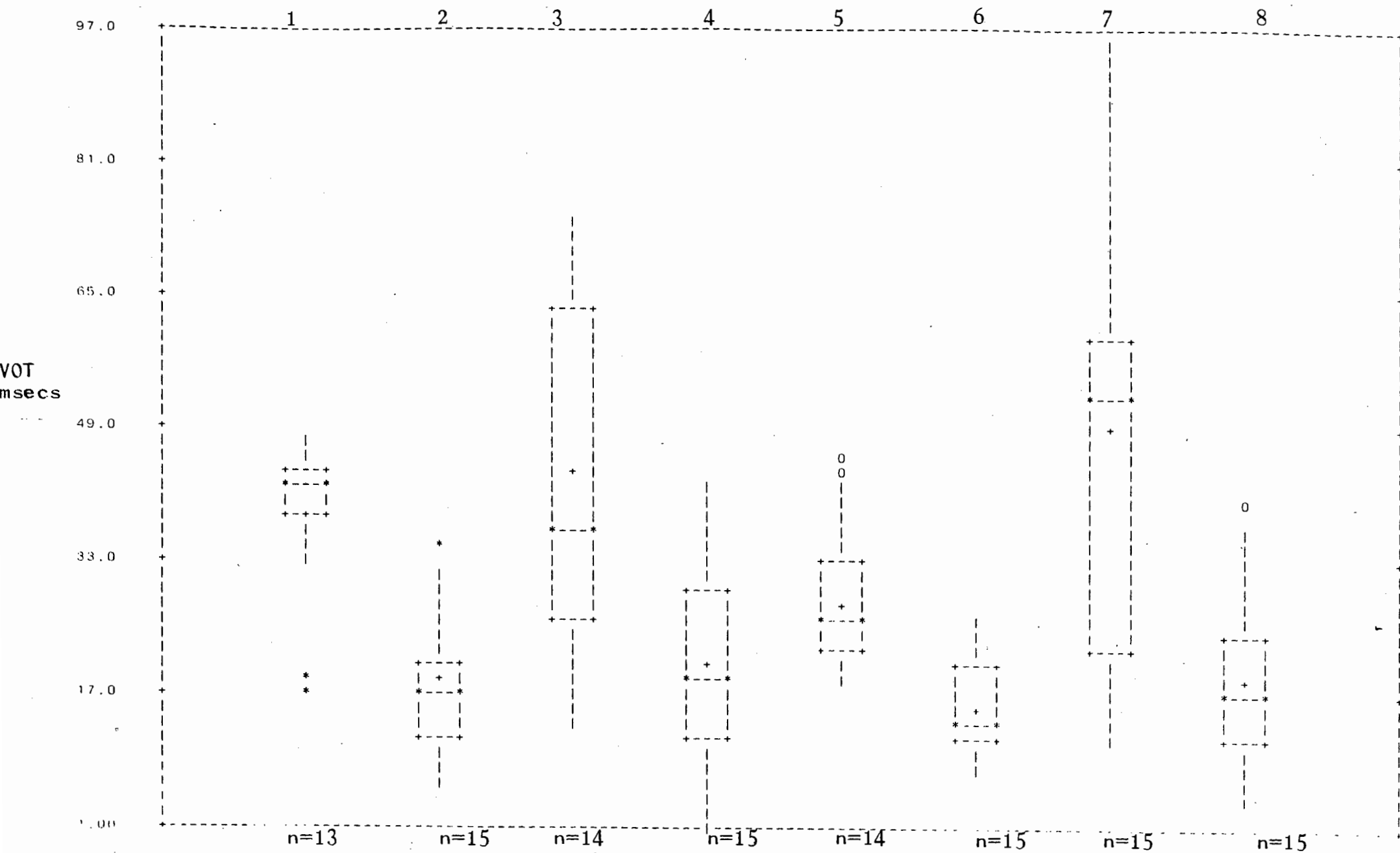


Fig. 6a(iii) Multiple box plots illustrating distributions of mean VOT scores for /taf/

Experimental Groups

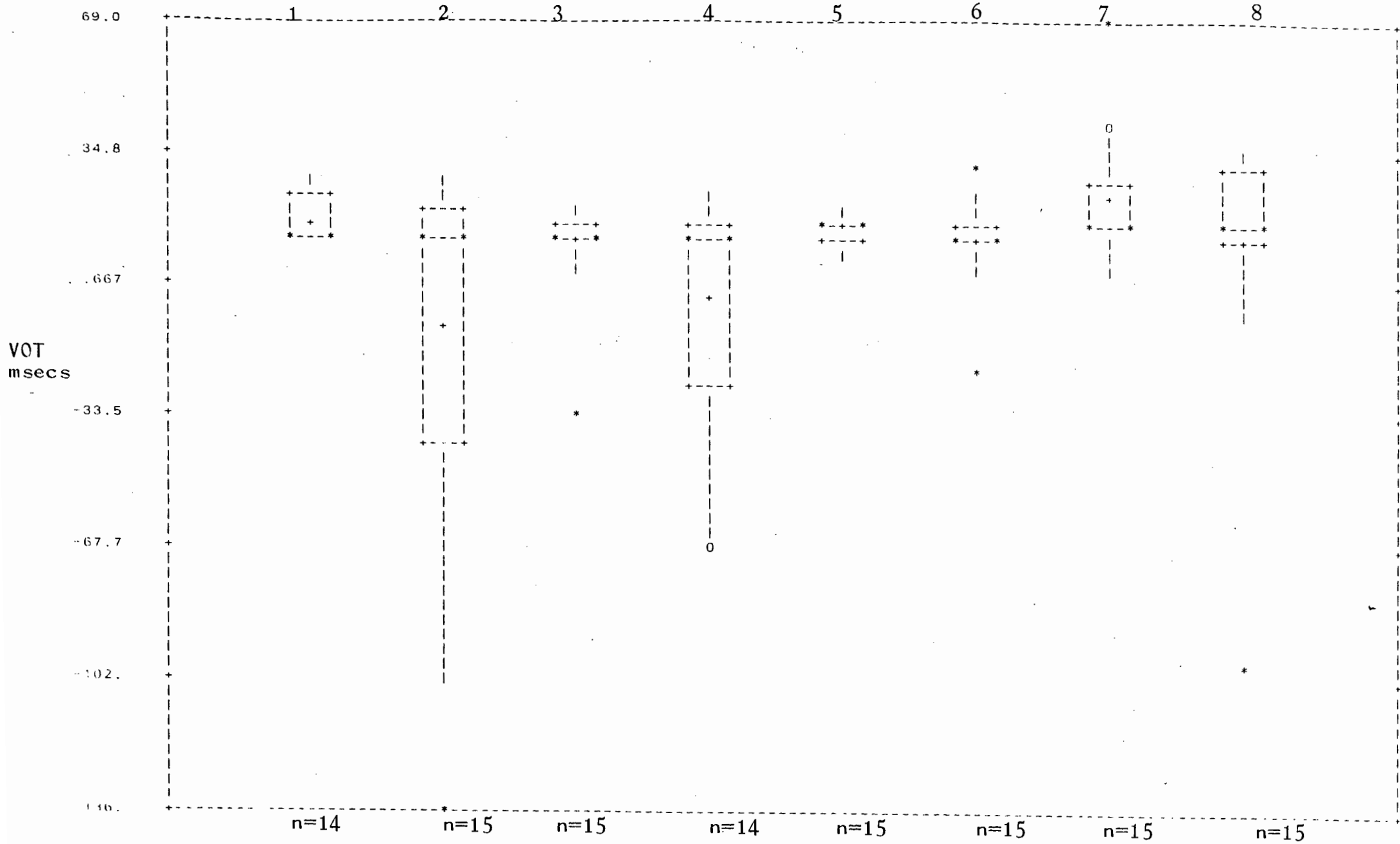


Fig. 6a(iv) Multiple box plots illustrating distributions of mean VOT scores for /daf/

Experimental Groups

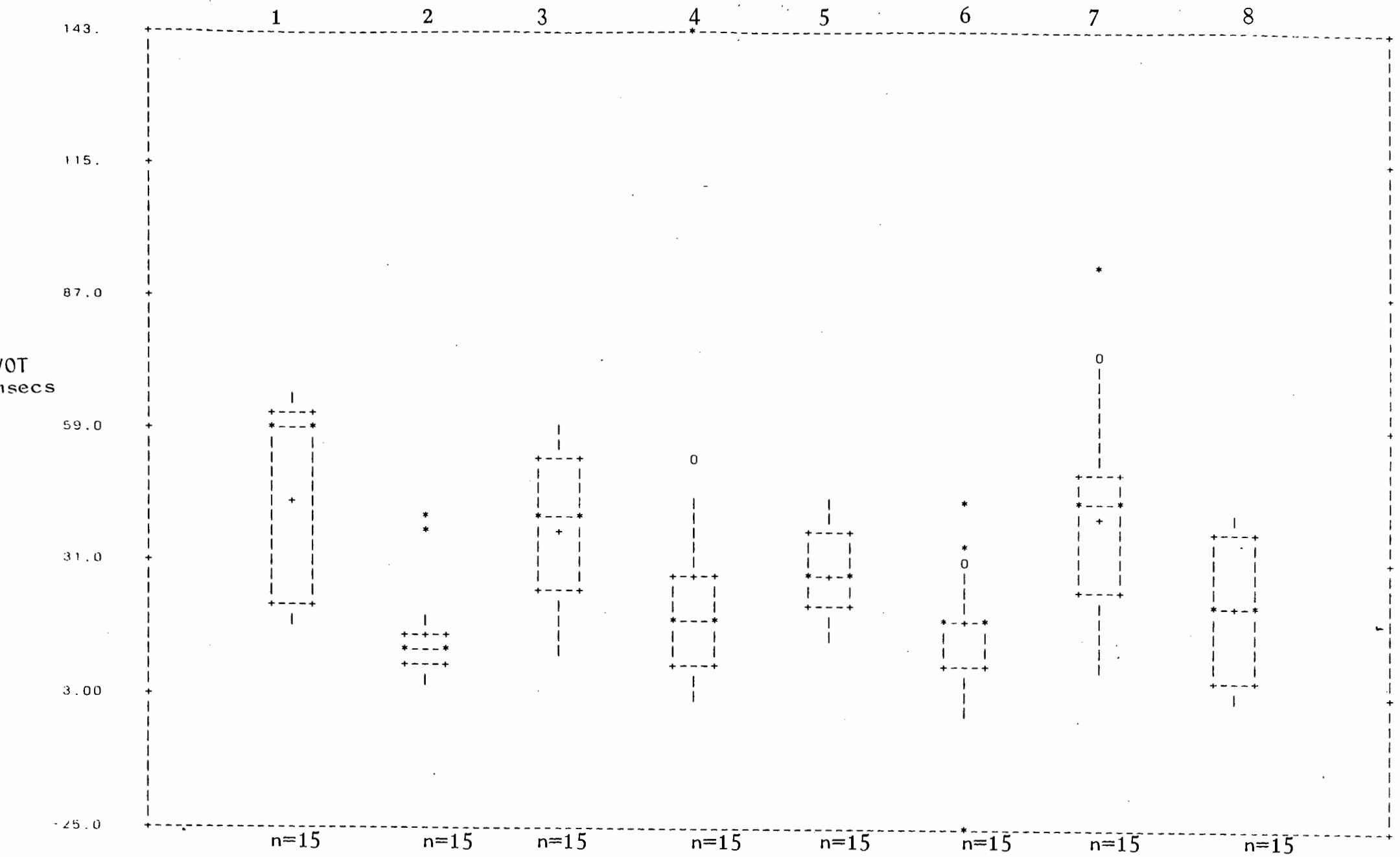


Fig. 6b(i) Multiple box plots illustrating distributions of MM2 VOT scores for /paf/

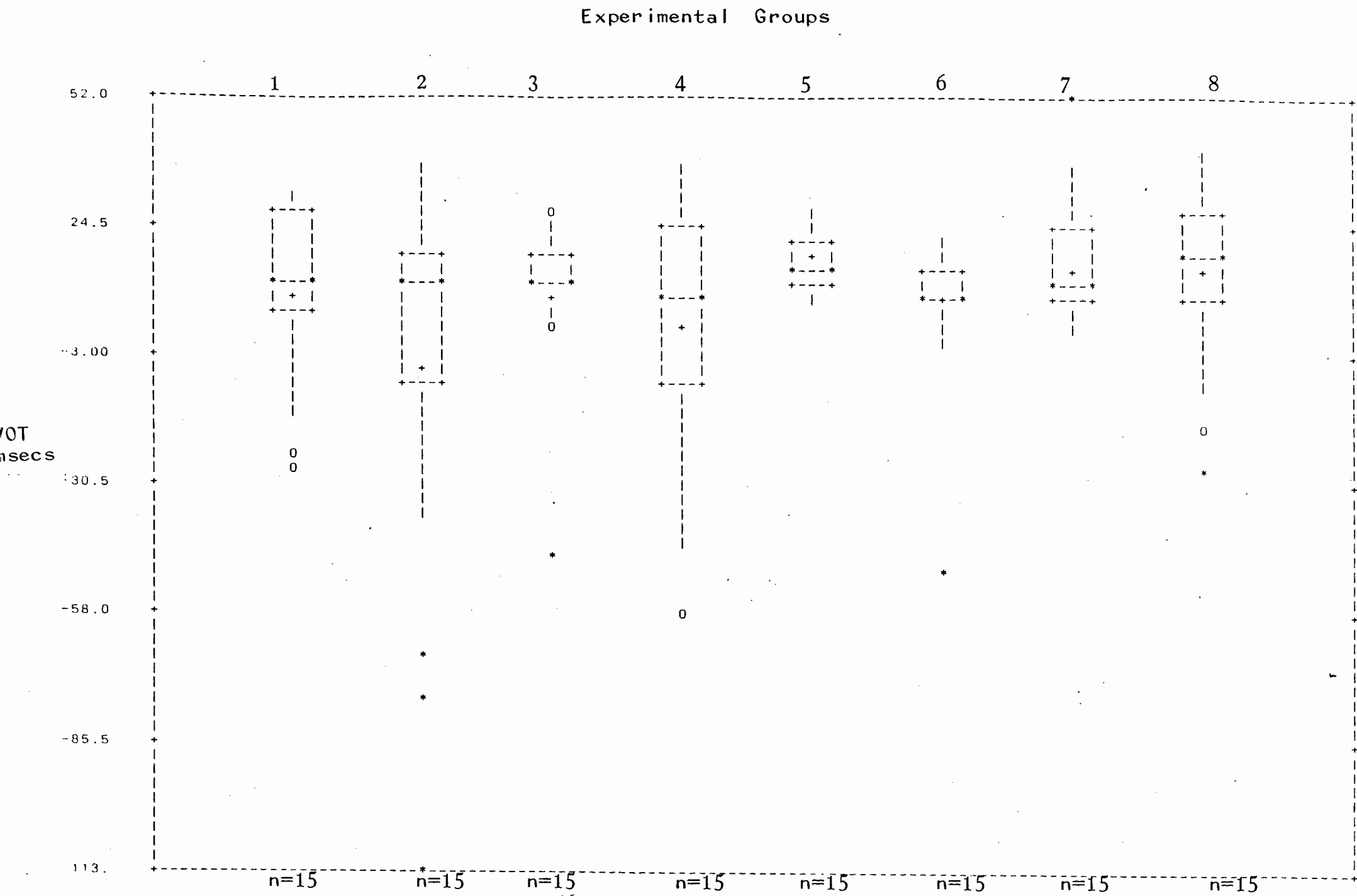


Fig. 6b(ii) Multiple box plots illustrating distributions of MM2 VOT scores for /baf/

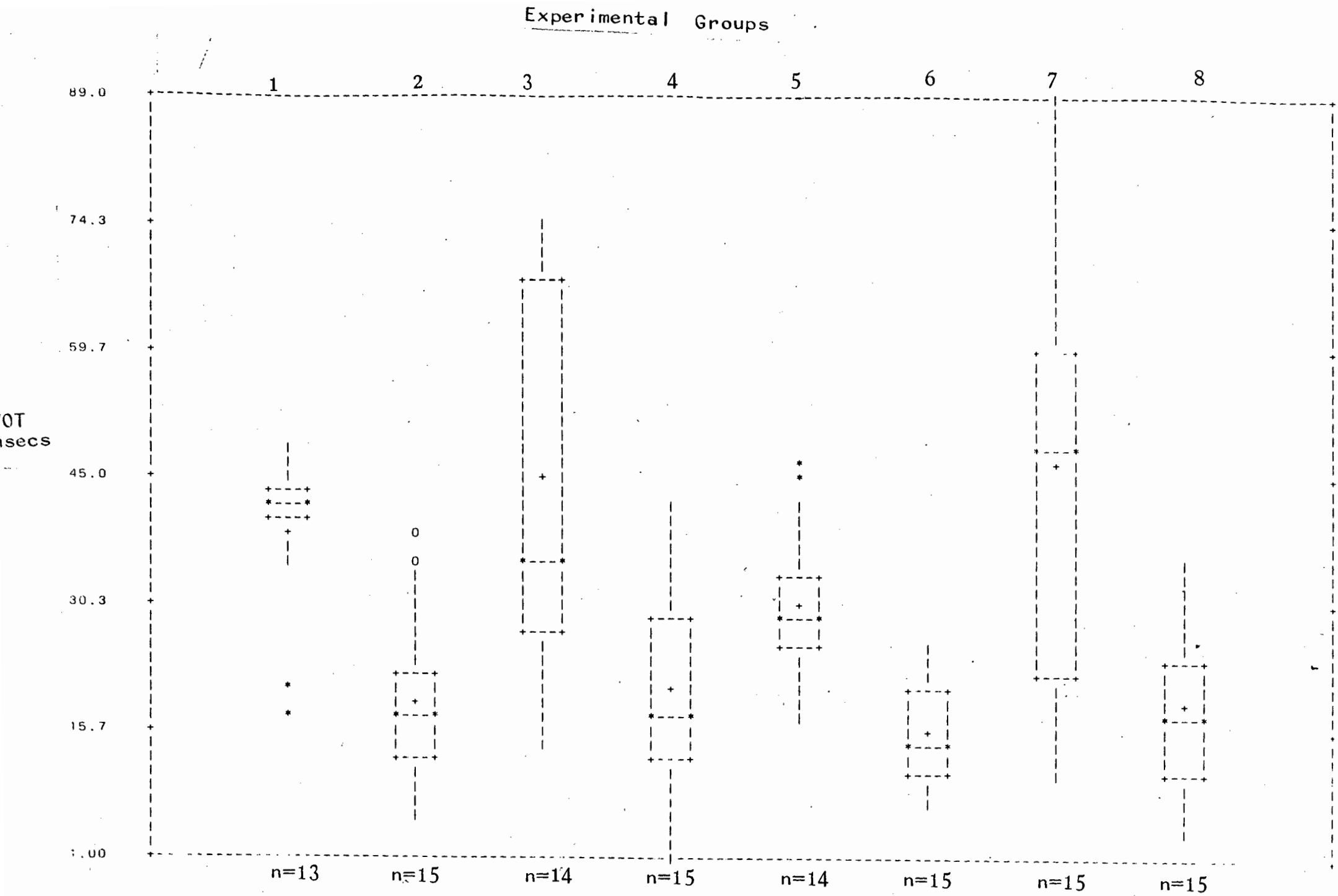


Fig. 6b(iii) Multiple box plots illustrating distributions of MM2 VOT scores for /taf/

Experimental Groups

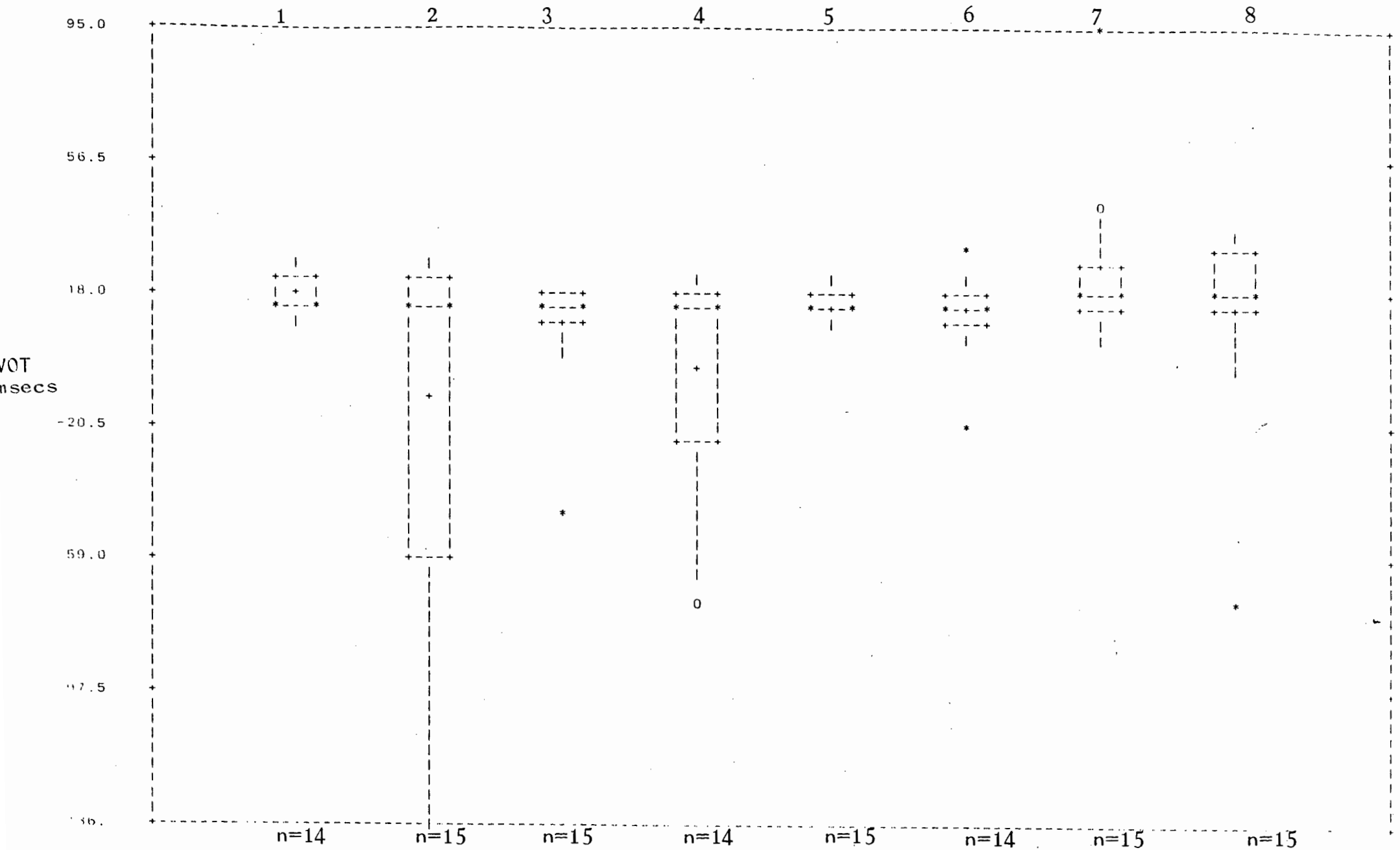


Fig. 6b(iv) Multiple box plots illustrating distributions of MM2 VOT scores for /daf/

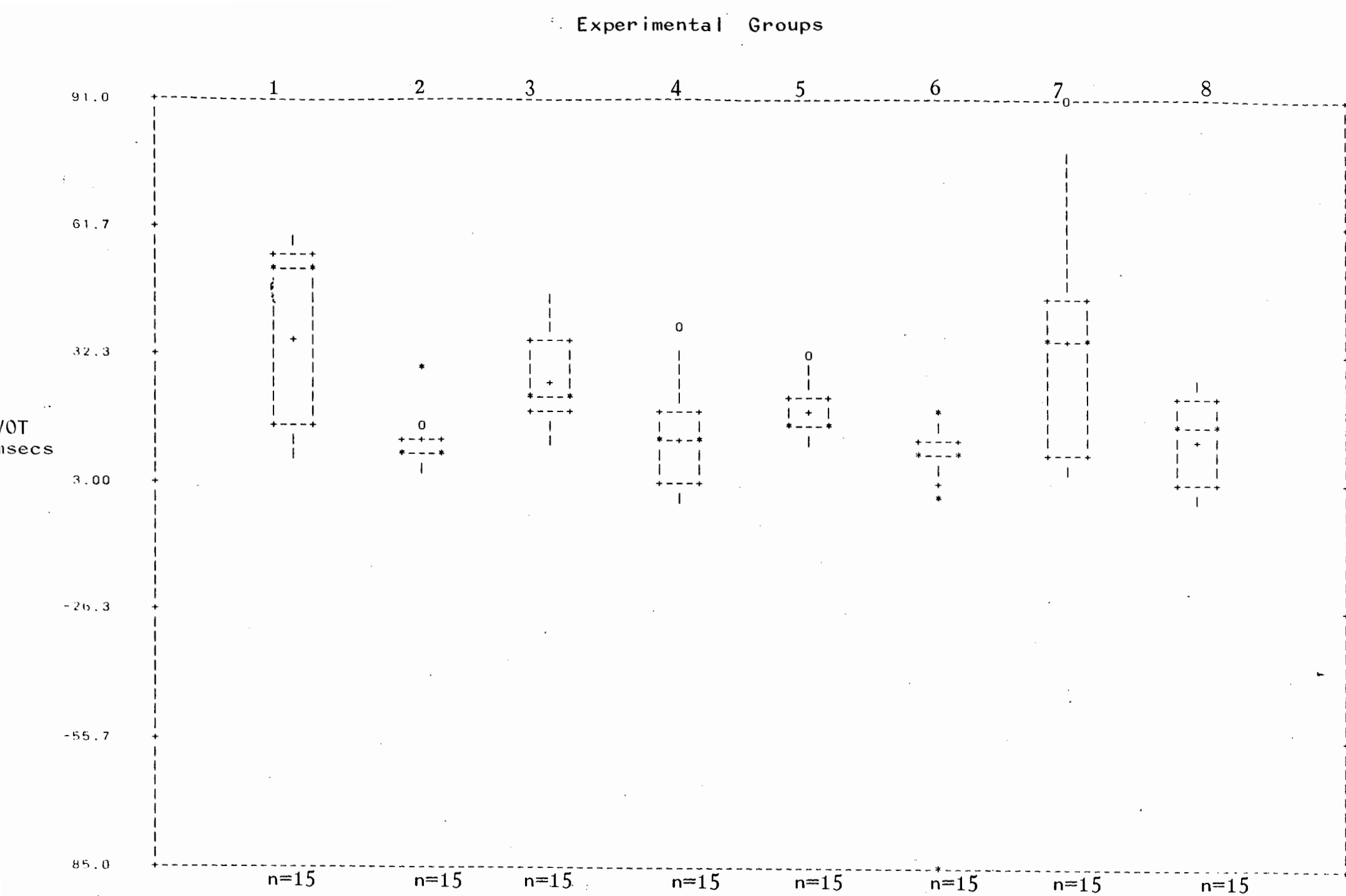


Fig. 6c(i) Multiple box plots illustrating distributions of minimum VOT scores for /paf/

Experimental Groups

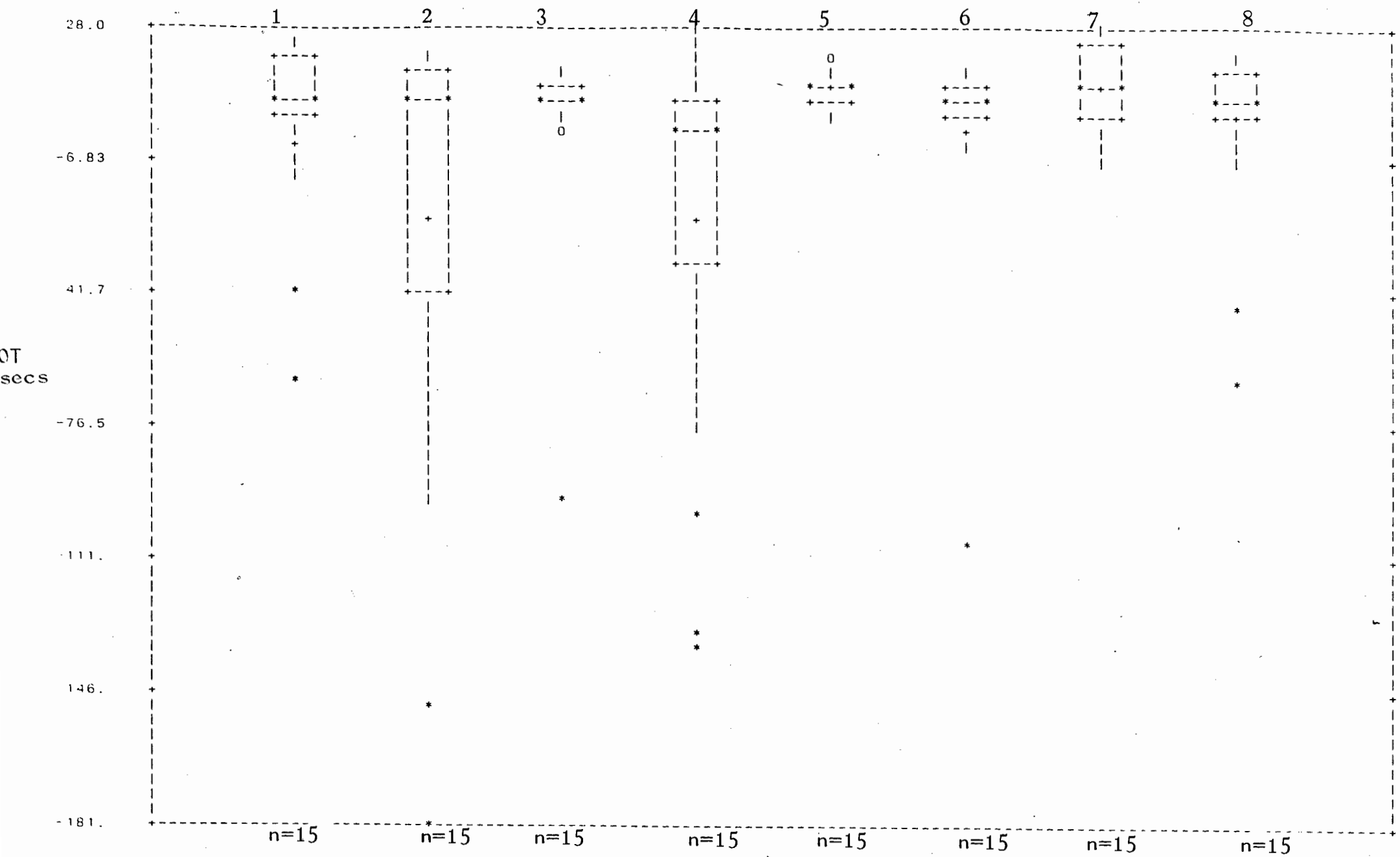


Fig. 6c(ii) Multiple box plots illustrating distributions of minimum VOT scores for /baf/

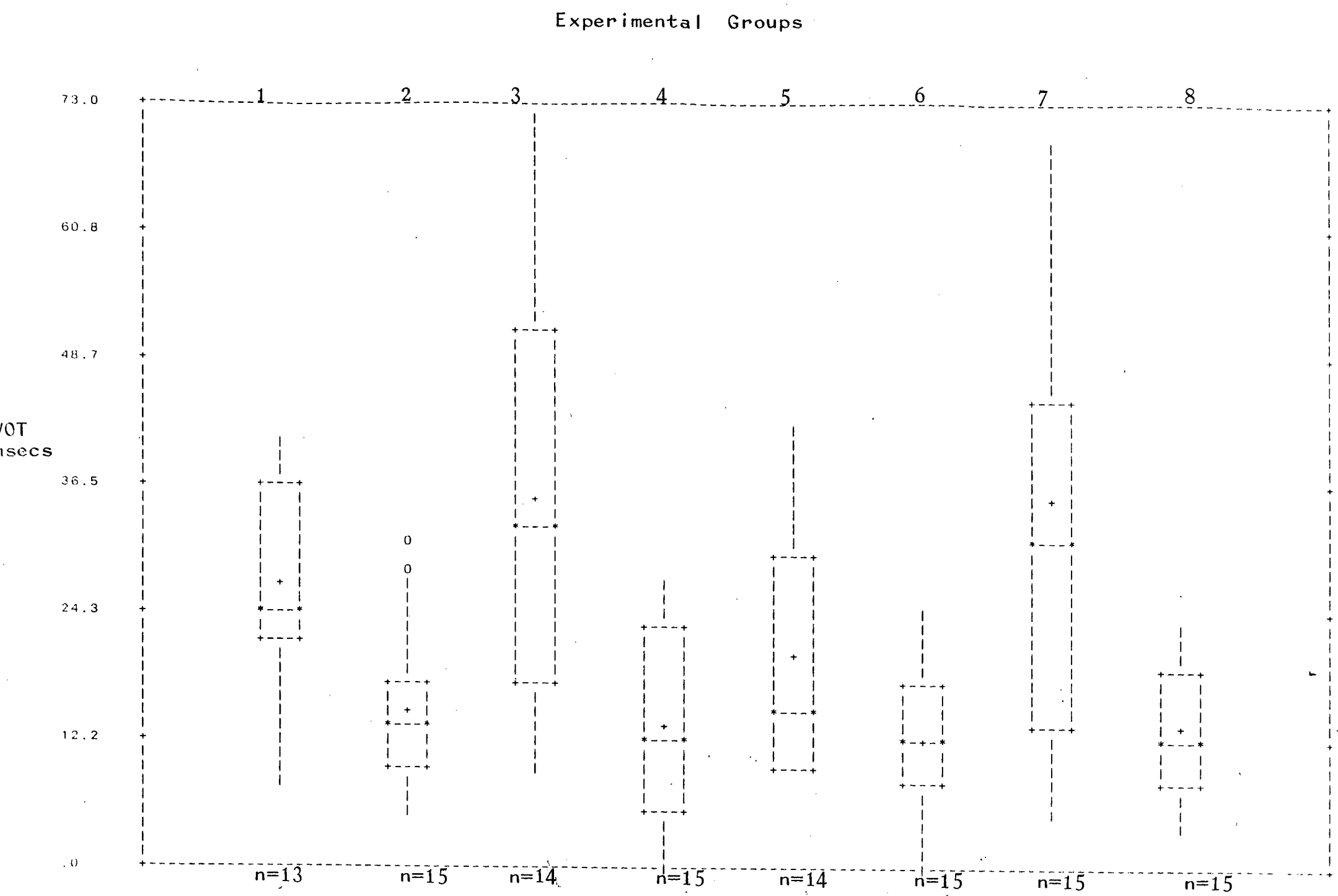


Fig. 6c(iii) Multiple box plots illustrating distributions of minimum VOT scores for /taf/

Experimental Groups

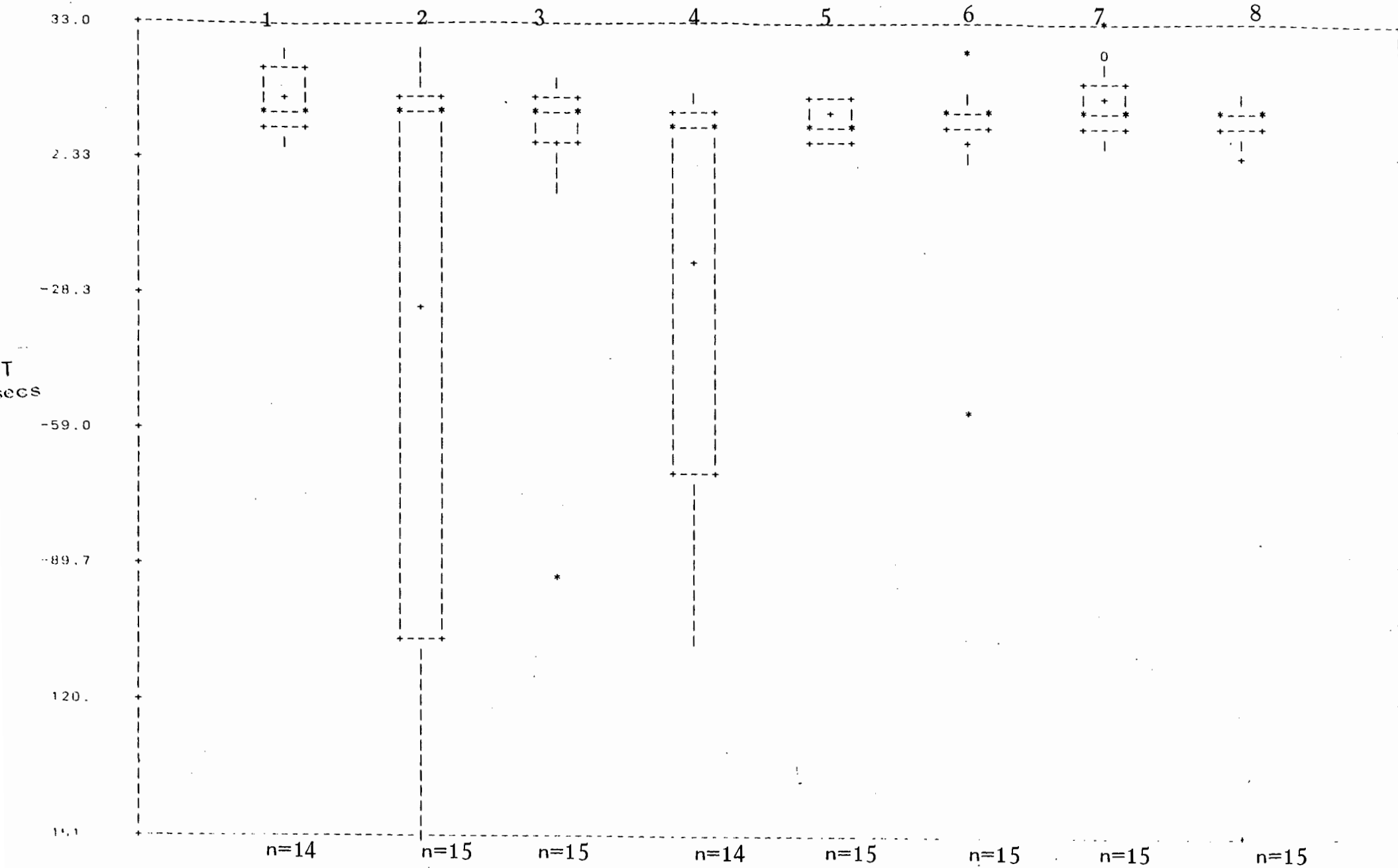


Fig. 6c(iv) Multiple box plots illustrating distributions of minimum VOT scores for /daf/

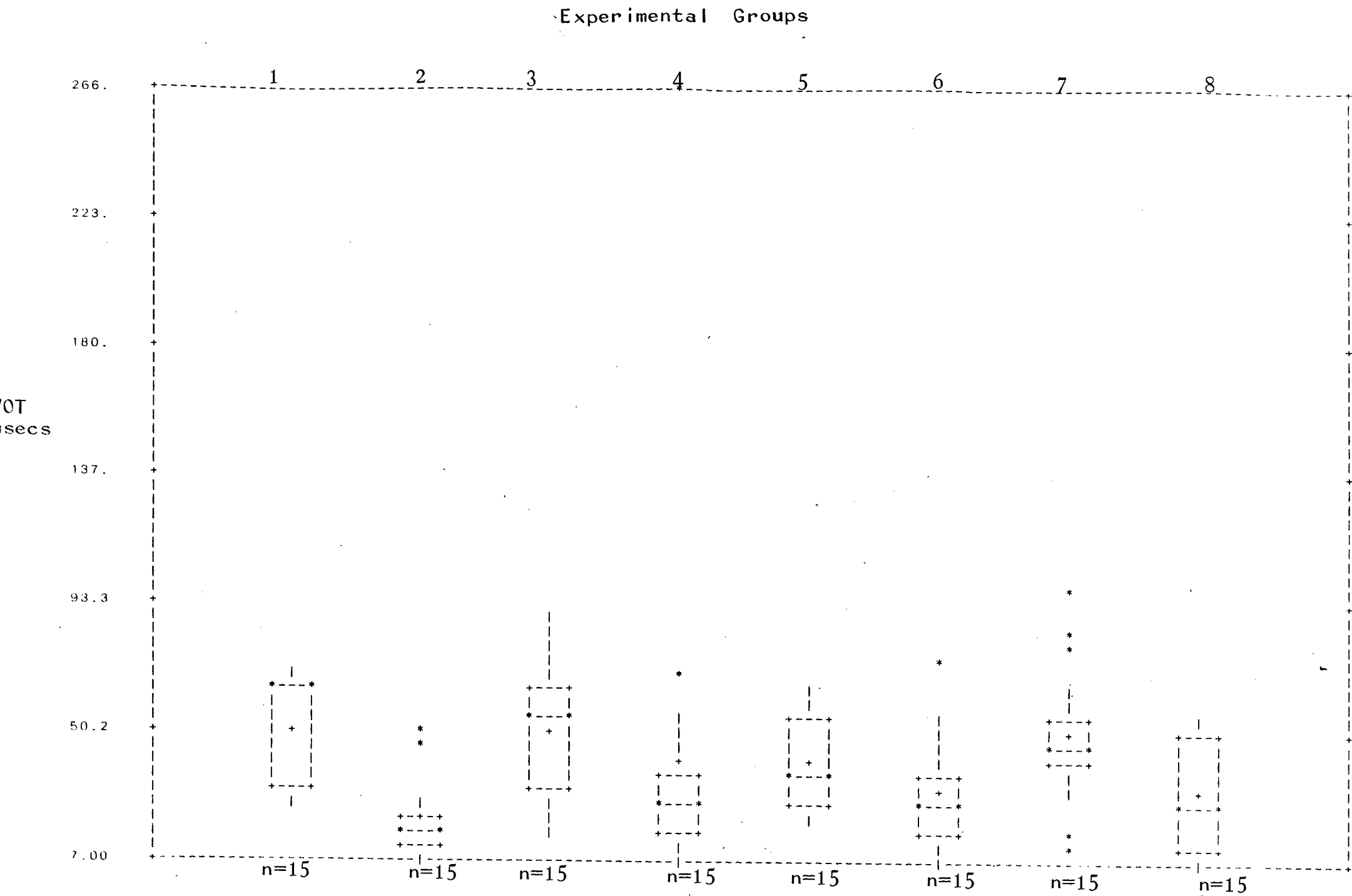


Fig. 6d(i) Multiple box plots illustrating distributions of maximum VOT scores for /paf/

Experimental Groups

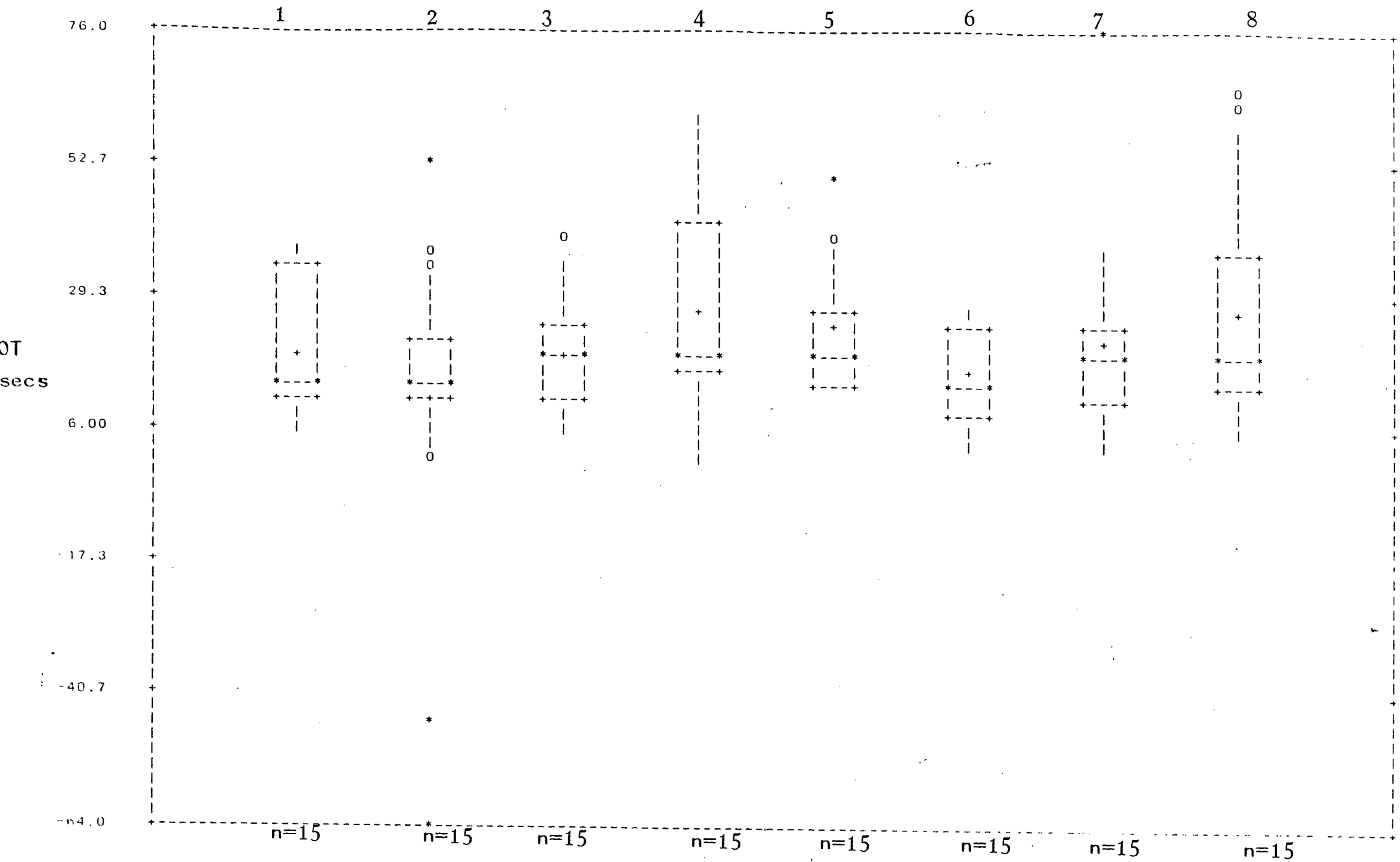


Fig. 6d(ii) Multiple box plots illustrating distributions of maximum VOT scores for /baf/

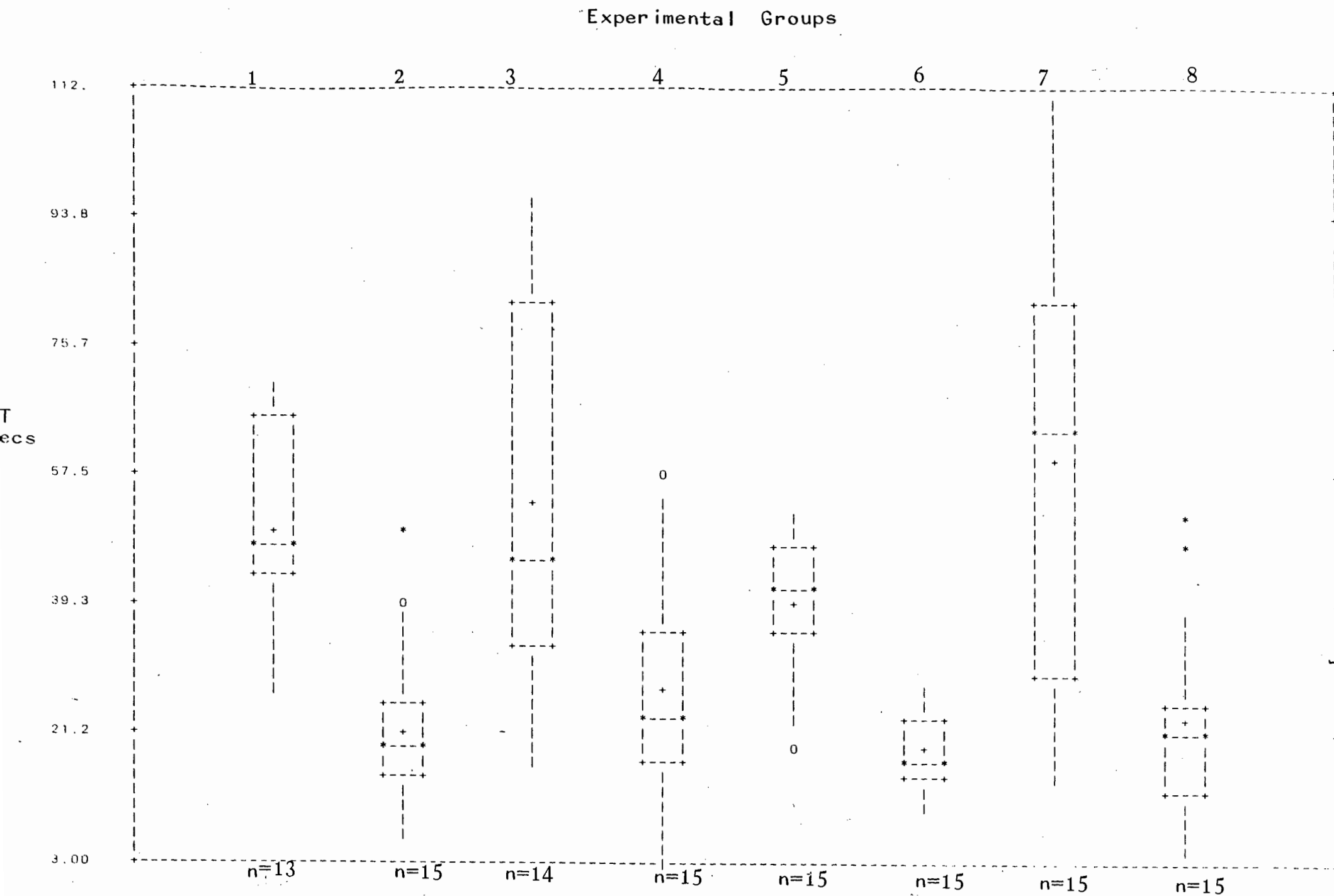


Fig. 6d(iii) Multiple box plots illustrating distributions of maximum VOT scores for /taf/

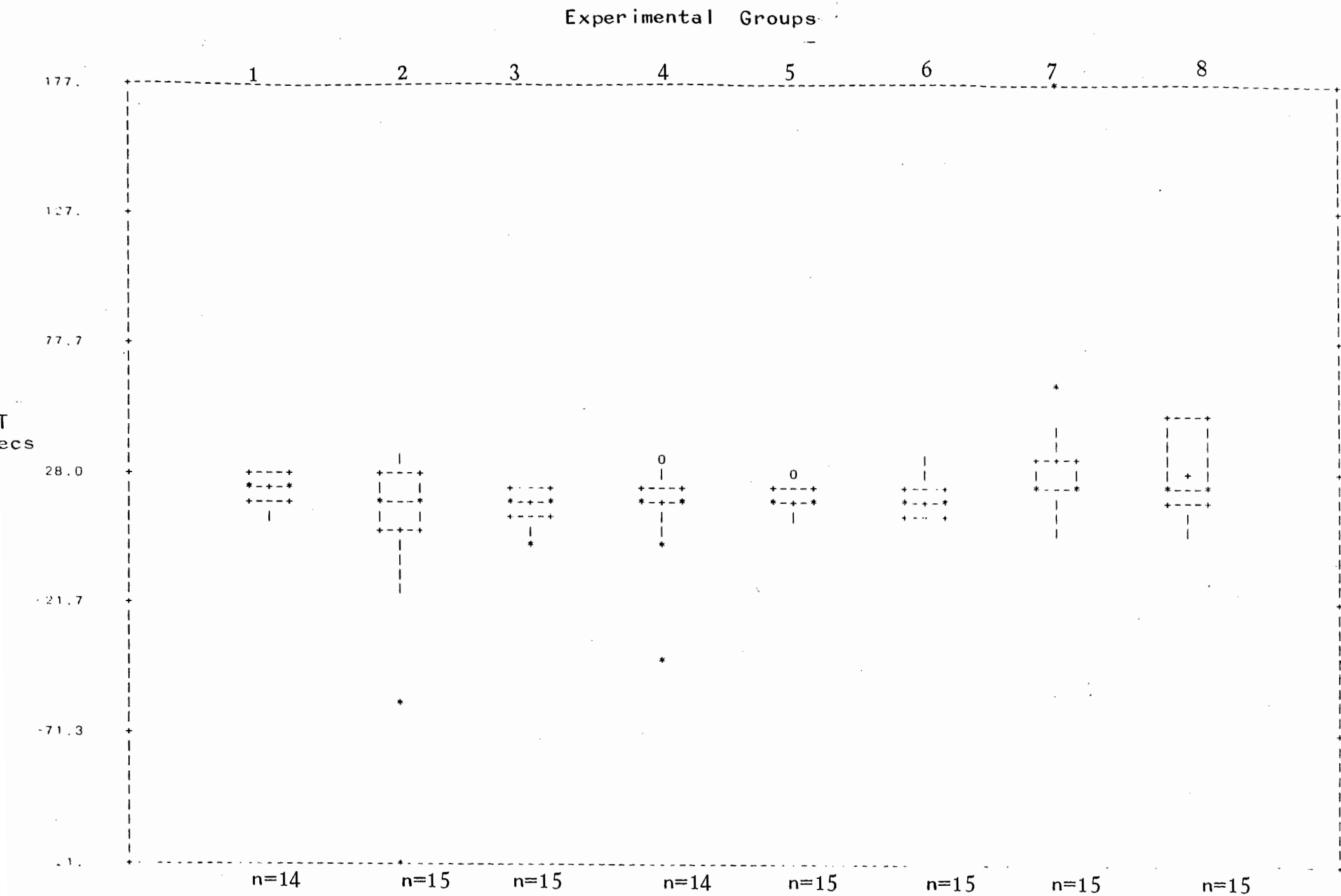


Fig. 6d(iv) Multiple box plots illustrating distributions of maximum VOT scores for /daf/

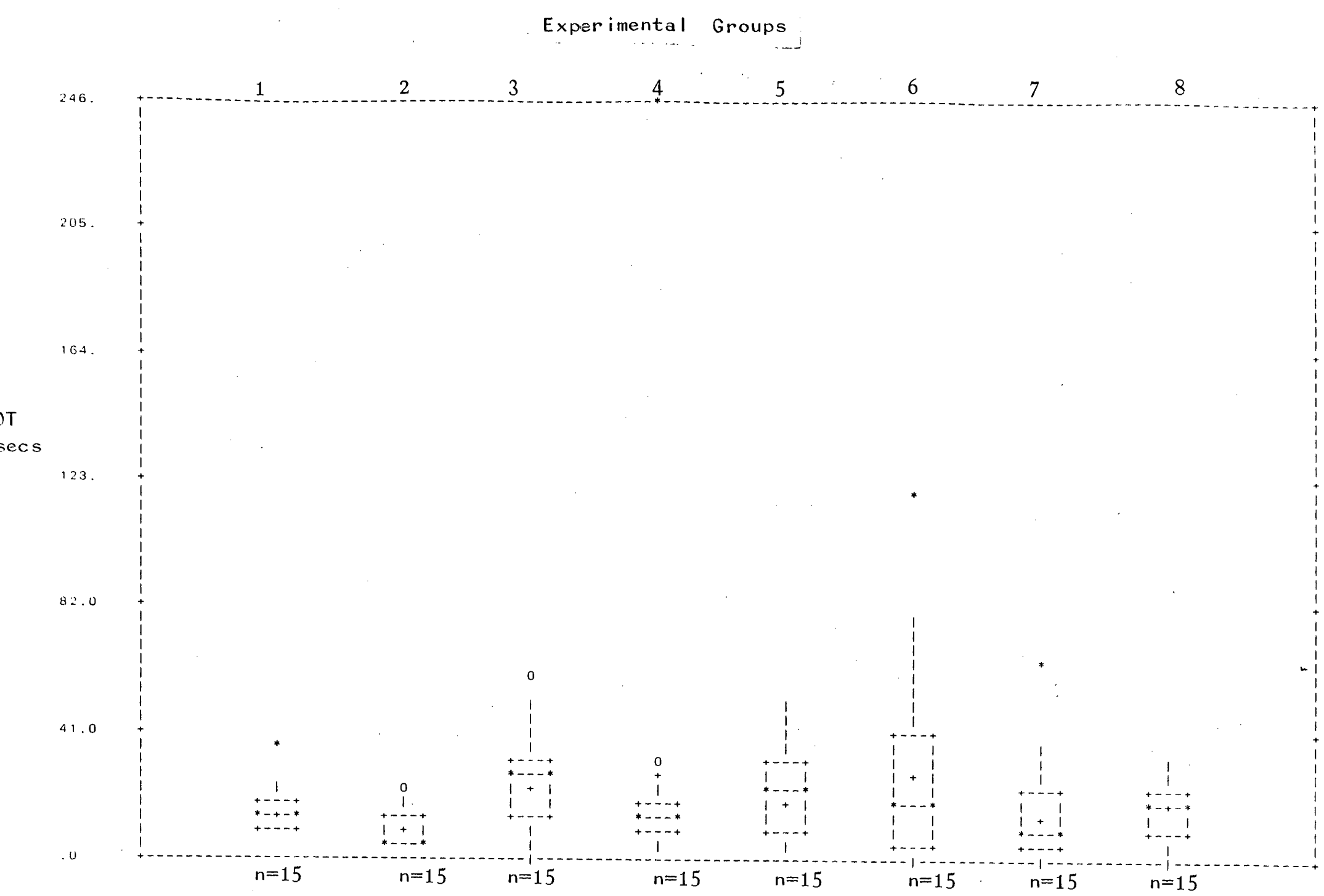


Fig. 6e(i) Multiple box plots illustrating distributions of the range of VOT scores for /paf/

Experimental Groups

VOT
secs

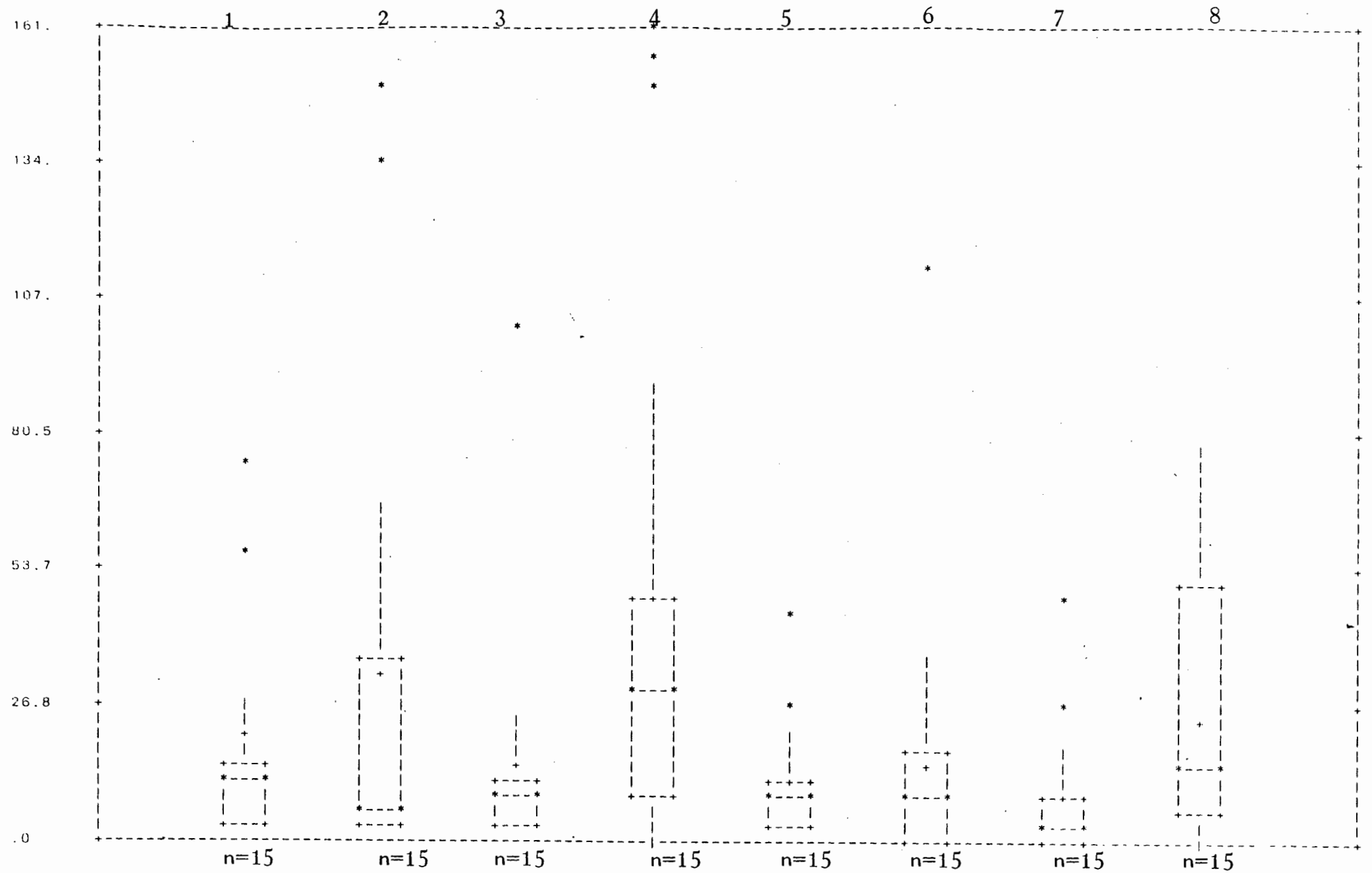


Fig. 6e(ii) Multiple box plots illustrating distributions of the range of VOT scores for /baf/

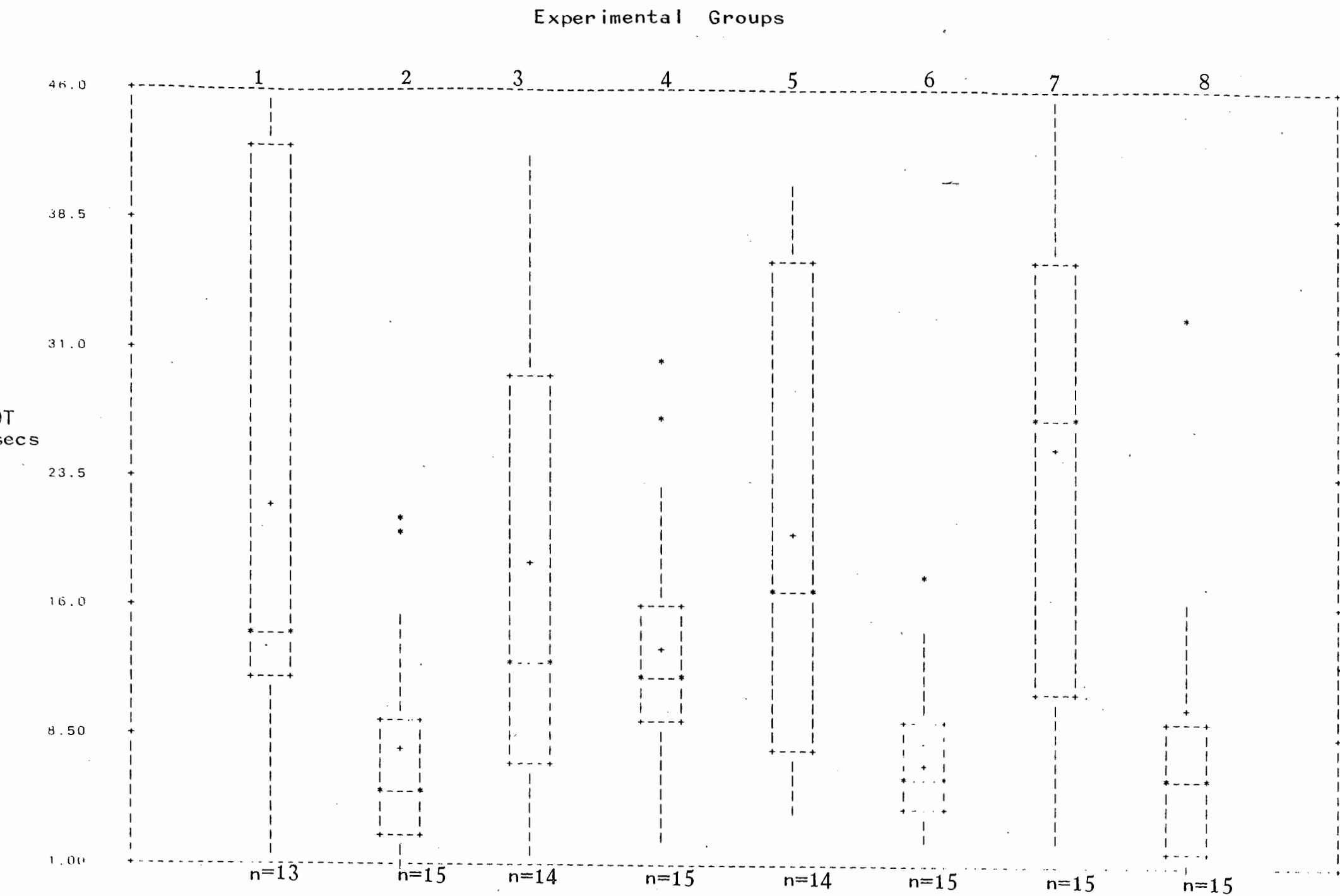


Fig. 6e(iii) Multiple box plots illustrating distributions of the range of VOT scores for /taf/

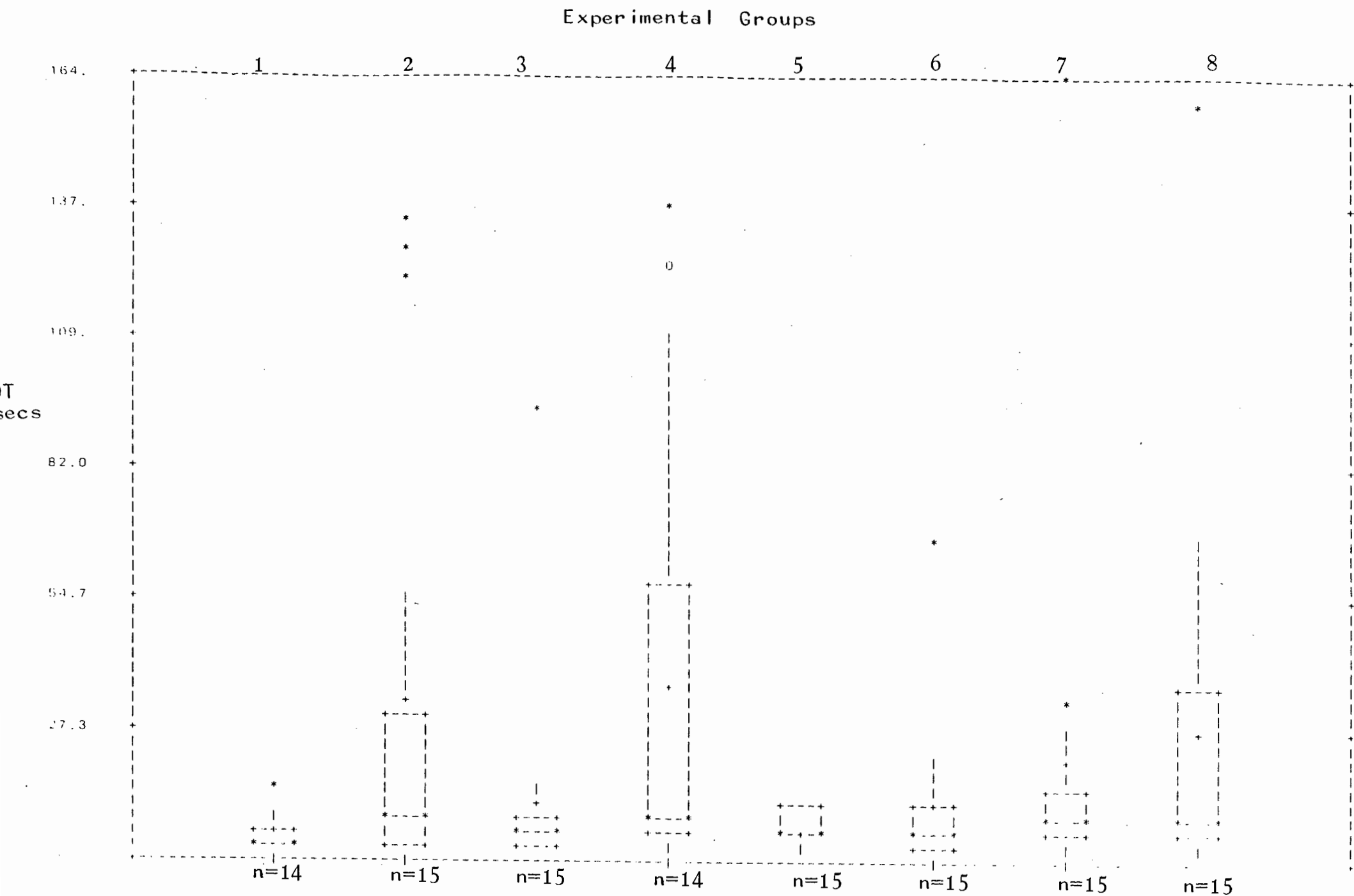


Fig. 6e(iv) Multiple box plots illustrating distributions of the range of VOT scores for /daf/

ote: A few extreme values were excluded in order to make the plots clearer.

PLOT OF RANGEPAF*MM2PAF SYMBOL IS VALUE OF GROUP

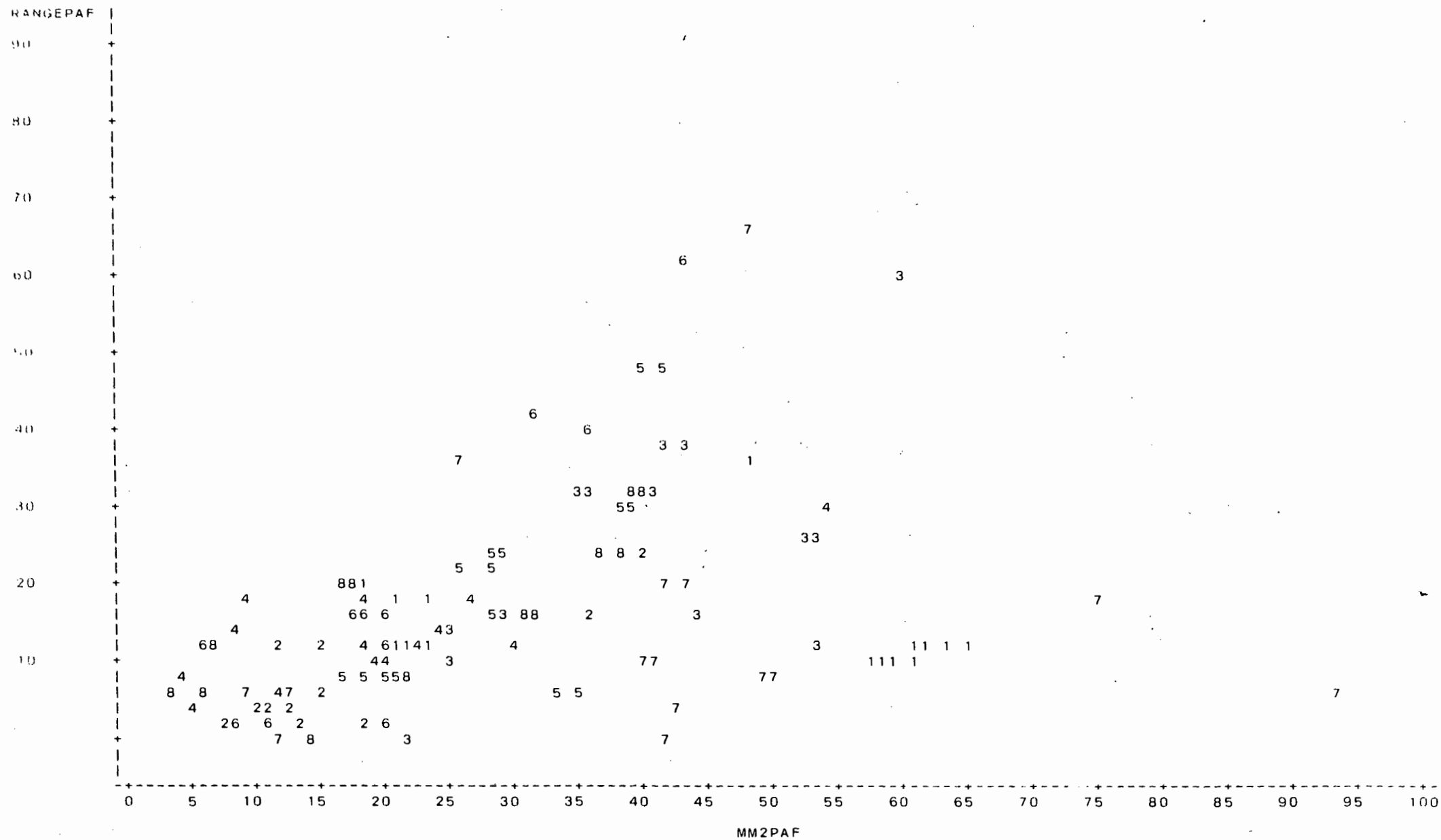
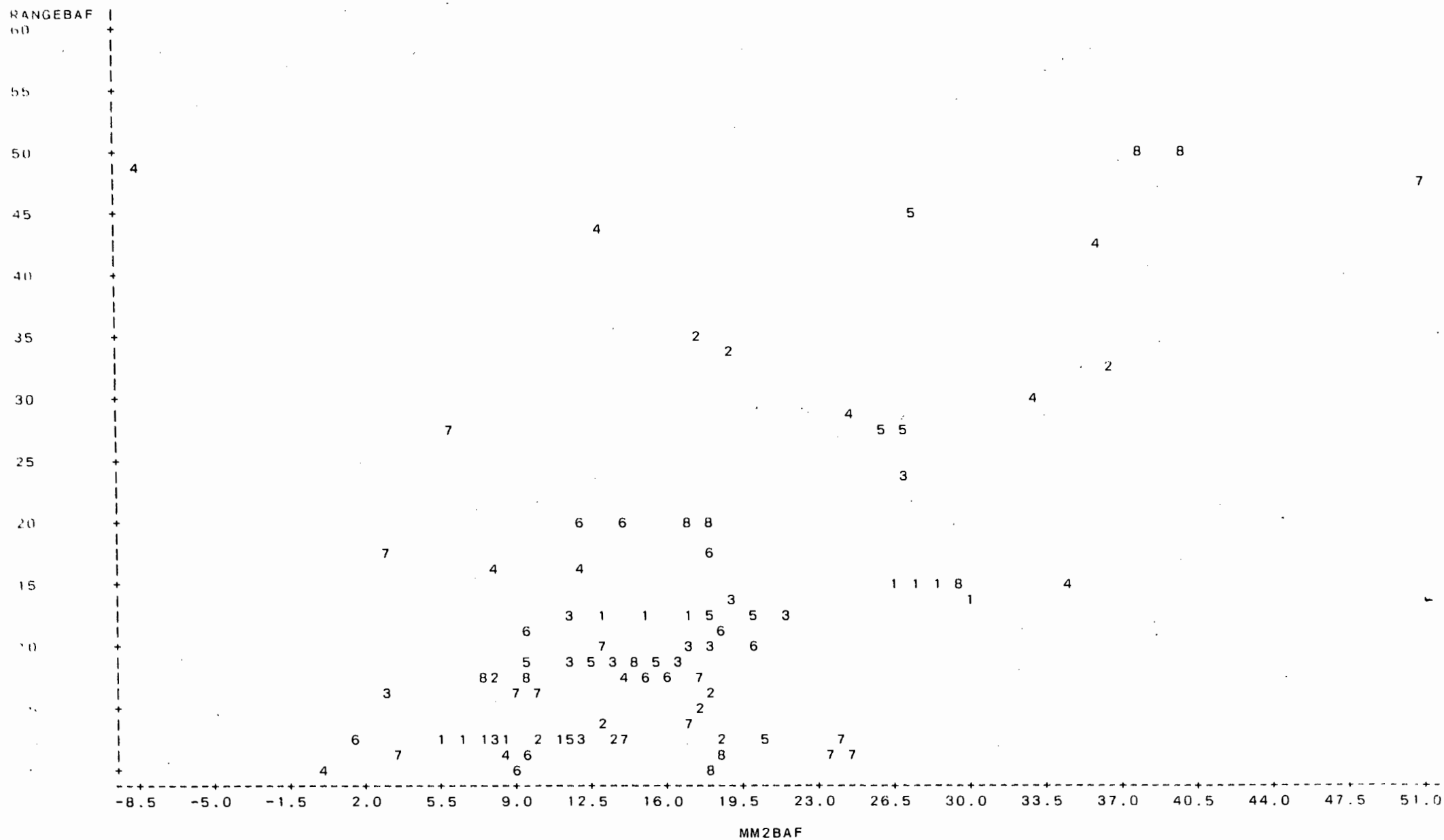


Fig 7a Plot showing heteroschedasticity of data for /naf/

Note: A few extreme values were excluded in order to make the plots clearer.

PLOT OF RANGEBAF*MM2BAF SYMBOL IS VALUE OF GROUP

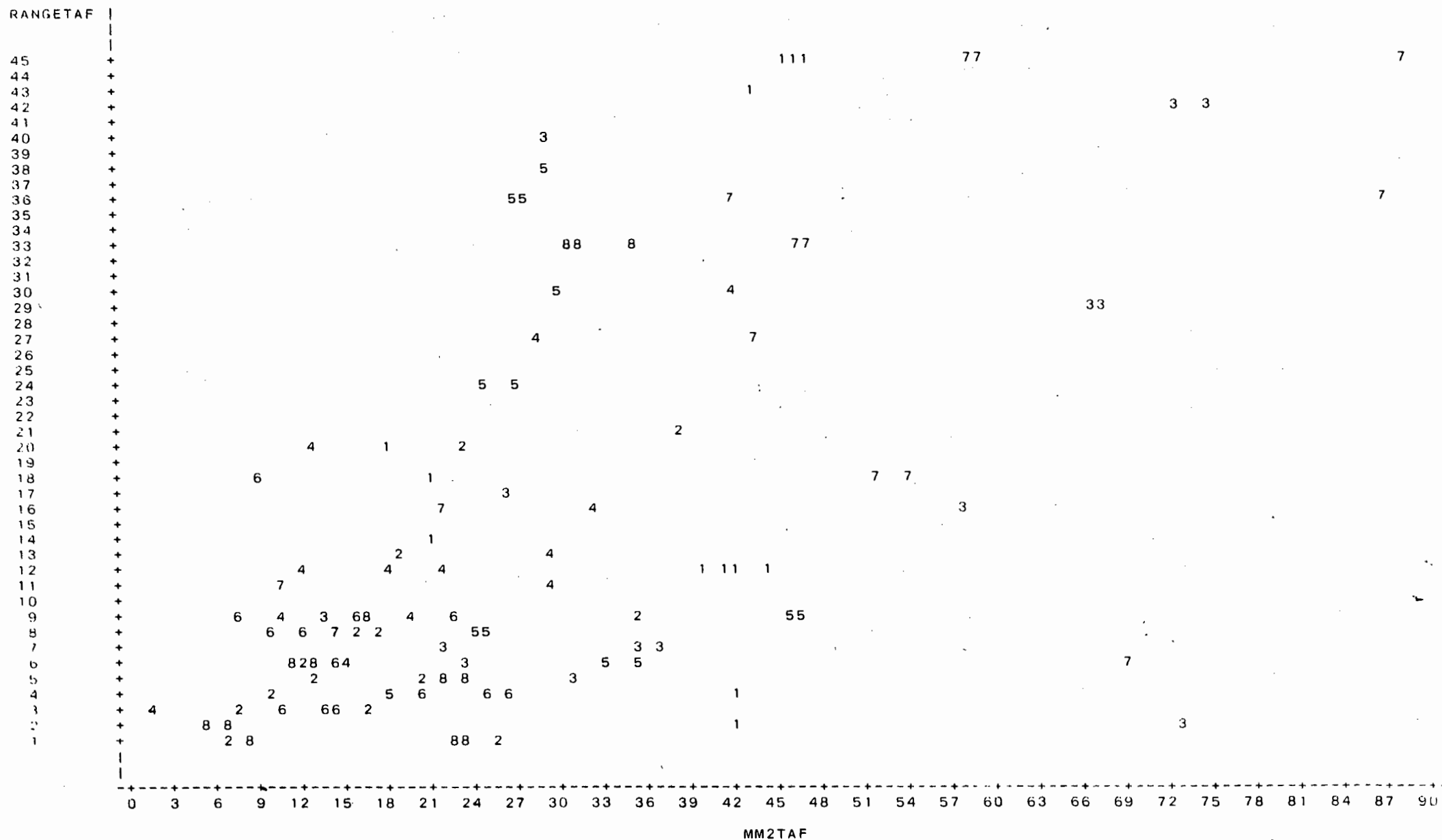


14 OBS HAD MISSING VALUES OR WERE OUT OF RANGE 17 OBS HIDDEN

Fig. 7b Plot showing heteroschedasticity of data for /haf/

PLOT OF RANGETAF*MM2TAF

SYMBOL IS VALUE OF GROUP



NOTE

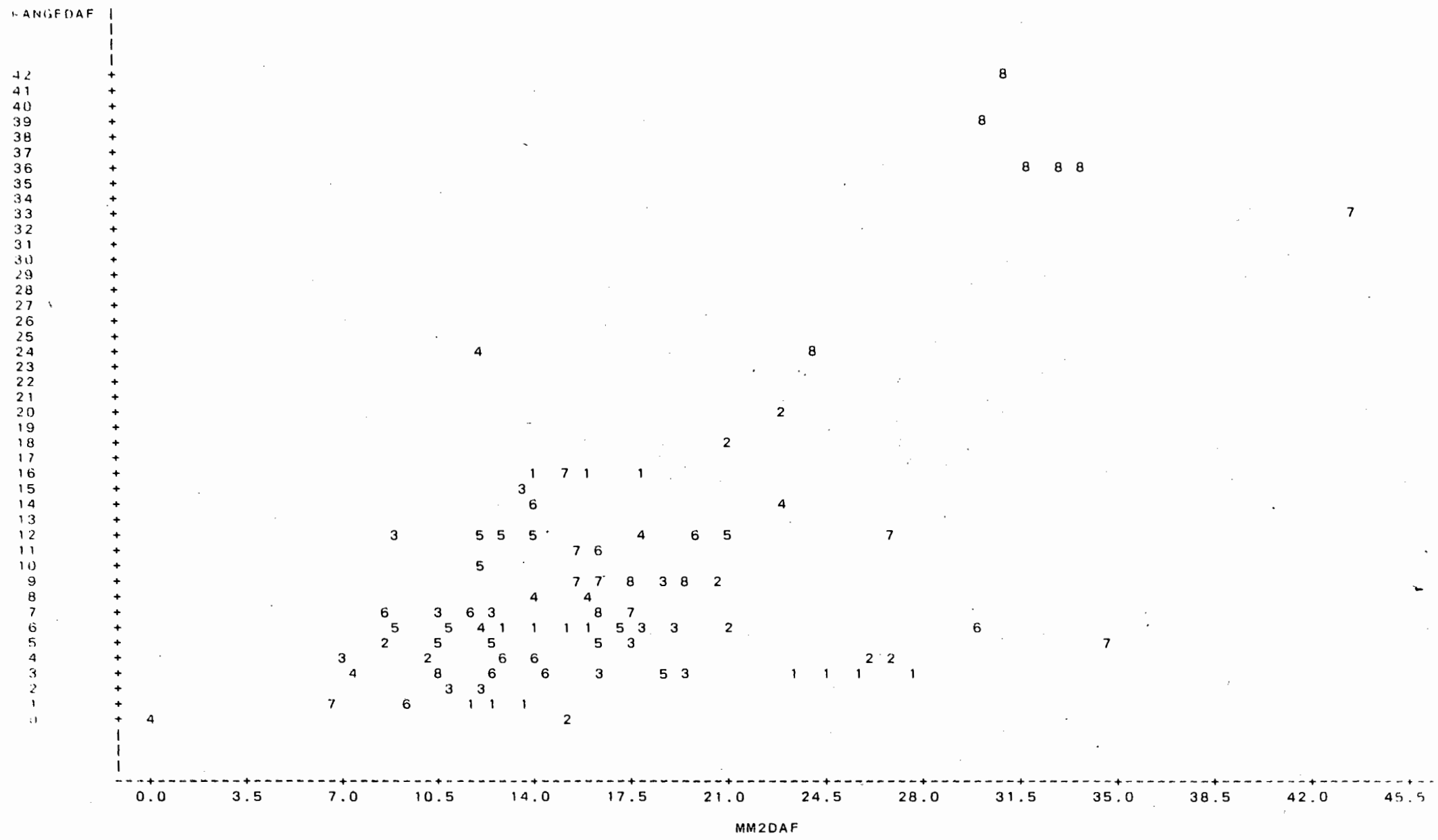
4 OBS HAD MISSING VALUES

9 OBS HIDDEN

Fig. 7c Plot showing heteroschedasticity of data for /taf/

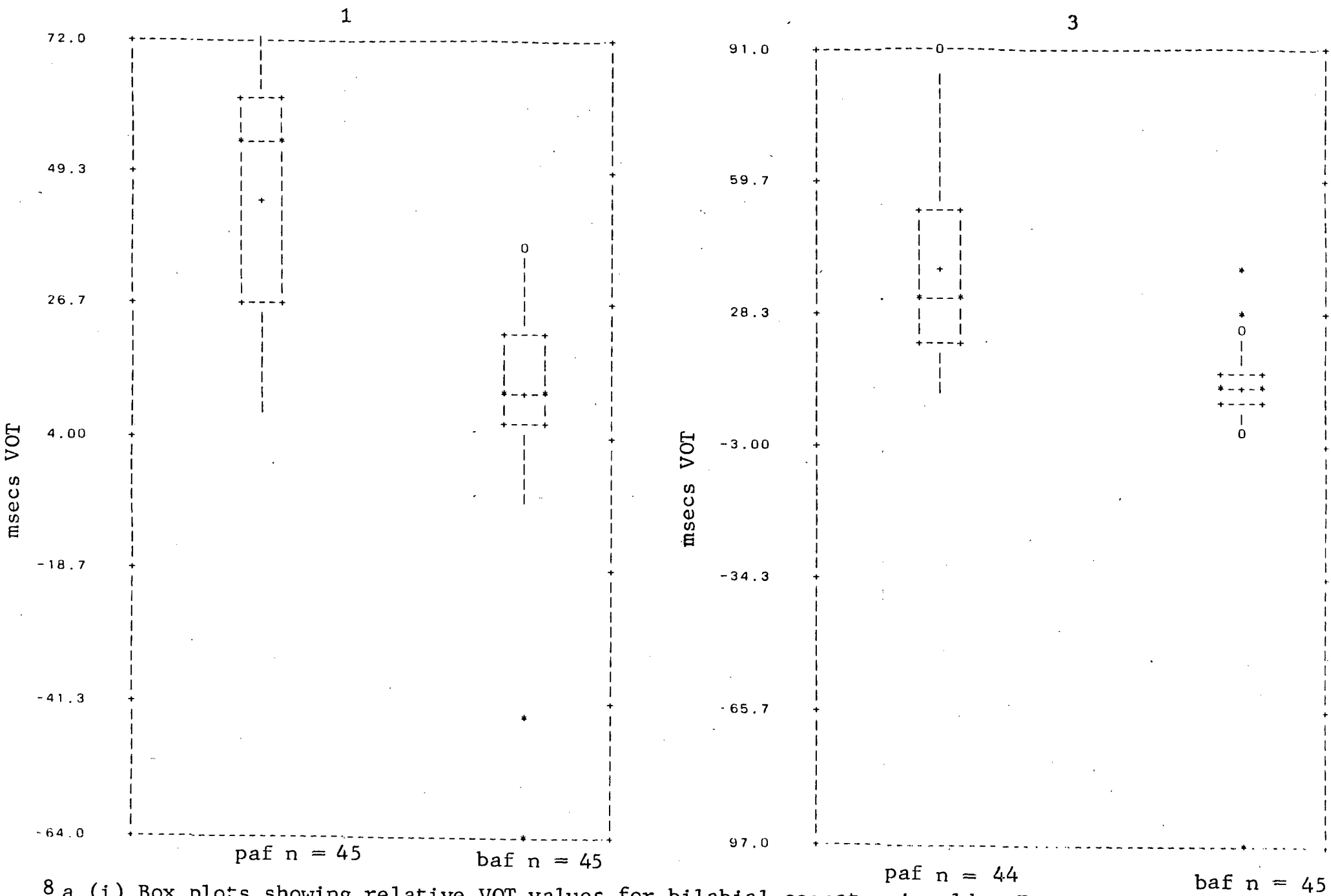
pte: A few extreme values were excluded in order to make the plots clearer.

PLOT OF RANGEDAF*MM2DAF SYMBOL IS VALUE OF GROUP



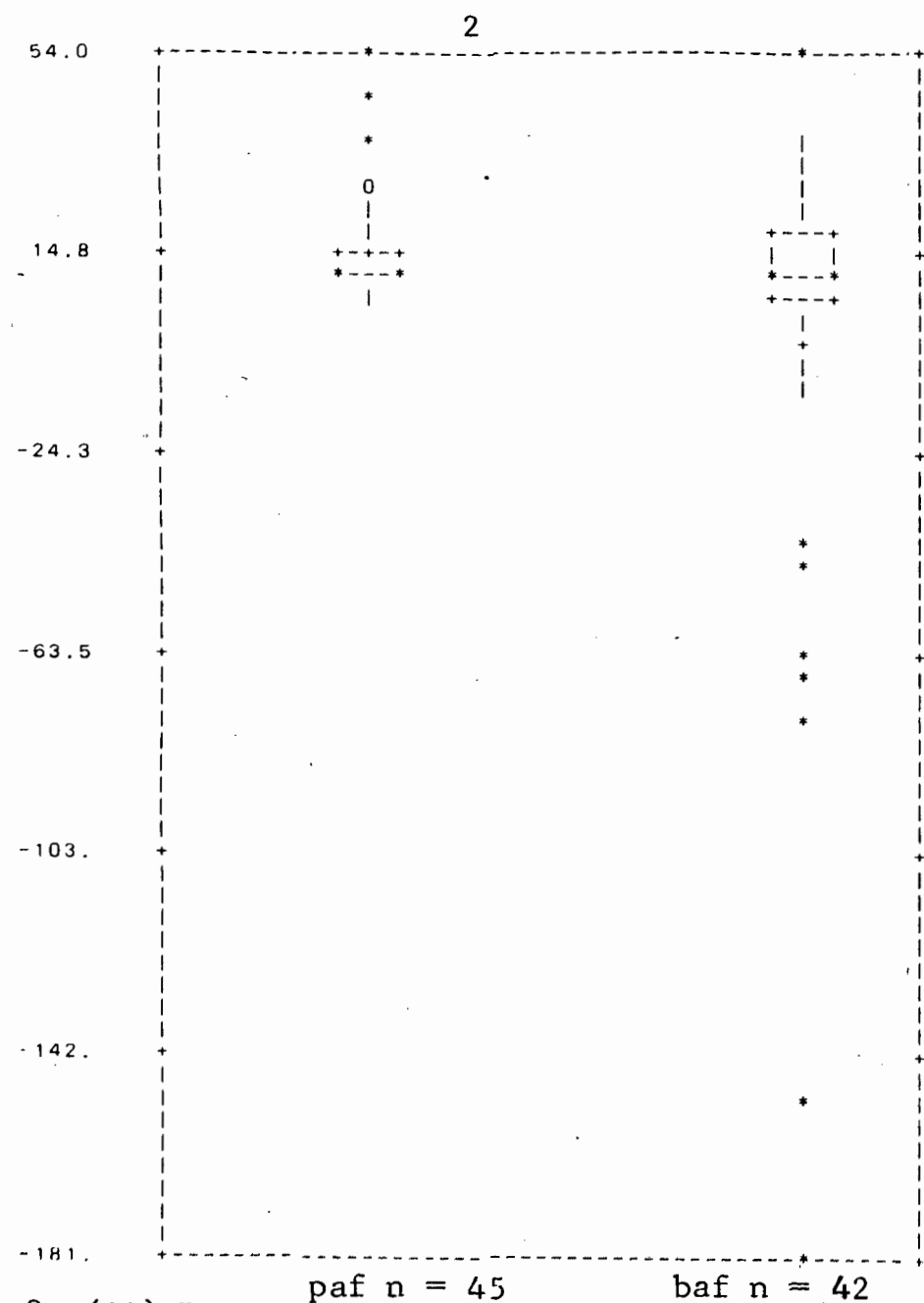
NOTE: 15 OBS HAD MISSING VALUES OR WERE OUT OF RANGE 19 OBS HIDDEN

Fig. 7d Plot showing heteroschedasticity of data for /daf/

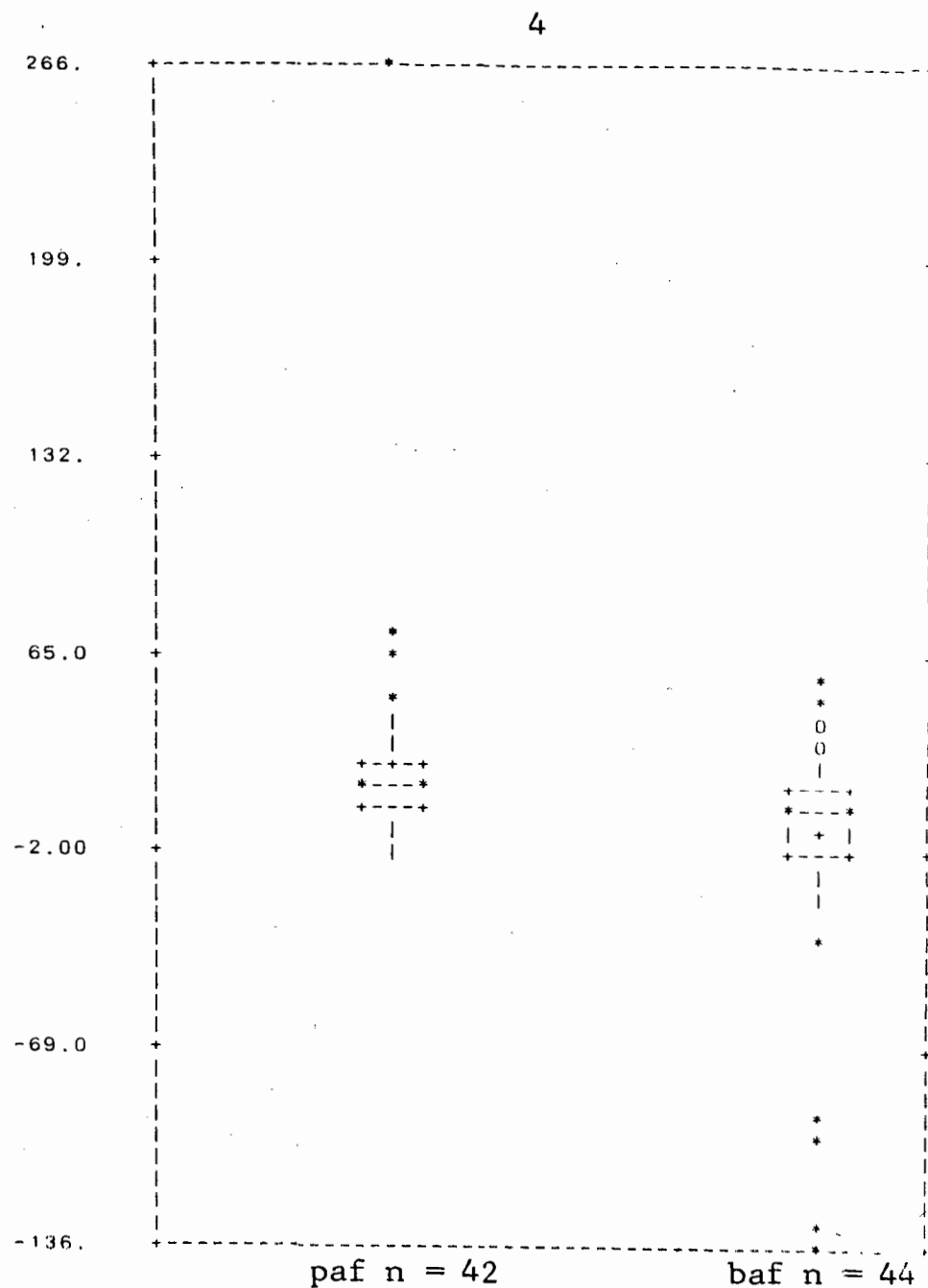


8 a (i) Box plots showing relative VOT values for bilabial cognates in older English nonstutterers and stutterers.

msecs VOT



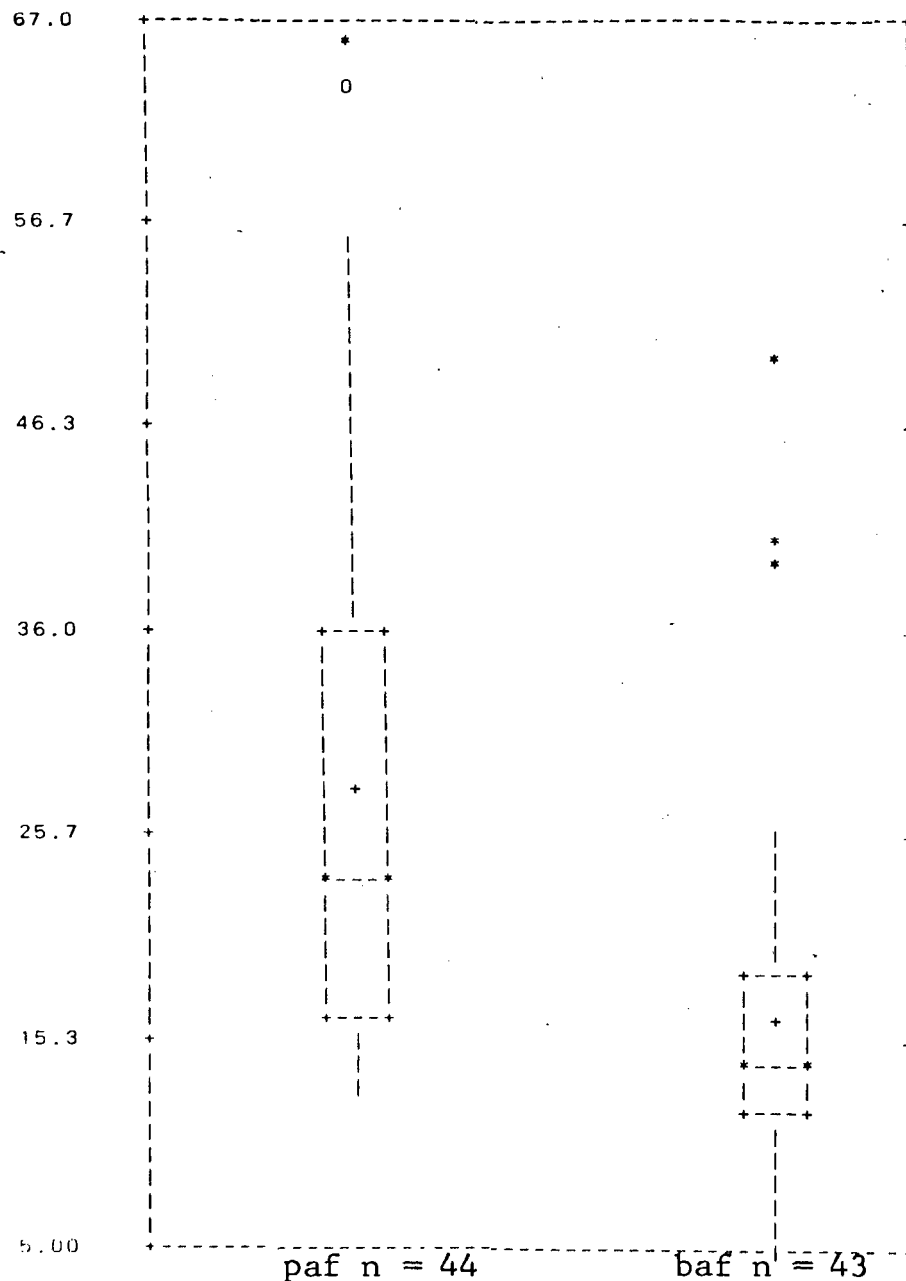
msecs VOT



8a (ii) Box plots showing relative VOT values for bilabial cognates in older Afrikaans nonstutterers and stutterers.

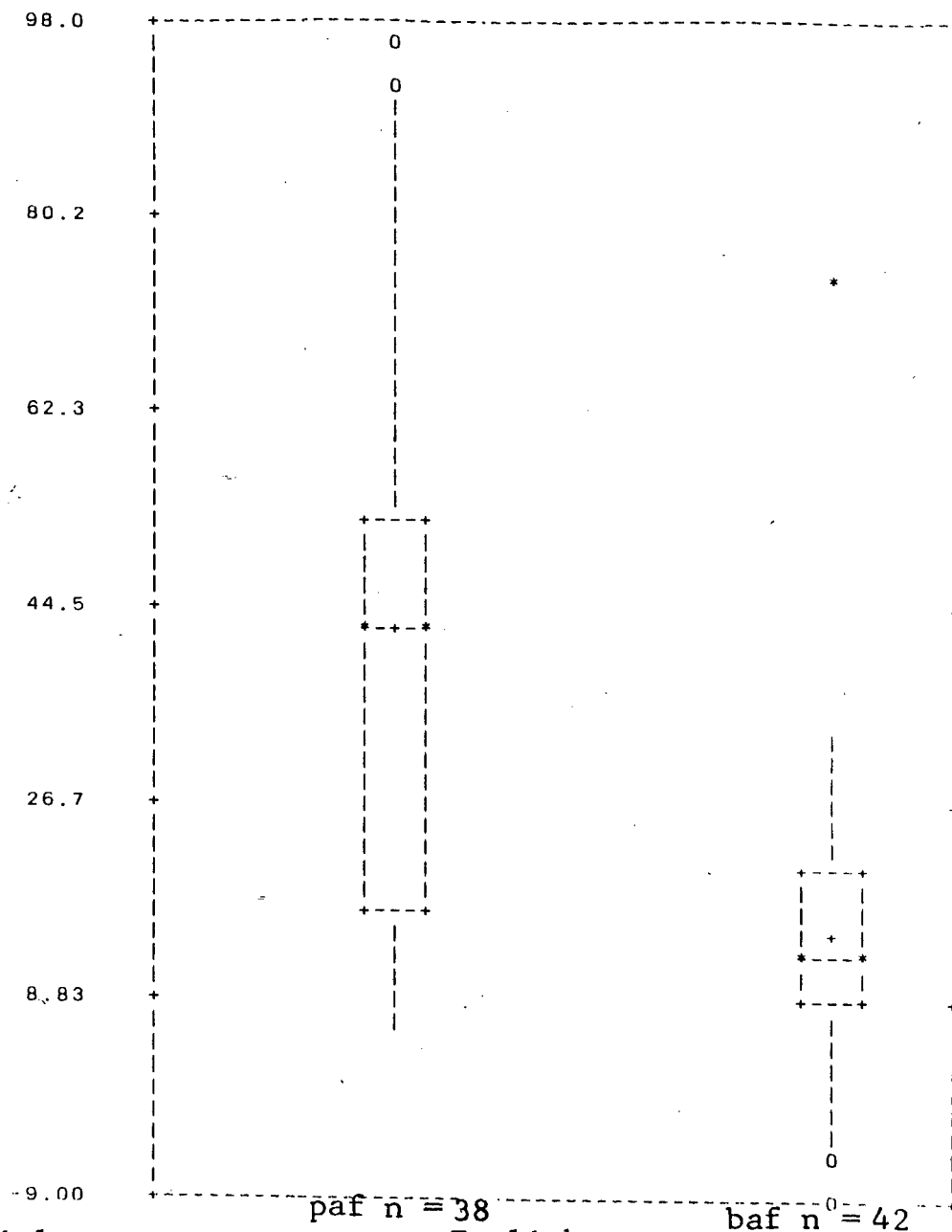
msecs VOT

5

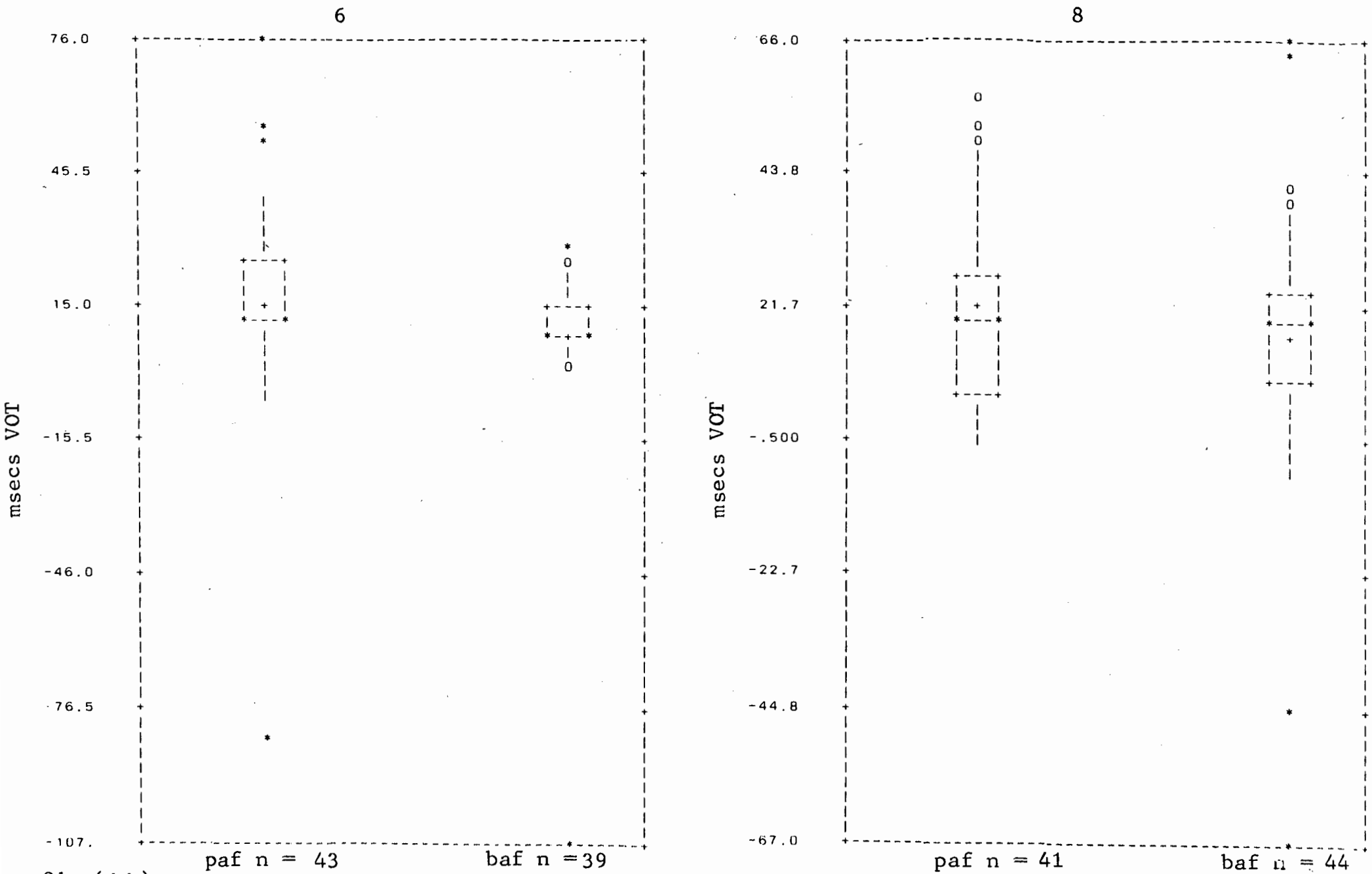


7

msecs VOT

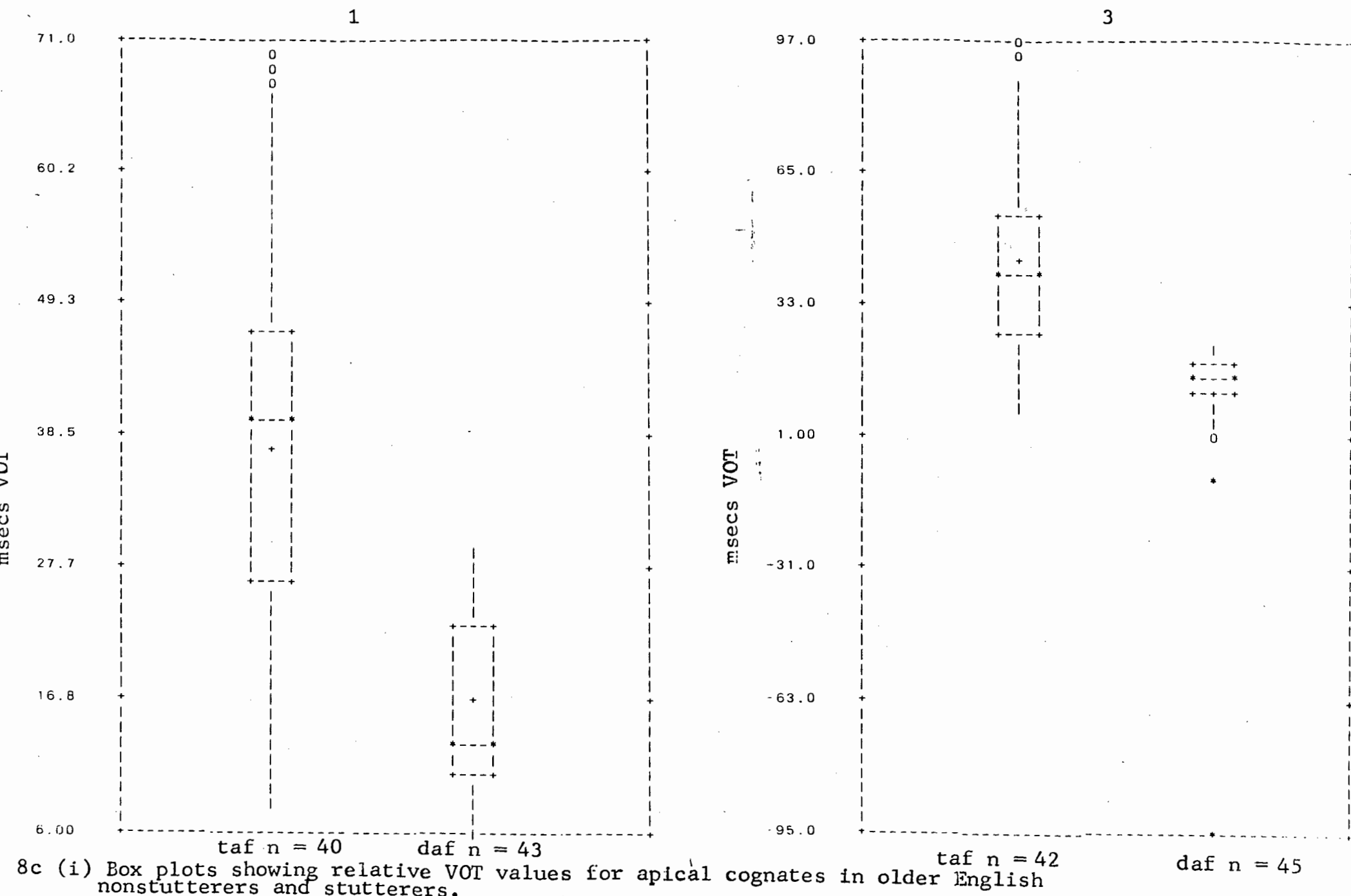


8b (i) Box plots showing relative VOT values for bilabial cognates in younger English non-stutterers and stutterers.

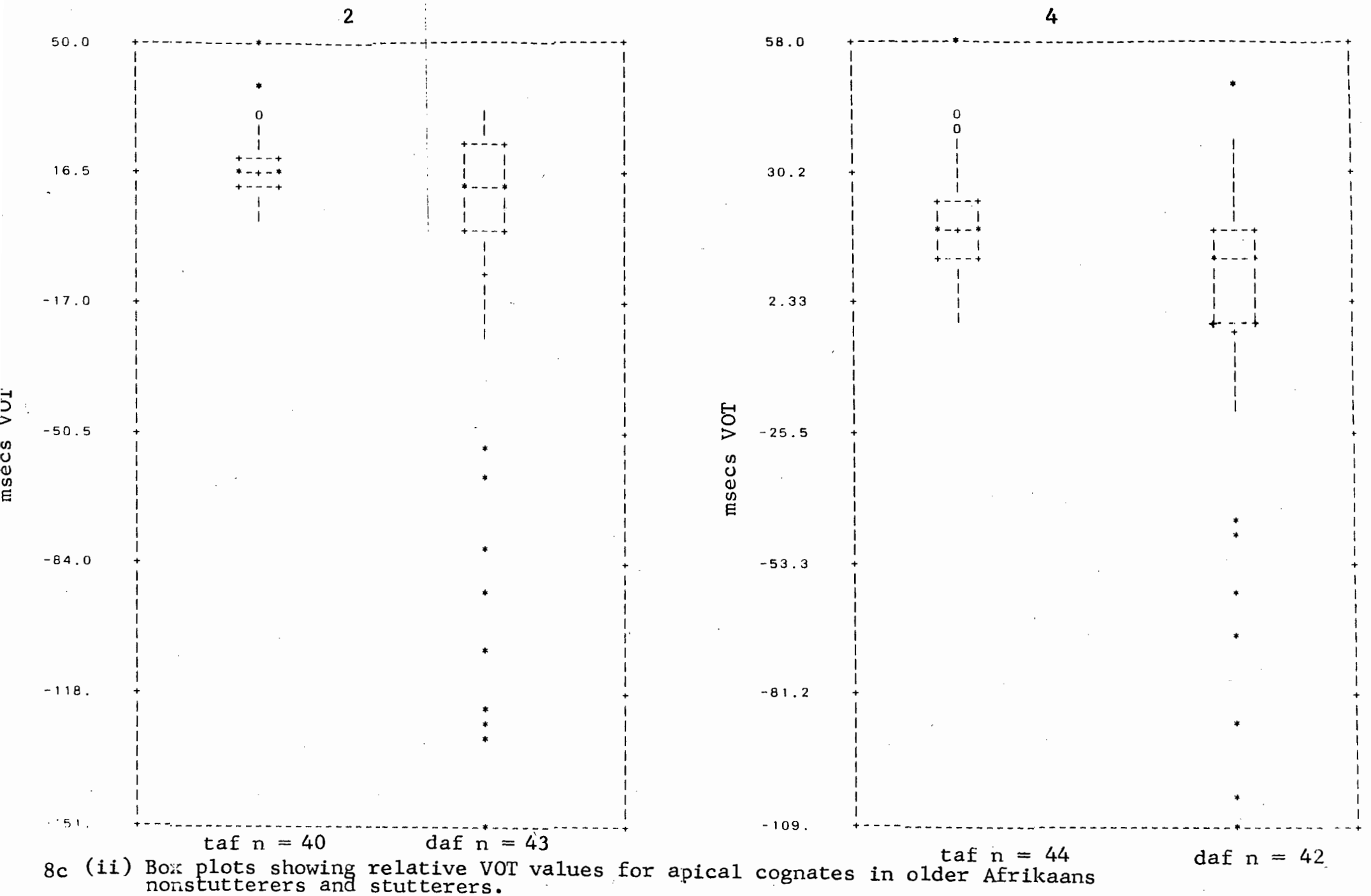


8b (ii) Box plots showing relative VOT values for bilabial cognates in younger Afrikaans nonstutterers and stutterers.

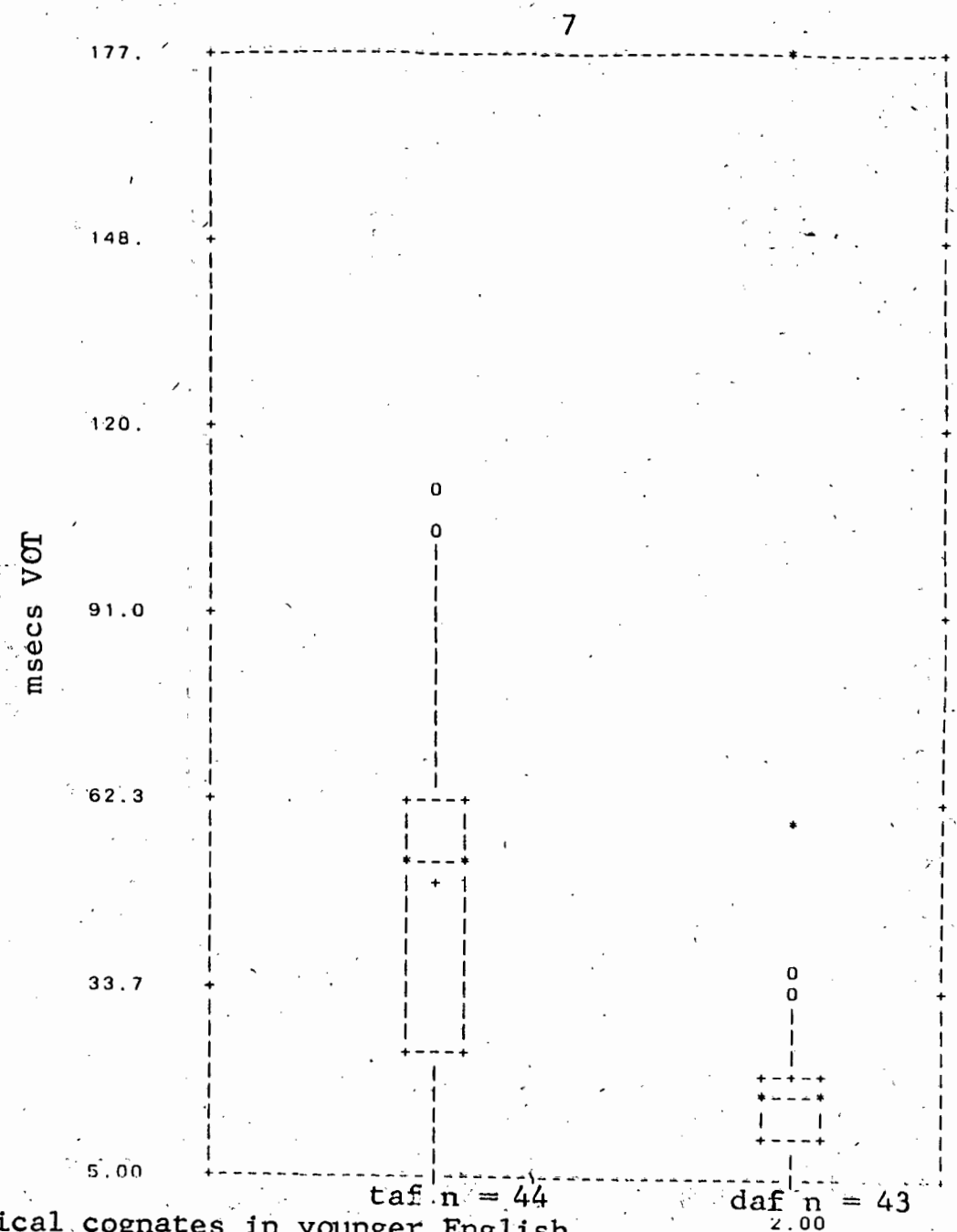
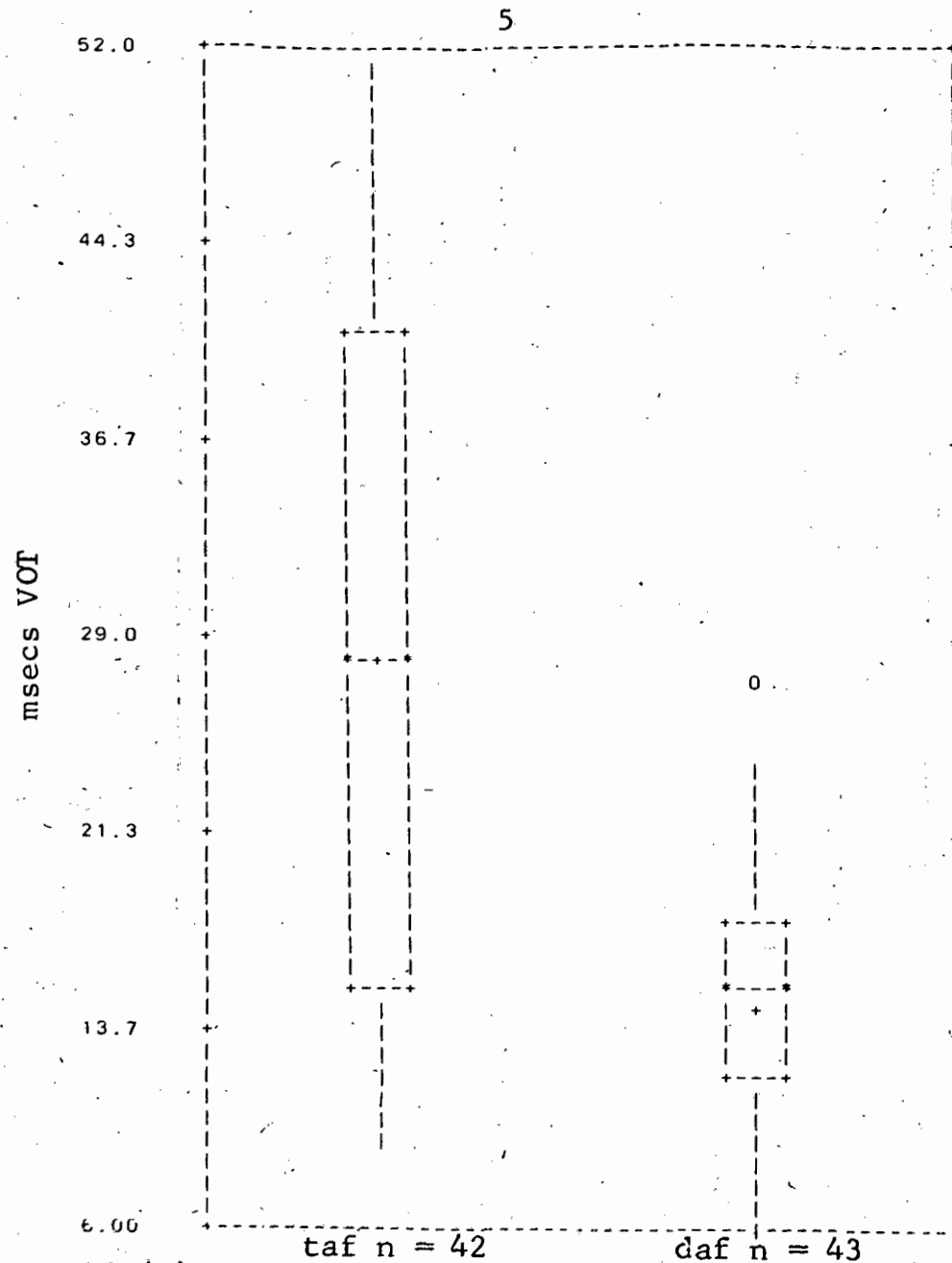
EXPERIMENTAL GROUPS



EXPERIMENTAL GROUPS



EXPERIMENTAL GROUPS



8d (i) Box plots showing relative VOT values for apical cognates in younger English nonstutterers and stutterers.

TABLE VIa Results of the Spearman's correlations in Group 1.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / NUMBER OF OBSERVATIONS

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000 15	0.59213 0.0200 15	0.47508 0.1009 13	0.68548 0.0048 15
MM2BAF	0.59213 0.0200 15	1.00000 0.0000 15	-0.26833 0.3754 13	0.86762 0.0001 15
MM2TAF	0.47508 0.1009 13	-0.26833 0.3754 13	1.00000 0.0000 13	-0.09570 0.7558 13
MM2DAF	0.68548 0.0048 15	0.86762 0.0001 15	0.09570 0.7558 13	1.00000 0.0000 15

Significant positive correlations (p smaller than .01) between:

1. MM2/paf/ and MM2/daf/
2. MM2/baf/ and MM2/daf/

TABLE VIb Results of the Spearman's correlations in Group 2.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / N = 15

	MM2PAF	MM2BAF	MM2IAF	MM2DAF
MM2PAF	1.00000 0.0000	0.44546 0.0961	0.55227 0.0328	0.09460 0.7374
MM2BAF	0.44546 0.0961	1.00000 0.0000	0.27932 0.3134	0.51567 0.0491
MM2IAF	0.55227 0.0328	0.27932 0.3134	1.00000 0.0000	0.38909 0.1517
MM2DAF	0.09460 0.7374	0.51567 0.0491	0.38909 0.1517	1.00000 0.0000

No significant correlations were found between syllables.

TABLE VIc Results of the Spearman's correlations in Group 3.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / NUMBER OF OBSERVATIONS

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000 15	-0.44086 0.1000 15	0.72988 0.0030 14	0.01610 0.9546 15
MM2BAF	-0.44086 0.1000 15	1.00000 0.0000 15	-0.17530 0.5489 14	0.66190 0.0072 15
MM2TAF	0.72988 0.0030 14	-0.17530 0.5489 14	1.00000 0.0000 14	0.10121 0.7306 14
MM2DAF	0.01610 0.9546 15	0.66190 0.0072 15	0.10121 0.7306 14	1.00000 0.0000 15

Significant positive correlations at the .01 level were found between:

1. MM2/paf/ and MM2/taf/
2. MM2/baf/ and MM2/daf/.

TABLE VI d Results of the Spearman's correlations in Group 4.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / NUMBER OF OBSERVATIONS

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000 15	0.04643 0.8695 15	0.64522 0.0094 15	-0.17382 0.5523 14
MM2BAF	0.04643 0.8695 15	1.00000 0.0000 15	0.28418 0.3046 15	0.52145 0.0558 14
MM2TAF	0.64522 0.0094 15	0.28418 0.3046 15	1.00000 0.0000 15	0.05727 0.8458 14
MM2DAF	-0.17382 0.5523 14	0.52145 0.0558 14	0.05727 0.8458 14	1.00000 0.0000 14

A significant positive correlation was found at the .01 level between MM2/paf/ and MM2/taf/.

TABLE VIe Results of the Spearman's correlations in Group 5.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho=0$ / NUMBER OF OBSERVATIONS

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000 15	-0.04847 0.8638 15	0.22148 0.4467 14	-0.06822 0.8091 15
MM2BAF	-0.04847 0.8638 15	1.00000 0.0000 15	-0.22873 0.4315 14	0.26165 0.3462 15
MM2TAF	0.22148 0.4467 14	-0.22873 0.4315 14	1.00000 0.0000 14	-0.13576 0.6435 14
MM2DAF	-0.06822 0.8091 15	0.26165 0.3462 15	-0.13576 0.6435 14	1.00000 0.0000 15

No significant correlations between syllables were found.

TABLE VI f Results of the Spearman's correlations in Group 6.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 15

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000	0.29829 0.2802	0.42512 0.1142	0.38006 0.1623
MM2BAF	0.29829 0.2802	1.00000 0.0000	0.69410 0.0041	0.58513 0.0219
MM2TAF	0.42512 0.1142	0.69410 0.0041	1.00000 0.0000	0.43292 0.1070
MM2DAF	0.38006 0.1623	0.58513 0.0219	0.43292 0.1070	1.00000 0.0000

A significant positive correlation was found at the .01 level between MM2/baf/ and MM2/taf/.

TABLE VIg Results of the Spearman's correlations in Group 7.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / N = 15

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000	0.22341 0.4235	0.79643 0.0004	0.28623 0.3010
MM2BAF	0.22341 0.4235	1.00000 0.0000	0.11975 0.6708	0.37601 0.1672
MM2TAF	0.79643 0.0004	0.11975 0.6708	1.00000 0.0000	0.21646 0.4384
MM2DAF	0.28623 0.3010	0.37601 0.1672	0.21646 0.4384	1.00000 0.0000

A significant positive correlation at the .01 level was found between MM2/paf/ and MM2/taf/.

TABLE VIIh . Results of the Spearman's correlations in Group 8.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / N = 15

	MM2PAF	MM2BAF	MM2TAF	MM2DAF
MM2PAF	1.00000 0.0000	0.67739 0.0055	0.72272 0.0023	0.38214 0.1598
MM2BAF	0.67739 0.0055	1.00000 0.0000	0.70099 0.0036	0.57551 0.0248
MM2TAF	0.72272 0.0023	0.70099 0.0036	1.00000 0.0000	0.54383 0.0361
MM2DAF	0.38214 0.1598	0.57551 0.0248	0.54383 0.0361	1.00000 0.0000

Significant positive correlations at the .01 level were found between:

1. MM2/paf/ and MM2/baf/
2. MM2/taf/ and MM2/baf/
3. MM2/paf/ and MM2/taf/.

A Distributions of MM21 /paf/

a) Central tendency

- (i) English-speakers had consistently higher medians than did Afrikaans-speakers.
- (ii) Older English nonstutterers had higher median values than did younger ones. This trend was reversed in the remaining groups, the differences being smaller for Afrikaans than for English groups.
- (iii) Stutterers had higher medians than did nonstutterers, the differences being smaller in the Afrikaans-speakers. An exception to this trend was the older English speakers, where nonstutterers had higher median values for VOT.

b) Spread

- (i) English-speakers had a consistently larger spread of MM2 scores compared with Afrikaans-speakers.
- (ii) Older subjects had greater spreads than did younger ones in the case of English nonstutterers. Afrikaans groups showed the reverse trend, younger speakers having the greater spread. The difference between the English stuttering groups was negligible.
- (iii) Stutterers showed greater spread for MM2 than did nonstutterers except for a reverse trend in the case of older English-speakers.

2 /baf/

a) Central tendency

There were minimal differences between English and Afrikaans groups, younger and older speakers, and stutterers and nonstutterers.

b) Spread

- (i) Afrikaans-speakers showed a greater spread of MM2 except in the case of young nonstutterers, where the trend was reversed.
- (ii) Older speakers showed bigger spread than did younger ones, except in the case of English stutterers.
- (iii) Stutterers showed greater spread for MM2 than did nonstutterers, except for a reverse trend in the case of older English speakers.

3 /taf/

a) Central tendency

- (i) There was a large, consistent trend toward higher median value in the case of English-speakers compared with Afrikaans-speakers.
- (ii) Older English nonstutterers had higher median values than did young ones. This trend was reversed in the English stuttering groups. There were minimal age differences between the Afrikaans groups.
- (iii) There was no difference in medians between the older Afrikaans stutterers and nonstutterers and a very small difference between the younger Afrikaans groups. Young English nonstutterers had far higher medians than did their nonstuttering counterparts. There was a modest reverse trend in the case of older English speakers.

b) Spread

- (i) Afrikaans nonstutterers had greater spread for MM2 than did English speakers. In the case of the stuttering group, a large reverse trend was seen.
- (ii) There was no difference in spread of MM2 between younger and older Afrikaans nonstutterers. Young English nonstutterers had greater spread than did older ones, while this trend was reversed in the stuttering groups.
- (iii) Stutterers showed consistently larger spread of MM2 than did nonstutterers. This trend was particularly marked in the case of English-speakers, owing to the large dispersion of scores in the English stutterers.

4 /daf/

a) Central tendency

There were minimal differences between groups.

b) Spread

- (i) Afrikaans-speakers had consistently larger spread than did English-speakers. This trend was much greater in older than in younger groups.
- (ii) Older speakers, especially Afrikaans ones, had greater spread than younger ones. The exception was a modest reverse trend in the English stutterers.
- (iii) In the case of young speakers, stutterers had greater spread of MM2 than did nonstutterers. There was a minimal difference between older stutterers and nonstutterers. Older Afrikaans nonstutterers had greater spread than did the stutterers. A

feature of the display is the large spread of MM2 scores for older Afrikaans nonstutterers, owing to instances of voicing lead.

B Distributions of maximum scores

1 /paf/

a) Central tendency

- (i) There was a consistent trend toward higher median values for maximum scores in the case of English-speakers compared with Afrikaans-speakers.
- (ii) Older English speakers had higher median values than did younger ones, the differences being greater in the case of the nonstuttering groups. No such age-related trend was observed for Afrikaans-speakers.
- (iii) Older Afrikaans stutterers and young English stutterers had higher median values for maximum scores than did their nonstuttering counterparts. This trend was reversed in older English speakers; while no difference was observed between the younger Afrikaans groups.

b) Spread

- (i) Except for the younger stuttering groups, English-speakers had a greater spread of maximum scores than did Afrikaans-speakers. If the adjacent and outlying scores of the young English stuttering group are taken into account, this trend is maintained. The spread for the older Afrikaans nonstutterers was particularly small.
- (ii) Older English groups had a greater spread of maximum scores than did younger ones. This difference was particularly marked for the stuttering groups. This trend was reversed in the Afrikaans groups, younger speakers being more variable than older.
- (iii) With the exception of young English speakers, stutterers showed greater spread than did nonstutterers. Again, if the adjacent and outlying scores in the young English stuttering group are taken into account, the trend is maintained.

2 /baf/

a) Central tendency

There were minimal inter-group differences.

b) Spread

- (i) With the exception of the older nonstuttering groups, Afrikaans-speakers showed greater spread of maximum scores than did English-speakers. This was particularly marked in the stuttering groups. Older English nonstutterers had a larger spread than did

older Afrikaans nonstutterers.

- (ii) There was a trend toward greater spread in older compared with younger speakers in the case of English nonstutterers and Afrikaans stutterers. Young Afrikaans nonstutterers had greater spread than did older ones. There was no difference between younger and older English stutterers.
- (iii) Afrikaans stutterers showed greater spread of maximum scores than did nonstutterers. This trend was reversed in the older English groups. There was a minimal difference between younger English stutterers and nonstutterers.

3 /taf/

a) Central tendency

- (i) There was a large, consistent trend toward higher median values for maximum scores in English compared with Afrikaans groups. This trend exceeded that for /paf/.
- (ii) Older speakers had higher median values than did younger. This trend was observed for both languages, but was greater in the case of English-speakers.
- (iii) There were minimal differences between Afrikaans stutterers and nonstutterers. Young English stutterers showed higher median values than did nonstutterers but this trend was reversed in the case of older English speakers.

b) Spread

- (i) English-speakers showed consistently bigger spread of maximum VOT scores than did Afrikaans-speakers.
- (ii) Older subjects had consistently bigger spread than did younger ones.
- (iii) Stutterers had consistently bigger spread than did nonstutters. On the whole, spread for /taf/ was far greater than for the other syllables.

4 /daf/

a) Central tendency

There were minimal differences between the groups with respect of median values.

b) Spread

On the whole, spread for /daf/ was smaller than that for the other syllables. Spread for /baf/ and /daf/ was comparable in older Afrikaans nonstutterers.

- (i) Except for a reverse trend in the case of older stutterers Afrikaans-speakers showed greater spread than did English-speakers.
- (ii) Older nonstutterers had bigger spread than did younger ones. No age trends were observed in English stutterers. Young Afrikaans stutterers showed a bigger spread than did older ones.

C Distributions of minimum scores

1 /paf/

a) Central tendency

- (i) English-speakers showed consistently higher median values compared with Afrikaans-speakers.
- (ii) Older English nonstutterers had higher median values than did younger ones. The reverse trend was noted in the English stuttering groups. There were negligible differences between Afrikaans groups.
- (iii) There were minimal differences between Afrikaans stutterers and nonstutterers. Young English stutterers had higher median values for minimum scores than did their controls. This trend was reversed in the older English groups.

b) Spread

- (i) English-speakers had consistently bigger spread of minimum scores compared with Afrikaans-speakers, although in the older stuttering groups this trend was small.
- (ii) Older English nonstutterers had greater spread than younger English nonstutterers. No age-related trends were seen in the Afrikaans nonstuttering groups. In the case of stutterers of both languages, the younger ones had greater spread for minimum scores than did the older ones.
- (iii) Stutterers had greater spread, ie. were more variable, than were nonstutterers except in the case of the older English groups, where the trend was reversed.

2 /baf/

a) Central tendency

- (i) Older English stutterers tended to have slightly higher median values than did older Afrikaans stutterers. There were minimal differences between the language groups in the remaining subjects.
- (ii) Young Afrikaans stutterers had slightly higher medians than did older ones. There were minimal age-related differences in the remaining groups.

- (iii) Older Afrikaans nonstutterers had slightly higher medians than did their stuttering counterparts. No differences of note occurred between the remaining stuttering and nonstuttering groups.

b) Spread

- (i) Older Afrikaans-speakers showed consistently greater spread for minimum scores than did English speakers, owing to a preponderance of negative values. Young nonstutterers maintained this trend, though to a lesser degree. Young stutterer showed the reverse trend.
- (ii) Young English stutterers had bigger spread of minimum scores than did older ones. The reverse age-related trend was seen in the remaining groups.
- (iii) Nonstuttering older speakers of both languages showed greater spread for minimum scores than did stutterers. This trend was reversed in younger speakers, although the differences between the groups was not as large.

3 /taf/

a) Central tendency

- (i) There was a large, consistent trend for English speakers to show higher median values for minimum scores than did Afrikaans-speakers. The trend was maintained, but somewhat smaller, in the young nonstutterers.
- (ii) Older English nonstutterers showed higher median values than did younger ones. There were minimal age-related trends in the other groups.
- (iii) Young English stutterers tended to have much higher medians than did nonstutterers. Older English speakers exhibited a small trend in this direction. There was no difference between Afrikaans stutterers and nonstutterers.

b) Spread

- (i) There was a large, consistent trend for English-speakers to have a greater spread of minimum scores than did Afrikaans-speakers. English stutterers showed particularly large ranges.
- (ii) In the case of English and, to a lesser extent, Afrikaans nonstutterers, younger speakers had bigger spread of minimum scores than did older speakers. The reverse trend was seen in the stuttering groups.
- (iii) Stutterers showed consistently bigger spread of minimum scores than did nonstutterers. This trend was smallest for the young Afrikaans-speakers.

4 /daf/

a) Central tendency

There were minimal differences between the groups.

b) Spread

- (i) In the case of older speakers, Afrikaans subjects had much greater spread of minimum VOT scores than did English subjects. This was due to the development of voicing lead in the older Afrikaans-speakers. A small trend in the reverse direction was seen in younger speakers.
- (ii) Older Afrikaans-speakers showed much bigger spread than did younger ones, mainly owing to the development of voicing lead. There was a small trend towards greater variability in older English nonstutterers compared with younger ones, but no age-related trends in the English stuttering group.
- (iii) Older nonstutterers showed bigger spread than did stutterers. There was a small reverse trend in the case of younger speakers.

D Distributions of the range

In this instance, the range was calculated for each subject and then grouped to form the distribution.

1 /paf/

a) Central tendency

- (i) There was a small trend towards higher medians in the case of English compared with Afrikaans-speakers. This trend was reversed in the young stutterers.
- (ii) In the nonstuttering groups, younger subjects had slightly higher medians for the range than did nonstutterers. This trend was reversed in the case of English stutterers, while no age-related trends were observed in the case of Afrikaans stutterers.
- (iii) Older stutterers had higher medians for the range compared with nonstutterers. The trend was reversed in the younger English groups, while there were no differences between the younger Afrikaans groups.

b) Spread

- (i) English stutterers had greater spread of the range than did Afrikaans stutterers. This trend was reversed in young nonstutterers. No difference was observed between the older English and Afrikaans nonstutterers.
- (ii) No difference was observed between younger and older English

stutterers. In the remaining groups, younger speakers were more variable.

- (iii) Older English stutterers had greater spread than did nonstutterers, but no difference was observed between older Afrikaans groups. The reverse trend was seen in the younger speakers, nonstutterers being more variable.

2 /baf/

a) Central tendency

- (i) Older English nonstutterers had higher medians for the range than did Afrikaans ones. A reverse trend was seen in the case of stutterers, being especially big in older stutterers. No difference was observed between the young nonstuttering groups.
- (ii) Older Afrikaans stutterers had higher medians than did younger ones. The age-related trends in the remaining groups were very small.
- (iii) Older Afrikaans stutterers had higher medians than did nonstutterers. The differences between the other stuttering and nonstuttering groups were very small.

b) Spread

- (i) Afrikaans-speakers tended to have consistently larger spread than did English-speakers.
- (ii) Older nonstutterers had bigger spread of the range than did younger ones. There was a small reverse trend in the case of Afrikaans stutterers, and no difference between younger and older stutterers.
- (iii) English nonstutterers had slightly bigger spread than did stutterers. Afrikaans stutterers had much bigger spread than did nonstutterers.

3 /taf/

a) Central tendency

- (i) Older Afrikaans stutterers showed higher medians for the range than did English ones. In the remaining groups this trend was reversed.
- (ii) Older speakers had higher medians than did younger ones in the English nonstutterers and Afrikaans stutterers. English stutterers showed a large reverse trend. There was a minimal difference between older and younger Afrikaans nonstutterers.
- (iii) Stutterers showed higher medians than did nonstutterers in the older Afrikaans and younger English groups. This trend was

reversed in the older English speakers. No difference was observed between young Afrikaans stutterers and nonstutterers.

b) Spread

- (i) English speakers, in general, had very large spread of the range, ie. the subjects' individual ranges showed a great deal of variability. English-speakers had consistently bigger spread than did their Afrikaans counterparts.
- (ii) No age-related trends were observed in the English groups. Older Afrikaans nonstutterers had slightly bigger spread than did younger ones. This trend was only seen in the Afrikaans stuttering groups if adjacent scores were taken into account.
- (iii) English nonstutterers had bigger spread than did stutterers, while the trend was reversed in the case of Afrikaans-speakers.

4 /daf/

a) Central tendency

There were minimal differences between the groups.

b) Spread

- (i) Afrikaans-speakers had consistently larger spread than did English-speakers.
- (ii) Older Afrikaans-speakers had bigger spread than did younger ones. There were minimal age-related differences amongst the English groups.
- (iii) There were no differences in spread of the range between the older English stutterers and nonstutterers. For the remaining groups, stutterers had bigger spread, ie. were more variable, compared with nonstutterers.

E Relative VOT distributions for cognate pairs

Figs.8a to 8d show multiple box plots illustrating relative VOT values for cognate pairs in the eight experimental groups. While there is a degree of overlap between VOTs for voiced and voiceless cognate pairs, older English-speakers tended to make clearer distinctions between them than did younger English controls and Afrikaans-speakers.

F Spearman's correlations

The results of the Spearman's correlations are illustrated in Table VIa to VIh. No meaningful trends emerged from this analysis.

VIII DISCUSSION

A Cross-language comparisons1 Central tendencya) Nonstutterers

English-speaking nonstutterers used longer VOTs on voiceless stops than did Afrikaans-speakers, as was clearly revealed in central tendency of the mean, MM2, maximum scores, minimum scores and the range. This was an expected finding and is consistent with the notion that South African English is a two-category dialect employing short-and long-lag VOT contrasts for voiced and voiceless stops respectively. The trend amongst English speakers toward long-lag VOTs on voiceless stops was greater in the case of the six- and seven-year-old children compared with the three- and four-year-olds. This finding agrees with the developmental finding reported elsewhere (Kewley-Port and Preston 1974), the children have to learn to lengthen VOT.

Table VII shows the means and some of the ranges for the older English and Afrikaans nonstuttering groups. Included for purposes of comparison are data from Lisker and Abramson (1964) on one Dutch adult speaker, 10 6-year-old American English speakers (Zlatin and Koenigsknecht (1976), and 6 Afrikaans- and 4 South African English-speaking adults (unpublished pilot study).

TABLE VII Means and ranges of VOT scores (in msec) for speakers of different languages based on the present data and literature sources

	p	b	t	d
South African English Adults $\bar{X}$ Range	+41.85 +26.40 to +64.80	-84.20 -100.00 to +17.00	+64.75 +31.00 to +118.80	+18.20 -53.80 to +35.20
American English Children (Zlatin & Koenigsknecht 1976) $\bar{X}$ Range	+72.22	-3.35	+68.47	+12.10
South African English Children $\bar{X}$ Range	+43.98 +8.00 to +71.00	+10.84 -63.00 to +37.00	+37.64 +8.00 to +70.00	+16.40 +6.00 to +27.00
Afrikaans Children $\bar{X}$ Range	+16.00 +5.00 to +52.00	+1.73 -180.00 to +53.00	+17.72 +6.00 to +49.00	+8.56 -150.00 to +33.00
Afrikaans Adults $\bar{X}$ Range	+30.60 +13.00 to +46.80	-65.88 -104.80 to -32.20	+34.73 +30.20 to +56.40	-49.33 -91.20 to +33.60
Dutch Adult (Lisker & Abramson 1964) $\bar{X}$ Range	+10.00 0.00 to +30.00	-85.00 -115.00 to -45.00	+15.00 +5.00 to +35.00	-80.00 -115.00 to -45.00

in the case of South African English-speaking children, means for voiceless stops are considerably smaller than those reported for American English children, yet they fall into the +20 to +70 adult long-lag range reported by Abramson and Lisker (1974). This discrepancy can be explained by Afrikaans influence on the South African English dialect, manifest in reduction of VOT for voiceless syllable-initial stop plosives. Older South African English children had not yet reached adult values for /t/. Mean VOTs for /b/ and /d/ fall into the short-lag category for the older English groups of children.

Afrikaans as spoken by child subjects appeared to resemble Dutch in that it used two categories, viz. 'voiced' and 'voiceless' unaspirated stops which all fall into either the short-lag category, as defined by Lisker and Abramson (VOT 0 to +20 or +25 msec) or which were randomly prevoiced. The voiceless stops produced by adult Afrikaans speakers were longer than those of the children, perhaps as a result of the influence of English.

Table VIII shows the mean VOTs and ranges for young South African English and Afrikaans nonstutterers as well as data for alveolar stops obtained from 6 2.7-3.3 year-old Canadian English children (Gilbert 1976).

TABLE VIII Means and ranges of VOT scores (in msec) for younger speakers of different languages based on the present and literature sources

		p	b	t	d
Afrikaans	$\bar{X}$	+15.87	+8.93	+16.20	+13.01
	Range	-84.00 to +75.00	-106.00 to +27.00	0.00 to +28.00	-54.00 to +33.00
South African English	$\bar{X}$	+27.53	+16.24	+26.94	+14.85
	Range	+13.00 to +66.00	+5.00 to +50.00	+9.00 to +51.00	+6.00 to +27.00
Canadian English (Gilbert 1976)	$\bar{X}$			+140.00	+29.00
	Range			+25.00 to +290.00	0.00 to +95.00

Mean VOTs for all stops were in the short-lag VOT category in the case of young Afrikaans-speakers, although they were smaller for voiced than for voiceless stops. In the young English speakers, mean VOTs for /b/ and /d/ fell into the short-lag category while those of the voiceless stops bordered on the long-lag category. VOTs for South African English children were considerably smaller than those of the Canadian English children, again probably owing to the influence of Afrikaans on the local dialects.

b) Stutterers

The expected language differences for voiceless stops were found between English- and Afrikaans-speakers, ie. that VOTs would be longer in English. This was revealed in central tendency of the mean, MM2, maximum and minimum scores.

2 Spread

a) Nonstutterers

Older groups showed bigger spread of the mean, MM2 and minimum scores in the case of Afrikaans-speakers compared with English. This variability was due to the development of voicing lead in some older Afrikaans children. With one isolated exception, voicing lead (prevoicing) had not yet developed in the younger Afrikaans speakers and so these inter-language differences did not extend to the younger groups. Zlatin and Koenigskecht (1976) also found voicing lead to be a feature of the older children in their American English samples. Only a few instances of voicing lead arose in the older English groups in the present study and these occurred more frequently on /b/ than /d/. In contrast, voicing lead in the Afrikaans-speakers tended to be longer and to occur more frequently on /d/ than on /b/.

Increased variability of the mean, MM2, maximum and minimum scores for /p/ in the older English groups probably reflected the development of the innately-variable long-lag category. If this reasoning is correct, the same trend should have been found for /t/. While that was the case for minimum and maximum scores and the range, the behaviour of the mean, and MM2 was difficult to explain. To a lesser extent, young English speakers showed a similar trend toward increased variability of VOT production for voiceless stops compared with Afrikaans-speakers, since they were beginning to lengthen VOT for the long-lag category.

Older Afrikaans-speakers showed more variability of mean, MM2, minimum scores and the range for voiced stop production than did English-speakers. This was consistent with the development of voicing-lead and was therefore not a feature of the younger groups.

b) Stutterers

On the whole, the stutterers showed the same cross-language trends as did the nonstutterers. The degree of variability amongst English-speaking stutterers was particularly large for /t/. /t/ requires the longest VOT-lag of all the stops and is thus physiologically more difficult to produce (Cooper 1977). It may thus be the most sensitive of the four stops for revealing heterogeneity of the stutterers in terms of their ability to produce complex vocal tract coordinations. The spread of the range for voiced stops was also larger for stutterers compared with nonstutterers. Once again, this highlighted the diversity of productions in this group.

B Age-related trends

1 Central tendency

a) Nonstutterers

English speakers showed age-related differences, which were interpreted as a developmental trend, manifest in VOT lengthening for voiceless stops. This was reflected in higher median values for older English speakers compared with younger ones on MM2, maximum and minimum scores.

b) Stutterers

For the most part, English stutterers failed to show the expected developmental trend of VOT lengthening for voiceless stops /p/ and /t/. Median values for most of the measures were, in fact, lower for older speakers. Two exceptions were modest increases in median VOTs for maximum scores of /p/ and minimum scores of /t/. Since long-lag VOT is physiologically more complex to produce, one might speculate that this failure to show the normal developmental pattern might reflect a neuromuscular maturational lag or dysfunction on the part of stutterers.

If an overall increase in VOT was found across groups with age, this might have indicated that subjects were adopting an artificially slow articulation rate as an anti-expectancy device or using slower transitions owing to a sluggish vocal tract. This was not found.

2 Spread

a) Nonstutterers

For the most part, there was a trend toward increased variability of VOT production with age in the English-speakers. In the case of voiceless stops this may be attributed to the inherent scope of the long-lag VOT category, which permits a wide variety of acceptable scores. This variability masks the decrease in spread which is reported to accompany maturation (Eguchi and Hirsh 1969; DiSimoni 1974d) and which was a feature of the Afrikaans-speakers. However, variability increased with age for voiced stops as well, perhaps as a result of re-adjustment of phonetic boundaries.

Afrikaans-speakers showed no change, or a decrease in variability with age for voiceless stops. Voiced stops were accompanied by increased variability with age in these groups, owing to the development of voicing lead as a stylistic variant in some speakers.

b) Stutterers

English stutterers demonstrated some increased variability of VOT production of voiceless stops with age, but the trend was less convincing than in the case of nonstutterers and may have been the result of failure to lengthen the VOT properly. Production of voiced stops did not change or decreased in variability.

Afrikaans stutterers behaved similarly to nonstutterers with regard to

voiceless stops. The two groups were also comparable in terms of increased variability for MM2 and minimum scores, reflecting the development of voicing lead.

C Comparisons between stutterers and nonstutterers

1 Central tendency

In the case of young English speakers, stutterers tended to produce longer VOTs on voiceless stops than did nonstutterers. There was a slight trend in this direction for voiced stops. Young Afrikaans stutterers showed a similar slight trend toward longer VOTs compared with nonstutterers on both voiced and voiceless stops. On the whole, older Afrikaans stutterers maintained the trend toward longer VOTs compared with nonstutterers though the trend was small and in some instances there were no differences between groups.

Older English stutterers showed the reverse trend for voiceless stops, ie. VOTs were shorter than those produced by nonstutterers. The two groups did not differ much on voiced stops. In general, however, stutterers produced longer VOTs than did nonstutterers. These results are in agreement with Agnello's child stuttering data (Agnello cited by Starkweather 1983) as well as that for adult stutterers at fluent utterance-initial positions (Healey and Gutkin 1984).

The trend towards longer VOTs on the part of stutterers in all but the older English groups might reflect a neuromuscular difficulty. The older English stutterers seemed to be experiencing difficulty with the increased physiological demands of voiceless stops since long-lag VOTs require more complex coordinations than do short-lag VOTs. The fact that Afrikaans stutterers, who did not have to contend with long-lag VOT, clearly differentiated between voiced and voiceless stops tends to rule out phonological confusion as accounting for the results. Older English stutterers failed to match their nonstuttering peers in terms of VOT lengthening for /paf/ and /taf/. This notion is supported by the data on developmental trends discussed in the previous section.

2 Spread

There was a large, consistent trend toward greater variability of VOT production by stutterers than nonstutterers for /taf/. This applied to both older and younger speakers. /taf/ appeared to be a particularly sensitive syllable for revealing group differences.

For the most part, stutterers were more variable than nonstutterers in VOT production for /paf/. An exception was the older English groups with respect of the mean, MM2 and minimum scores. The two groups did not differ in terms of range of maximum scores for /paf/, however, and the stutterers had a bigger spread of the range reflecting great intra-group variability amongst the stutterers.

In the case of young Afrikaans-speakers, stutterers showed increased variability compared with nonstutterers for voiced, as well as voiceless stops. This trend for voiced stops tended to be reversed for some measures

in the case of older speakers, the increased variability on the part of older Afrikaans nonstutterers reflecting the development of voicing lead in certain speakers. In the case of young English-speakers, stutterers tended to be more variable than nonstutterers on voiced, as well as voiceless, stops. Perhaps the increased variability on the part of younger English and Afrikaans stutterers compared with nonstutterers could be a manifestation of linguistic or neuromuscular immaturity.

IX CONCLUSIONS

A Cross-language data

1. English-speaking nonstutterers used longer VOTs on voiceless stops compared with Afrikaans-speakers, this trend being greater in the case of older compared with younger speakers.
2. South African English-speakers employed short- and long-lag VOT categories for voiced and voiceless stops respectively, however VOT values were smaller than those reported for American and Canadian English children.
3. Afrikaans-speakers appeared to use two sets of unaspirated stops which fell into the short-lag category. Voiced stops were randomly prevoiced.
4. Older Afrikaans nonstutterers were more variable in their production of voiced stops than were English-speakers, mainly owing to the development of voicing lead.
5. English nonstutterers were more variable than Afrikaans-speakers for voiceless stops, and this was attributed to the wide range of permitted scores in the long-lag category.
6. On the whole, stutterers showed the same cross-language trends as did the nonstutterers. However variability of production tended to be somewhat larger in the stuttering groups.

B Normal developmental data

1. English nonstutterers demonstrated a developmental trend toward lengthening of VOT scores for voiceless stops. Variability of production increased as well, probably due to the wide range of permitted scores in the long-lag VOT category and this masked presumed decrease in variability with age as a function of improved neuromaturation. Greater variability of VOT for /t/ may also reflect the greater precision of relative onset of muscle gestures required for the voiceless stop.
2. Afrikaans nonstutterers did not display VOT lengthening for voiceless stops with age, since they did not employ the long-lag category. Their variability of VOT production on voiceless stops decreased with

age, probably as a function of more mature neuromuscular skills and is in agreement with the literature. However, variability of VOT production on voiced stops increased with age and this was attributed to the development of voicing lead in some speakers.

C Comparisons between stutterers and nonstutterers

1. English stutterers failed to show the expected developmental trend of VOT lengthening for voiceless stops. Variability of production of voiceless stops did increase with age, but the trend was smaller than in the case of nonstutterers.
2. Afrikaans stutterers behaved similarly to nonstutterers in terms of increasing variability of VOT production of voiced stops with age owing to the development of voicing lead.
3. With the partial exception of older English stutterers, stutterers demonstrated longer VOTs than did nonstutterers of both languages and this is in agreement with the literature. However the extent of the between group differences varied between age groups and languages.
4. Older English stutterers appeared to be experiencing difficulty with the physiological demands of the long-lag VOT category. This was reflected in their failure to match the VOT lengthening of their nonstuttering peers. Since Afrikaans stutterers clearly distinguished between voiced and voiceless stops, the developmental lag on the part of English stutterers in terms of voiceless stop production seemed to reflect a neuromuscular timing disorder rather than a phonological one. The nature of the difficulty is unknown, however, since data from experiments three and four did not support the idea that stutterers might simply have slower articulation than nonstutterers.
5. For the most part, stutterers of both languages were more variable in their productions of voiceless stops than were nonstutterers. Young stutterers of both languages were more variable than were nonstutterers in terms of VOT production on voiced stops as well. This enhanced variability of VOT production on the part of stutterers may be indicative of neuromuscular immaturity.

CHAPTER THREE

EXPERIMENT TWO

THE ACQUISITION OF CATEGORICAL LABELLING INVOLVING THE VOICING DISTINCTION

- I Aims of the experiment
- II Hypothesis
- III Outline of the experimental design
- IV Material
- V Procedures for data collection
- VI Data analysis
- VII Results
- VIII Discussion
- IX Conclusions

I AIMS OF THE EXPERIMENT

The aims of this experiment were:

1. To compare English- and Afrikaans-speaking children (stutterers and nonstutterers) with respect of their performance on tasks requiring categorical labelling and employing the voiced/voiceless auditory perceptual-phonological distinction.
2. To compare the performance on such categorical labelling tasks of younger and older subjects (stutterers and nonstutterers) from both languages.
3. To ascertain whether or not stuttering children differed from non-stutterers in terms of their performance on such labelling tasks.

Although the nature of this experiment differed from the other three in the present study it was felt to be necessary to include a measure of the receptive capacities of the subjects, related to the dimensions being measured on the productive side, since a positive finding concerning the receptive abilities of stutterers would caution against over-interpretation (in the direction of neuromuscular explanations) of the findings on the other three experiments.

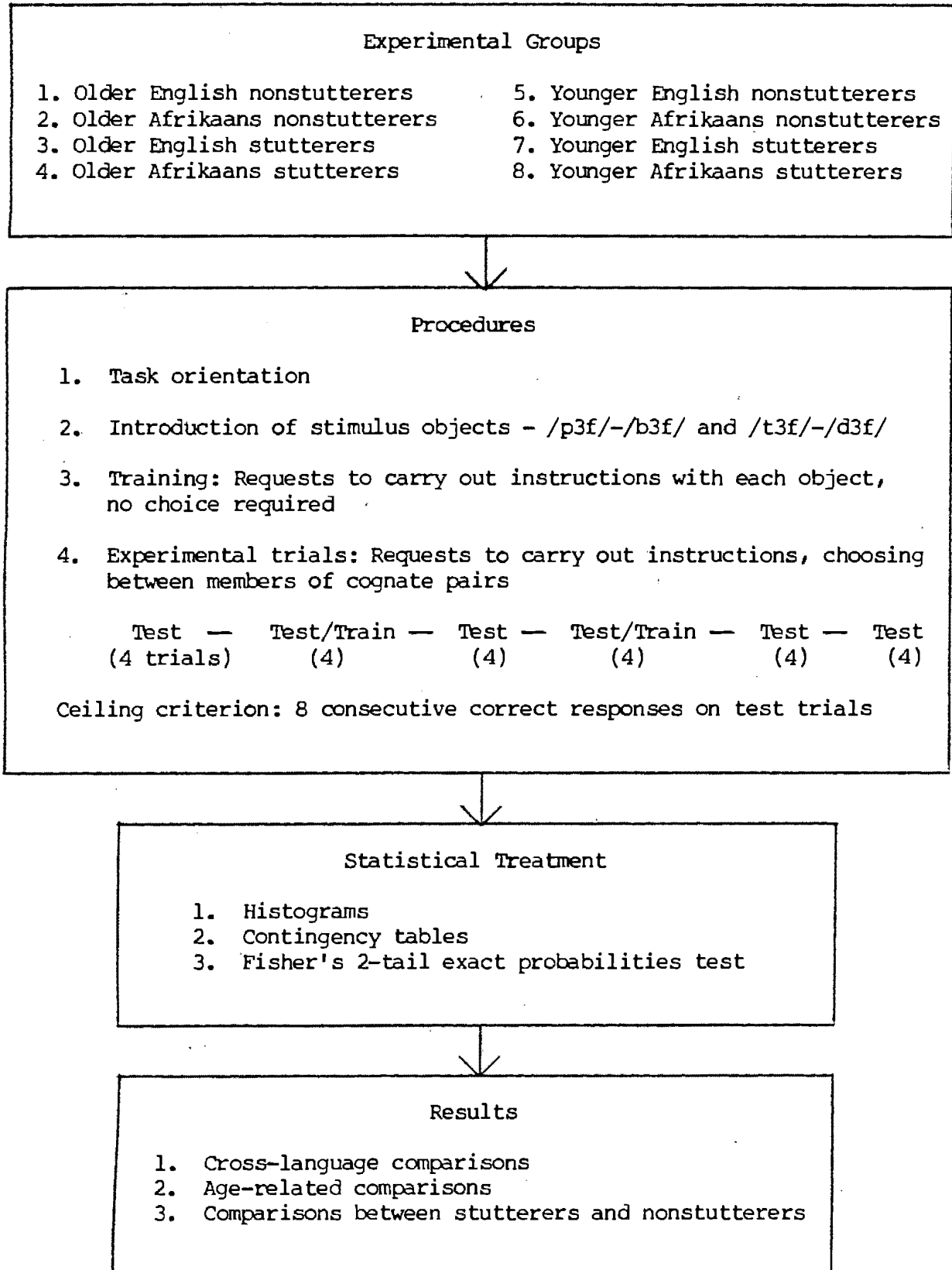
II HYPOTHESIS

1. Since it was demonstrated in experiment one that VOT values for voiced/voiceless cognates fall into the short-lag category for the Afrikaans-speaking children, it was anticipated that they would find the auditory perceptual component of the categorical labelling task more difficult than would the English-speakers. Short-lag VOTs may be associated with fewer perceptual cues, such as lack of F1-transition information, compared with long-lag VOT. It was thus hypothesized that the young Afrikaans-speaking children would require more training trials than their English-speaking peers to achieve correct labelling and that fewer of them might achieve it by the time testing was abandoned. These cross-language differences were no longer expected to be apparent in the older groups, owing to the effects of maturation.
2. It was postulated that older children would need fewer additional training trials, if any, to achieve correct labelling than would younger children. While some younger children might fail to achieve correct labelling by the end of testing, all the older children were expected to have achieved it.
3. Since many of the studies reviewed in Chapter One have strongly suggested the presence of some sort of motor disorder of speech timing in stutterers and the results of investigation into the linguistic abilities of stutterers have so far failed to identify specific disorders (Andrews et al 1982) it was not expected that the stuttering children in this study would differ from the nonstutterers in terms of their performance on the categorical labelling tasks.

III OUTLINE OF THE EXPERIMENTAL DESIGN

A summary of the design for this experiment appears in Table IX:

TABLE IX Outline of research design for experiment two



IV MATERIAL

Four objects, which were unlikely to have had any prior semantic associations for the subjects were assigned names consisting of CVC nonsense syllables. These syllables were phonologically acceptable in both English and Afrikaans, viz:

/p3f/ /b3f/ /t3f/ /d3f/

The syllables formed two sets of minimal pairs incorporating the voicing distinction at each place-of-articulation.

The objects were painted cardboard figures, differing in basic shape and colour. They were given individual facial characteristics and features which transformed them into "funny little people" or "snaakse klein mannetjies". Fig.9 in the Appendix shows sketches illustrating the four objects.

V PROCEDURES FOR DATA COLLECTION

The procedures used were similar to those employed by Garnica (1971) in her more structured repetition of Schvatchin's earlier study (1948).

The task facing the subjects was to learn which of the four nonsense syllable labels, /p3f/ /b3f/ /t3f/ or /d3f/, fitted which object. They had to demonstrate categorical labelling by carrying out the experimenter's requests to perform actions with the appropriate objects. /p3f/ and /b3f/ were always presented together, as were /t3f/ and /d3f/.

Testing took place individually, in the same sound-treated rooms as were used for experiment one. The same two experimenters were used, so that each subject was given instructions by an adult speaker of his home language. The instructions are only described in English in the following sections. Equivalent forms were used with Afrikaans subjects. The English-speaking experimenter used the high schwa vowel and aspirated the initial stop plosive in naming the experimental objects. The Afrikaans-speaking experimenter used unaspirated initial stops and a somewhat lower neutral vowel, although it was not quite a low schwa.

Step 1. Task orientation

A toy car and a ball were placed in front of the subject and named aloud by the experimenter. The subject was then asked by the experimenter to perform three actions with each object, eg. "Put the ball on the table." "Drive the car under the chair." "Give me the car". "Kick the ball."

Responses were accepted as correct if the subject selected the appropriate object and attempted to perform some action with it. Comprehension of the prepositions in the requests, motor skill in executing the tasks, etc, were not prerequisites for success. If a subject was unwilling or unable to carry out a request, the experimenter demonstrated it and then encouraged the child to imitate the action.

None of the subjects failed the orientation trials. Once the car and ball had

been removed the experimental objects were introduced in pairs, in the following way:

Step 2. Introduction of experimental objects

The experimenter introduced the first pair of experimental objects as follows: "Here are two funny little people who have come to play with us today. Look, here's one of them." (Shows object 1). "This is /p3f/. /p3f/ says hello.....(child's name). Say hello to /p3f/." The experimenter then went on to point out distinguishing features of the object's appearance, after which it was placed in front of the subject. The second object was then introduced. Experimenter: "Here's another funny little person who's come to play. He has a different name. His name is /b3f/." Object two was discussed, the child encouraged to repeat the name, and it was then placed alongside the first object. Their names were then repeated aloud by the experimenter, who pointed to them in turn.

Step 3. Training trials: Requests to perform actions with the objects, no choice being required

The experimenter named one of the objects and asked the subject to perform a simple action with it, eg. "This is /p3f/. Let /p3f/ sit on the chair." Correct responses were rewarded if the appropriate object was selected, even if the action was incorrect. Requests for action were not standardized but adapted to suit the interest and motivational levels of the individual subjects. If the subject chose the incorrect object, the experimenter interrupted the activity, telling him that he had made a mistake. The experimenter pointed to the correct object, repeated the instruction and rewarded the subject by means of praise when it was subsequently carried out correctly. The response for that trial was scored as incorrect and an extra trial given for that object. Once the subject had correctly carried out three requests with each of the two objects, the experimental trials began.

Step 4. Experimental trials: Requests to perform actions with the objects, a choice being required

The experimenter asked the subject to perform a series of actions with one or the other object. The child was given no clues as to which was the appropriate object to select. The requests took the following forms:

1. Giving the object to the experimenter, eg. "Give me /p3f/."
2. Placing the object, eg. "Put /t3f/ on the table."
3. Showing the object something, eg. "Show /b3f/ the car."
4. Feeding the object, eg. "Give /d3f/ a cup of tea."
5. Letting the object 'talk' on a toy telephone.
6. Pointing to the object.
7. Shooting at the object with a toy gun.

8. Hiding the object.

As was the case with the previous step, instructions were not predetermined but varied on an ad hoc basis according to the interests and abilities of the individual children. Instructions were only given if the subject was attending to the experimenter. The objects were presented in cognate pairs. Subjects were randomly assigned to receive /p3f/-/b3f/ or /t3f/-/d3f/ first. The trials for each pair of objects were structured as follows:

1. 4 test trials (2 instructions for each syllable).
2. a) 4 more test trials, if all of (1) were scored correct.
b) If any error occurred on (1), 4 training trials were given, 2 for each syllable.
3. 4 test trials.
4. a) 4 test trials or
b) 4 training trials.
5. 4 test trials.
6. 4 more test trials if (5) were scored correct, following training trials on (4).

The maximum possible trials attempted by a subject was 24. In practice, most subjects performed fewer trials, since a ceiling of eight consecutive test trials, correctly performed, was the criterion for cessation of testing. After 24 trials, the procedures were discontinued even if a subject was still making errors and the second pair of objects was introduced. All the trials, for a given subject, took place within one uninterrupted session.

VI DATA ANALYSIS

1. Histograms (Figs.10a and 10b).
2. Contingency tables were devised, illustrating the percentage of subjects in each group who required varying amounts of training trials in order to reach the criterion. Table X contains the contingency tables for the /p/-/b/ pair while Table XI contains tables for /t/-/d/. Figs.11a to 11d show learning curves for the acquisition of cognate pair labelling in the experimental groups.
3. The Fisher 2-tail exact probabilities test was performed to test for independence of the /p/-/b/ and /t/-/d/ pairs.

VII RESULTS

The histograms will not be discussed separately since the same results are reflected in the contingency tables.

A Contingency tables

1 Younger subjects

a) /p-/b/

Once the experimental trials began, very few of the younger subjects, stutterers or nonstutterers, applied the correct labels to the objects without undergoing further training. However, the younger subjects from the respective language groups differed in terms of the number of trials required to reach the criterion. 46.67% of the nonstuttering English-speakers reached criterion after one set of additional training trials, and a further 40% after 2 additional sets of training trials. Only 13.33% failed to reach the criterion. In contrast, while more young Afrikaans nonstutterers achieved correct labelling on the first experimental trials (13.33%) as compared with none of the English speakers, only a further 6.67% did so after two sets of training trials. 73.33% of the young Afrikaans nonstutterers failed to reach criterion.

These differences between the language groups were also demonstrated by the stuttering groups. However, their performance was a little better than that of the nonstutterers, with only 6.67% of English stutterers and 60% of Afrikaans stutterers failing to reach criterion.

b) /t-/d/

As was the case with the /p-/b/ cognate pair, very few of the younger subjects achieved correct labelling without additional training trials. The differences between the two language groups were less marked for this pairing than for /p-/b/, however after one additional set of training trials 46.67% of the English nonstutterers and 40% of the Afrikaans nonstutterers had reached criterion. The criterion was never reached by 53.33% of English nonstutterers and 60% of Afrikaans nonstutterers. These cross-language trends were maintained by the young stutterers. Once again, they fared considerably better than nonstutterers in achieving categorical labelling, only 20% of the English-speakers and 26.67% of the Afrikaans-speakers failing to reach criterion for /t-/d/.

Young English-speakers, both stutterers and nonstutterers, appeared to find the /p-/b/ labelling task easier than the /t-/d/ one. The reverse was true for Afrikaans-speakers.

2 Older Subjects

As was anticipated, there was a trend for older subjects to perform considerably better on the categorical labelling tasks than did younger subjects. Results for /p-/b/ and /t-/d/, were similar for these older groups.

86.67% of English nonstutterers and 93.33% of Afrikaans nonstutterers achieved correct labelling of /p/-/b/ without additional training trials. None failed to reach the criterion. 93.33% of English nonstutterers and 80% of Afrikaans nonstutterers achieved correct labelling of /t/-/d/ without additional training. Once again, none failed to reach criterion.

There was a slight tendency for English-speaking stutterers to perform poorer than their nonstuttering peers. On the /p/-/b/ task, 73.33% achieved correct labelling without further training, the remainder reaching criterion after one additional set of training trials. For the /t/-/d/ pair, 73.33% of this group achieved correct labelling on commencement of the experimental trials, a further 20% after one additional set of training trials, while 6.67% failed to reach criterion.

A striking finding was that older Afrikaans-speaking stutterers performed considerably poorer than their nonstuttering peers on both the /p/-/b/ and /t/-/d/ labelling tasks. For /p/-/b/, only 53.33% of Afrikaans stutterers achieved correct labelling without further training (compared with 93.33% of their nonstuttering controls) 26.67% of the Afrikaans stutterers failed to reach criterion. The figures for /t/-/d/ are comparable, ie. 60% of older Afrikaans stutterers achieved correct labelling without additional training (compared with 80% of the controls) while 26.67% never reached criterion.

The contingency table data of Tables X and XI was plotted on learning curves (Figs.11a to 11d).

B Results of the Fisher 2-tail exact probabilities test

The Fisher test was administered to ascertain whether or not there was a significant association between the performance of individuals on the /p/-/b/ pairing compared with the /t/-/d/ task (Table XII). The only significant positive finding was that of an association between the cognate pairs in the case of the older English stutterers. However, with a probability value of 0.0330 this was only significant at the 5% level of confidence. The overall, and somewhat surprising, finding was that performance on the /p/-/b/ labelling task was independent of performance on the /t/-/d/ task.

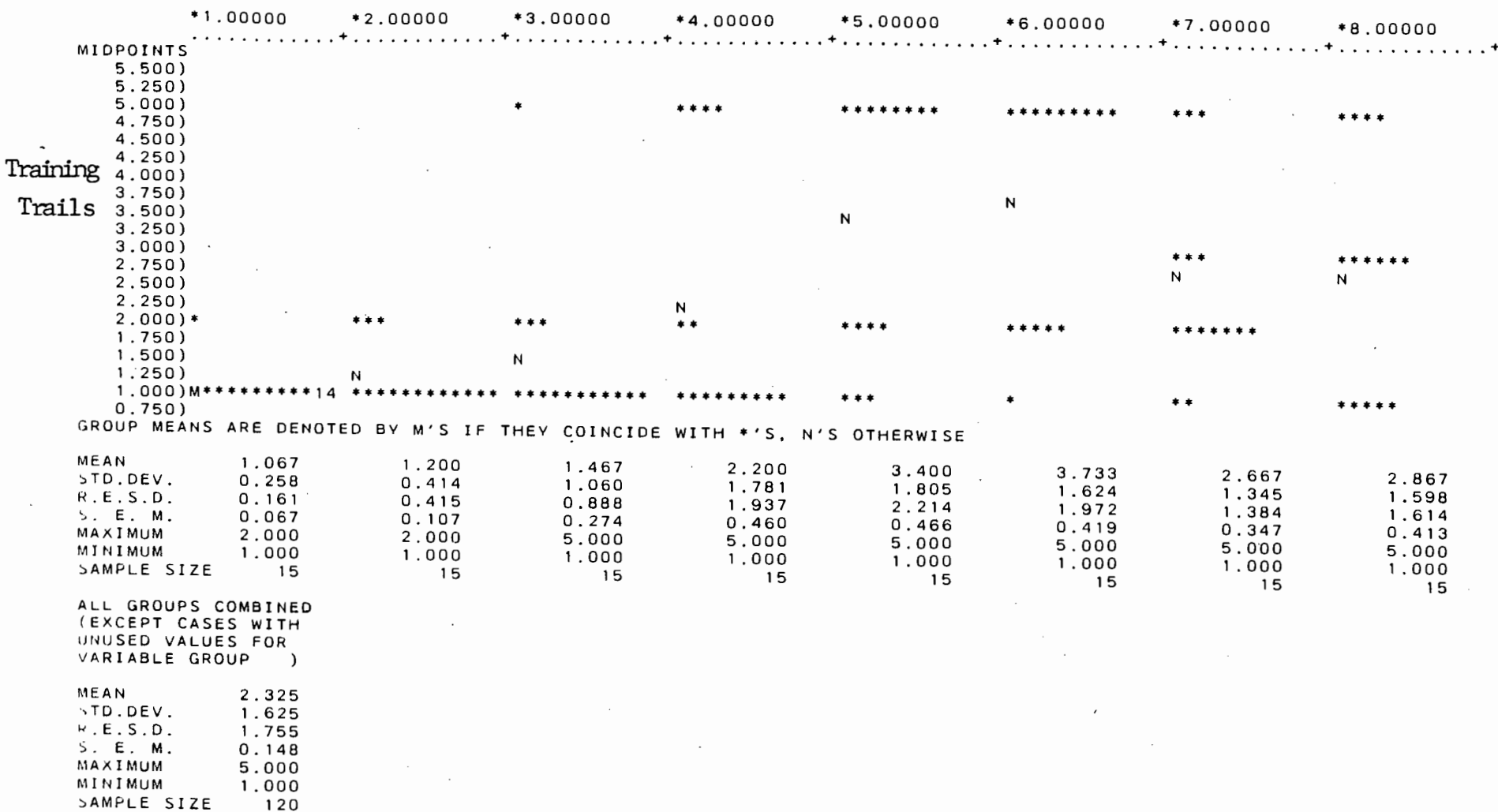


Fig. 10b Histograms showing the numbers of subjects requiring varying degrees of training for categorical labelling of the /t3f/-/d3f/ pair.

TABLE X

Contingency table illustrating the numbers and percentages of subjects in each group requiring additional training trials to reach criterion for categorical labelling involving the /p/-/b/ distinction.

		EXPERIMENTAL GROUPS								TOTAL
		1	2	3	4	5	6	7	8	
A	Frequency	13	14	11	8	0	2	4	2	54
	Column %	86.67	93.33	73.33	53.33	0.00	13.33	26.67	13.33	45.00
B	Frequency	2	1	4	2	7	1	5	4	26
	Column %	13.33	6.67	26.67	13.33	46.67	6.67	33.33	26.67	21.67
C	Frequency	0	0	0	1	6	1	5	0	13
	Column %	0.00	0.00	0.00	6.67	40.00	6.67	33.33	0.00	10.83
D	Frequency	0	0	0	4	2	11	1	9	27
	Column %	0.00	0.00	0.00	26.67	13.33	73.33	6.67	60.00	22.50
		15	15	15	15	15	15	15	15	120
		12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	100.00

Key to y-axis: A = Results after the basic training trials (Step 3).

B = Results after 1 additional set of training trials.

C = Results after 2 additional sets of training trials.

D = Number and % of subjects failing to achieve correct labelling by test cessation.

TABLE XI

Contingency table illustrating the numbers and percentages of subjects in each group requiring additional training trials to reach criterion for categorical labelling involving the /t/-/d/ distinction.

EXPERIMENTAL GROUPS										
	1	2	3	4	5	6	7	8	TOTAL	
A	Frequency	13	14	11	8	0	2	4	2	57
	Column %	86.67	93.33	73.33	53.33	0.00	13.33	26.67	13.33	47.50
B	Frequency	2	1	4	2	7	1	5	4	25
	Column %	13.33	6.67	26.67	13.33	46.67	6.67	33.33	26.67	20.83
C	Frequency	0	0	0	1	6	1	5	0	9
	Column %	0.00	0.00	0.00	6.67	40.00	6.67	33.33	0.00	7.50
D	Frequency	0	0	0	4	2	11	1	9	29
	Column %	0.00	0.00	0.00	26.67	13.33	73.33	6.67	60.00	24.17
		15	15	15	15	15	15	15		120
		12.50	12.50	12.50	12.50	12.50	12.50	12.50		100.00

Key to y-axis:

- A = Results after the basic training trials (step 3).
- B = Results after 1 additional set of training trials.
- C = Results after 2 additional sets of training trials.
- D = Number and % of subjects failing to achieve correct labelling by test cessation.

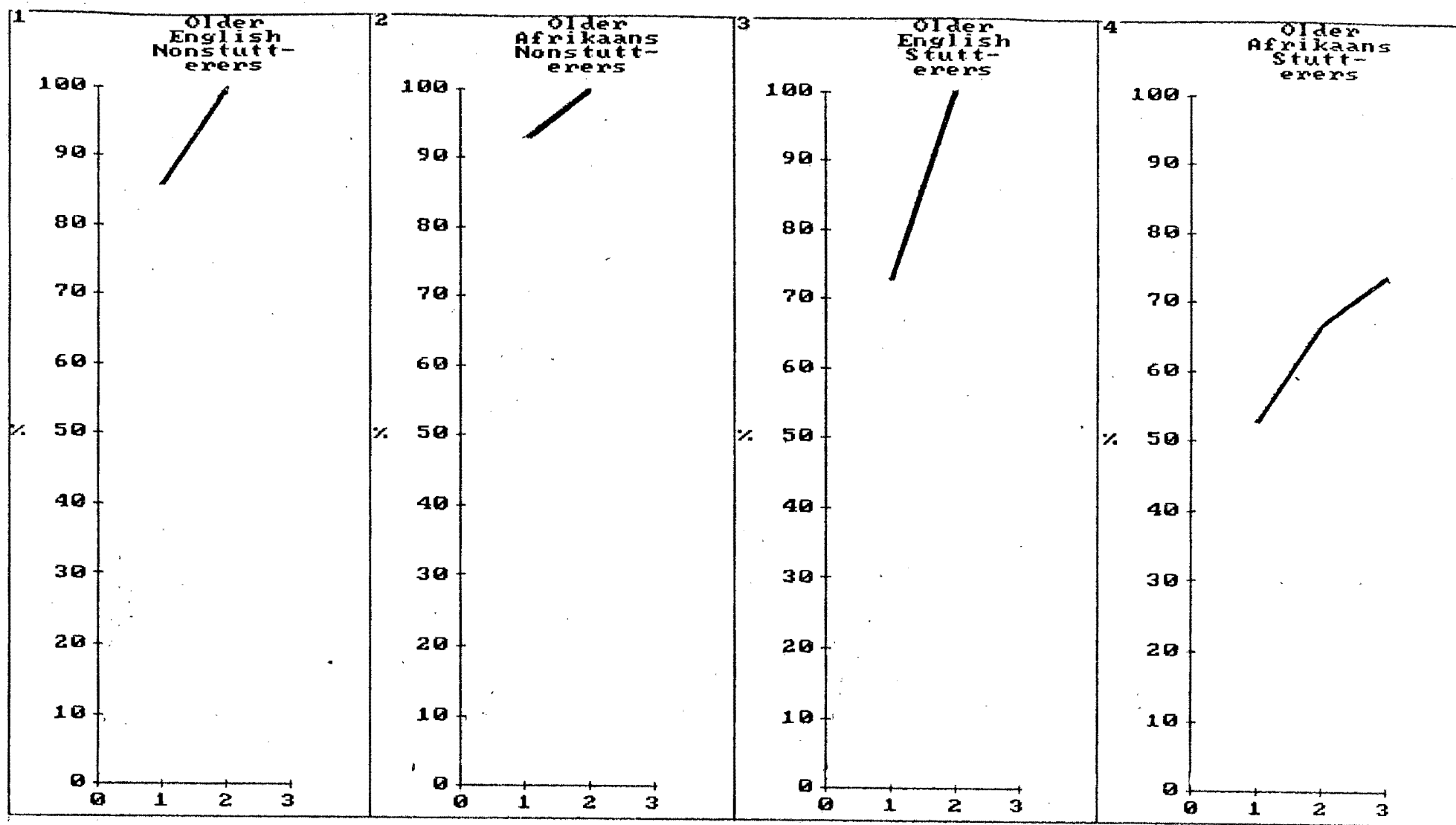


fig. 11a Learning curves illustrating performance of older groups on the categorical labelling task for the /p/-/b/ pair.

Key: y-axis = % Subjects achieving correct labelling
 x-axis = 1 - after demonstration
 2 - after one additional set of training trials
 3 - after two additional sets of training trials.

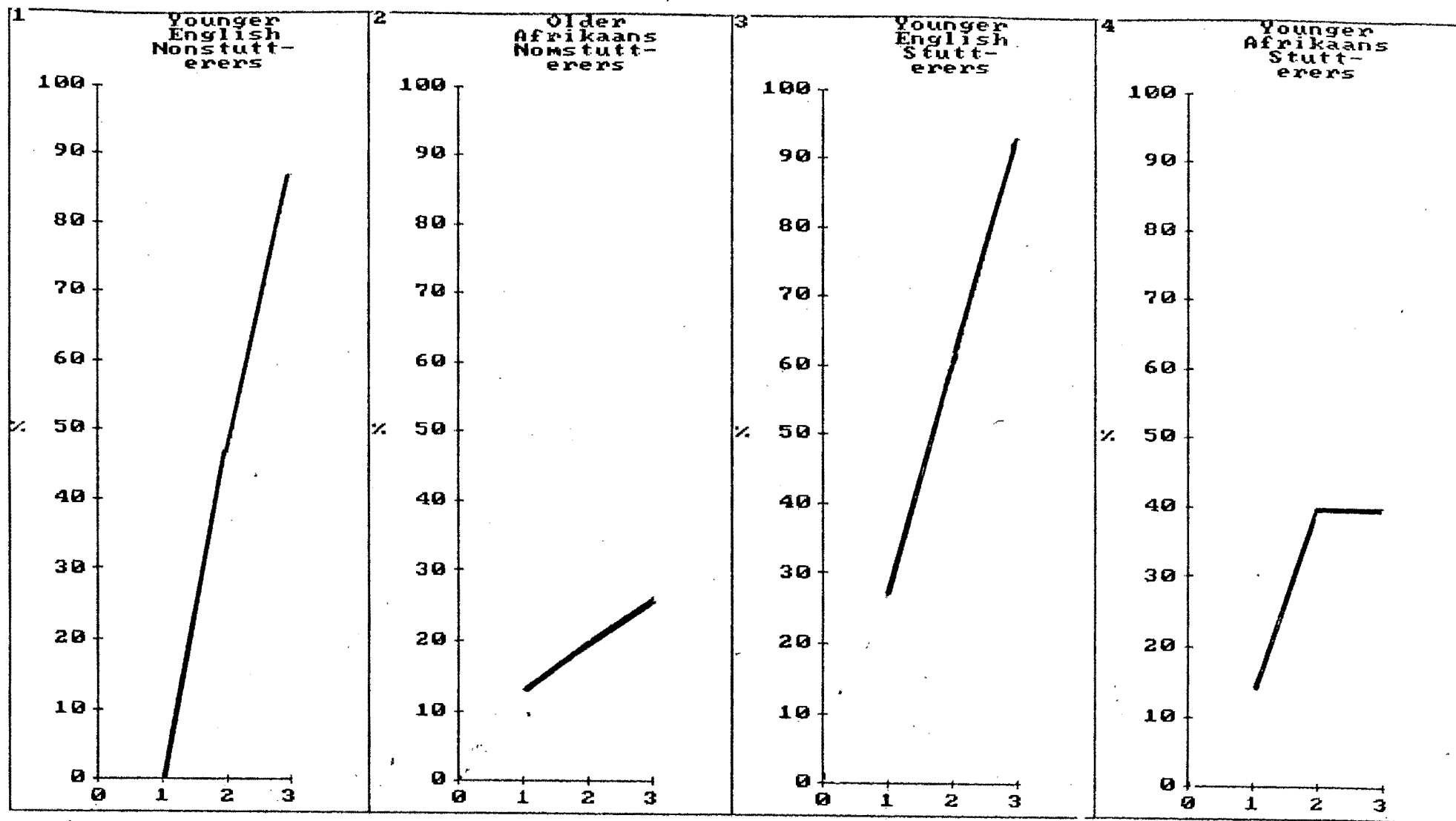


Fig. 11b Learning curves illustrating performance of younger groups on the categorical labelling task for the /p/-/b/ pair.

Key: y-axis = % Subjects achieving correct labelling
x-axis = 1 - after demonstration
2 - after one additional set of training trials
3 - after two additional sets of training trials.

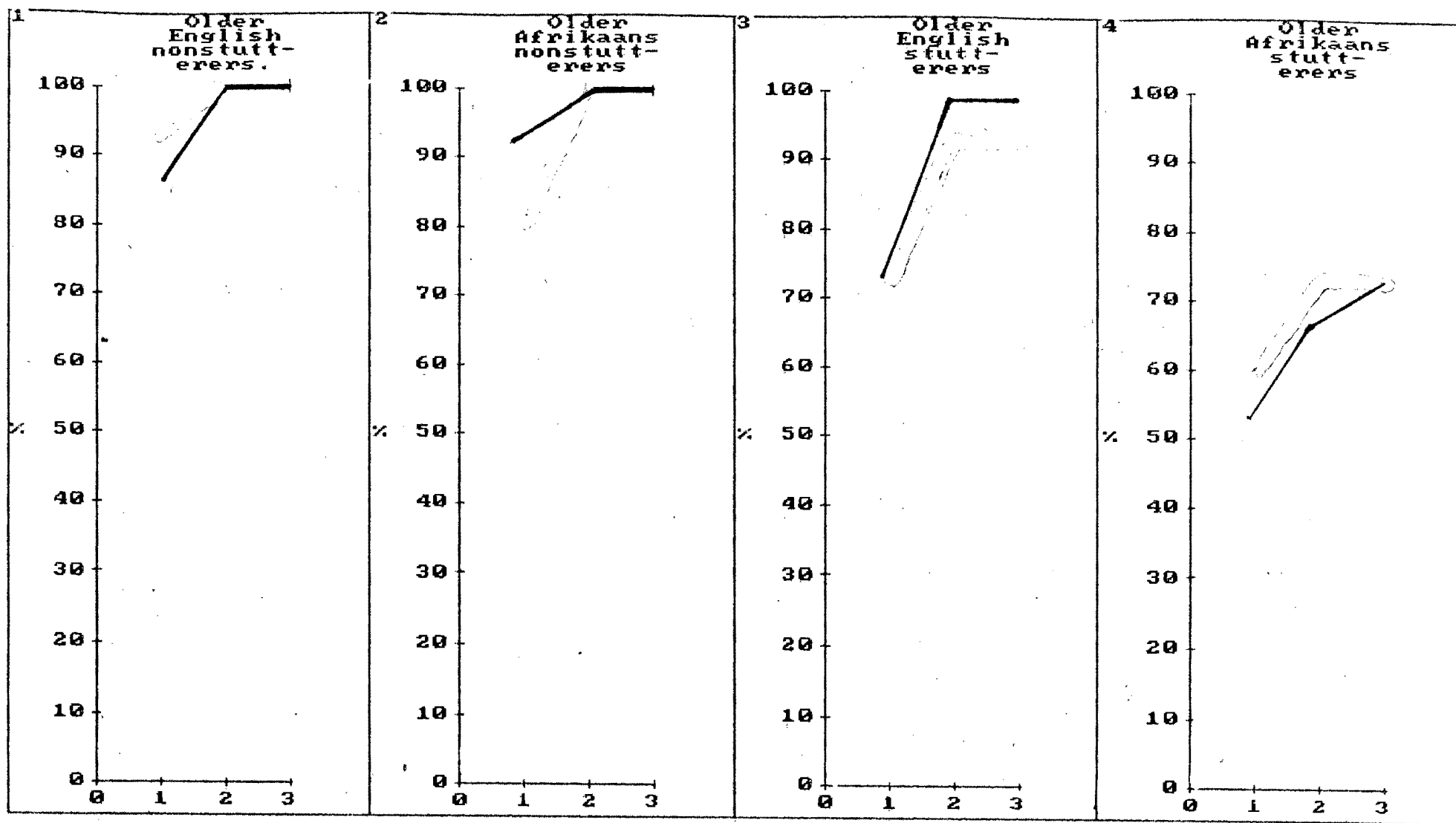


Fig 11c Learning curves showing performance of older groups on the /t/-/d/ categorical labelling task.

Key: y-axis = % Subjects achieving correct labelling

x-axis = 1 - after demonstration

2 - after one additional set of training trials

3 - after two additional sets of training trials.

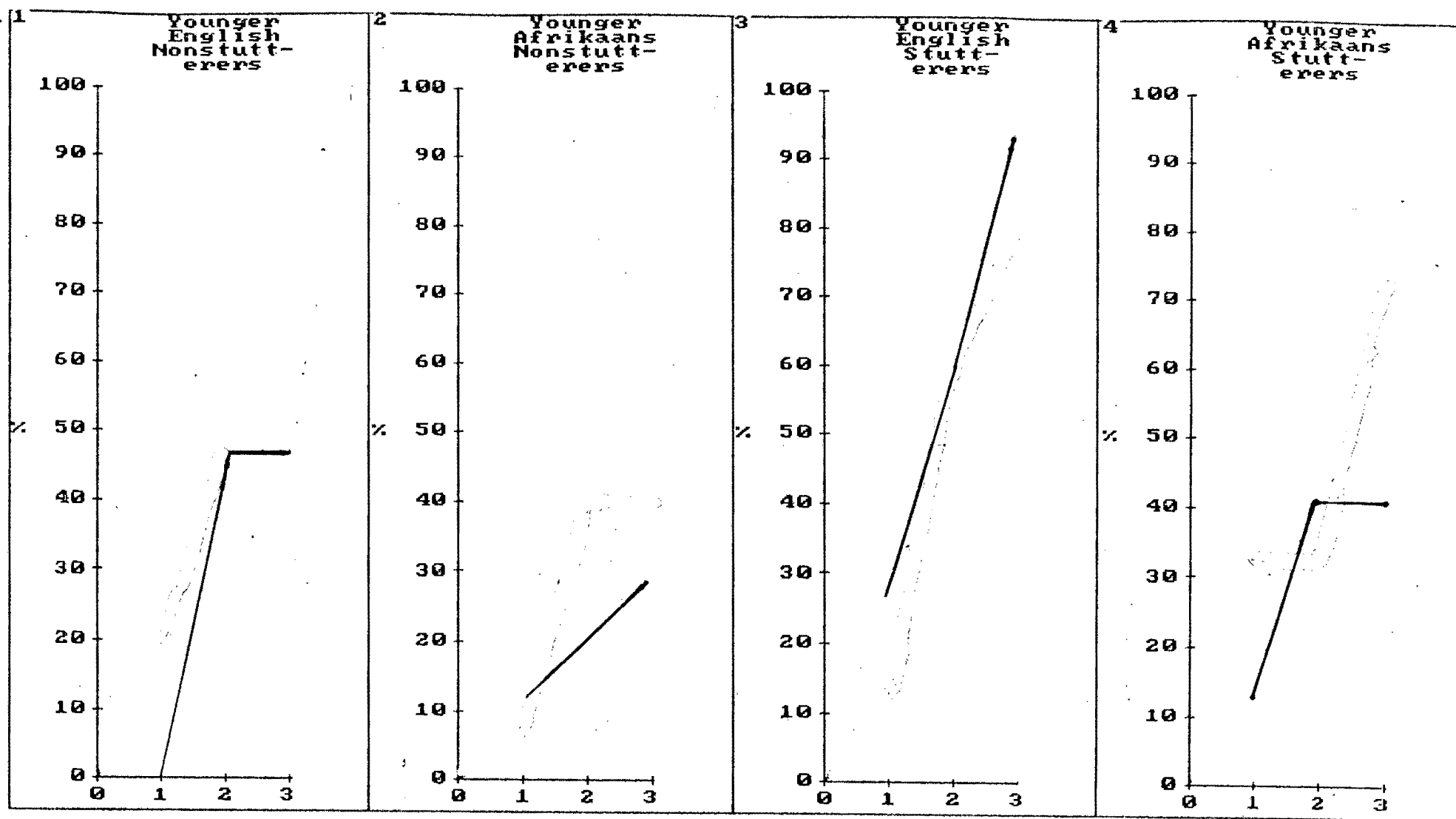


Fig. 11d Learning curves showing performance of younger groups on the /t/-/d/ categorical labelling task.
 Key: y-axis = % Subjects achieving correct labelling.
 x-axis = 1 - after demonstration
 2 - after one additional set of training trials
 3 - after two additional sets of training trials.

TABLE XII Results of the Fisher 2-tail test for exact probabilities

Group 1				Group 2			
	1	2	Total		1	2	Total
1 Freq	12	1	13	1 Freq	12	2	14
%	85.71	100.00	86.67	%	100.00	66.67	93.33
2 Freq	2	0	2	2 Freq	0	1	1
%	14.29	00.00	13.33	%	0.00	33.33	6.67
Total	14	1	15	Total	12	3	15
	93.33	6.67	100.00		80.00	20.00	100.00
Probability=1.0000				Probability=0.2000			
Group 3				Group 4			
	1	2	Total		1	2	Total
1 Freq	10	1	11	1 Freq	6	2	8
%	90.91	25.00	73.33	%	66.67	33.33	53.33
2 Freq	1	3	4	2 Freq	3	4	7
%	9.09	75.00	26.67	%	33.33	66.67	100.00
Total	11	4	15	Total	9	6	15
	73.33	26.67	100.00		60.00	40.00	100.00
Probability=0.0330				Probability=0.3147			
Group 5				Group 6			
	1	2	Total		1	2	Total
1 Freq				1 Freq	0	2	2
%				%	0.00	14.29	13.33
2 Freq	3	12	15	1 Freq	1	12	13
%	100.00	100.00	100.00	%	100.00	85.71	86.67
Total	3	12	15	Total	1	14	15
	20.00	80.00	100.00		6.67	93.33	100.00
				Probability=1.0000			
Group 7				Group 8			
	1	2	Total		1	2	Total
1 Freq	1	3	4	1 Freq	2	0	2
%	50.00	23.08	26.67	%	40.00	0.00	13.33
2 Freq	1	10	11	2 Freq	3	10	13
%	50.00	76.92	73.33	%	60.00	100.00	86.67
Total	2	13	15	Total	5	10	15
	13.33	86.67	100.00		33.33	66.67	100.00
Probability=0.4762				Probability=0.0952			

Key: 1 On x- and y-axes = results after basic training trials.

2 On x- and y-axes = subjects requiring additional training trials.

VIII DISCUSSION

1 Cross-language findings

Cross-language differences in performance on the categorical labelling tasks were apparent in the younger groups. Young English-speakers performed markedly better than did their Afrikaans-speaking peers. They required less additional training to achieve correct labelling and most of them had achieved it by the end of testing. This trend was demonstrated by both stutterers and nonstutterers. The explanation probably lies in the fact that Afrikaans employs short-lag VOT categories for both voiced and voiceless stops. Afrikaans listeners, in hearing their own language, may have relatively few perceptual cues available to them, other than VOT. In common with the French-speaking children in the Simon and Fourcin study (1978), they did not have the same access as did the English children to F1 transition information.

In agreement with Schvachkin (1948 translation in Ferguson and Slobin 1973) it was found that subjects could correctly repeat the objects' names even when they had not achieved correct labelling. Inability to correctly perform the labelling task must, therefore, reflect a cognitive level higher than that of auditory perception-oral motor encoding. It seems to be language-specific and a learned phenomenon, as opposed to basic VOT boundary identification, which appears to be an innate psychoacoustic capability (Kuhl and Miller 1978).

The Afrikaans listeners in this study had a more difficult basic perceptual task than did their English counterparts and, although they coped adequately when simply repeating the syllables, when they were stressed by the more complex categorical labelling task, their performance deteriorated. Since there is no reason to believe that Afrikaans children are more poorly endowed than are English children in other components of the categorical labelling task, such as auditory memory, visual perception, auditory-visual integration, etc, it seems feasible to attribute the findings of this experiment to differences in the availability of auditory perceptual cues in the respective languages.

2 Age-related data

Very few of the younger subjects achieved correct labelling without additional training trials and, by the time testing was discontinued, many of them were still having difficulty in applying the voiced-voiceless perceptual contrast within the categorical labelling paradigm. However, the marked cross-language differences in this regard should be noted and are clearly reflected in the contingency tables.

In the older age groups, few of the nonstutterers required any additional training to achieve correct labelling and none of them failed to achieve it. It appeared that, by 6 and 7 years of age, performance was approaching adult values.

3 Comparisons between stutterers and nonstutterers

In the younger age groups, the performance of the stutterers was comparable

CHAPTER FOUR

EXPERIMENT THREE

AN EXAMINATION OF THE CLOSURE DURATION OF MEDIAL STOP PLOSIVES IN /a/ AND /i/
VOWEL ENVIRONMENTS IN VCV NONSENSE SYLLABLES

- I Aims of the experiment
- II Outline of the experimental design
- III Hypotheses
- IV Material
- V Procedures
- VI Data analysis
- VII Statistical treatment
- VIII Results
- IX Discussion
- X Conclusions

I AIMS OF THE EXPERIMENT

The aims of this experiment were to determine whether there were any trends differentiating the eight experimental groups in terms of stop closure duration in VCV nonsense syllables. The following dimensions were of interest:

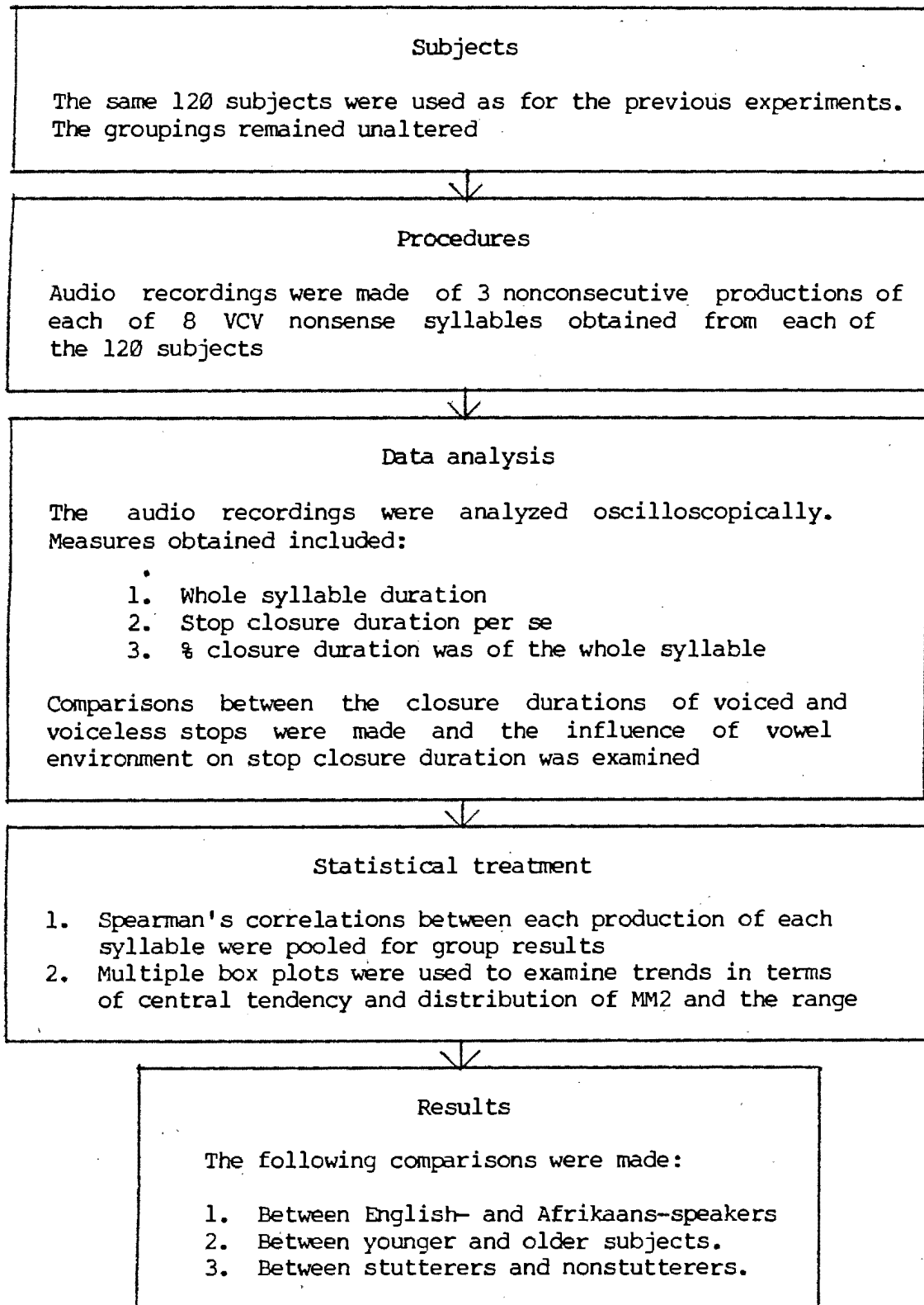
1. Stop closure duration.
2. Whole syllable duration.
3. If whole syllable duration varied amongst the groups, it was considered necessary to examine the percentage of the syllable occupied by stop closure duration.
4. The voicing distinction as manifest in differential stop closure duration values.
5. The influence of the vowel environment on stop closure duration.

The objectives included a cross-language comparison between English- and Afrikaans-speakers, an attempt to establish age-related trends and a comparison between stutterers and nonstutterers in terms of the above dimensions.

II OUTLINE OF THE EXPERIMENTAL DESIGN

A summary of the design for this experiment appears in Table XIII:

TABLE XIII Outline of research design for experiment three



III HYPOTHESES

1. Cross-language comparisons

It was postulated that:

- a) Actual stop closure duration values would differ between English- and Afrikaans-speakers, being longer for voiceless stops in the case of English-speakers.
- b) English- and Afrikaans-speakers would show similar trends in terms of the voicing distinction and the influence of vowel environment, ie. medial stop closure durations were expected to be longer in the case of voiceless stops compared with voiced stops, and in /i/ compared with /a/ environments.

2. Age-related comparisons

- a) It was predicted that age-related trends would be seen in both language groups, as well as in stutterers and nonstutterers, with regard to the voicing distinction and the influence of vowel environment on stop closure duration. These trends were expected to be in the direction of lengthening of closure duration of voiceless stops and in the /i/ environment in older speakers relative to younger ones.
- b) A further age-related trend was anticipated in all groups in the direction of a shortening of whole syllable durations in older speakers.
- c) It was further predicted that variability of production on all measures would be less in the older than in the younger subjects.

3. Comparisons between stutterers and nonstutterers

- a) It was postulated that whole syllable durations would be longer in the case of stutterers compared with nonstutterers.
- b) Stop closure durations were expected to be longer in stutterers compared with nonstutterers.
- c) It was anticipated that the stuttering subjects would show the normal voicing and vowel-environment developmental trends but would demonstrate slower acquisition of these temporal characteristics than was the case with nonstutterers. Specifically, it was hypothesized that older stutterers would perform like younger nonstutterers while the performance of younger stutterers would be inferior to that of younger nonstutterers.

The first two parts of hypothesis three reflect the suggestion in the literature (Starkweather 1982) that stutterers may move their vocal and articulatory mechanisms more slowly than nonstutterers. Section (c) proposes that stutterers differ from nonstutterers in terms of their ability to acquire and use speech timing rules which may depend on

phonological as well as aerodynamic and neuromuscular abilities.

IV MATERIAL

Three randomized word lists were used, each containing the same eight VCV nonsense syllables (See Table XIV of the Appendix). These lists yielded three nonconsecutive productions of each of the following syllables by each subject:

/apa/	/aba/	/ata/	/ada/
/ipi/	/ibi/	/iti/	/idi/

Thus, each voiced or voiceless labial or alveolar stop plosive occurred in medial position within a low-back and high-front vowel context. It was decided to keep the vowels preceding and following the stop in each syllable constant, since there is conflicting evidence regarding the influence of the preceding vowel on stop closure duration (Schwartz 1969; Butcher and Weiher 1976), although the final vowel is generally thought to exert most influence (Anderson 1975).

V PROCEDURES

The subjects were tested individually, the testing of each speaker being completed within one session not exceeding ten minutes.

A Older speakers

In the case of the 6- and 7-year-old children, testing took place in an acoustic booth. The stimulus syllables were prerecorded on audio tape and delivered to two loudspeakers via a Maico Ma 24 audiometer at 65 dB SPL. A 1000 Hz calibration signal preceded presentation of the syllables. The subject was comfortably seated in a chair with the loudspeakers facing him on the right and left sides, approximately one metre from each ear and at ear level. In front of the subject was the same audio recording equipment as that used in experiment one.

The subject received the stimuli spoken by an adult native speaker of his own language. The adult speakers were the same two female experimenters that were used in experiments one and two. The voiceless stop plosives in the syllables were aspirated by the English-speaker only. The second, ie. postconsonantal, vowels were stressed by both speakers. In all instances, the stimulus syllables were preceded by the carrier phrase, "Say the word..." / "Sê die woord..." The experimenter sat near the subject so as to operate the tape recorder for recording the subject's responses and to encourage him to respond, if necessary. Presentation of the stimuli was initiated by an assistant in an adjacent room where the audiometer was located. Before presentation of the stimuli, the experimenter gave the following instructions in the language appropriate to the subject:

"You are going to hear a lady talking to you through these loudspeakers. She will say some funny words which you must repeat. If she says,

'Say the word /aka/', you must say /aka/. Do you understand? Let's practise one. Say the word /iki/.'

Once the subject had demonstrated understanding of the task by a correct response on the practice item, the stimulus and recording tapes were activated. No attempt was made to control the subjects' articulation rates or stress patterns. It was hoped that they would automatically imitate the stress pattern of the adult model and this did, in most instances, occur. It was not considered feasible to accurately control articulation rate, although modest success in this regard has been reported elsewhere with longer utterances (Smith et al 1983).

B Younger speakers

In the case of the younger subjects, testing took place individually in the same sound-treated room as for experiment one. The same adult speakers who had recorded the stimuli for use with the older children interacted with the younger ones. Since flexibility of presentation was necessary in the case of the younger subjects, the stimuli were presented 'in vivo'. Thus, rigid control of the stimuli was forsaken in the interests of obtaining the required number of productions from each subject. The order of presentation of the stimuli remained unaltered, but testing was sometimes interrupted by some of the subjects who made remarks, fidgeted or needed encouragement to carry on. The live voice presentation may have introduced uncontrolled allophonic variations into the stimulus syllables, which implies that the younger subjects may not have heard exactly what the older subjects heard, nor what their peers heard.

Instructions to each younger subject were as follows:

"I'm going to say some words to you and you must copy me. Say the word /aka/. Good. Now say the word /iki/."

The experimental stimuli were presented and recording begun once the subject demonstrated understanding of the task and appeared willing to cooperate.

VI DATA ANALYSIS

The audio recordings of the subjects' utterances were analyzed oscilloscopically using the same instrumentation as for experiment one. Recordings of the older subjects' responses were used unaltered, since there was a fairly even intersyllabic pause of approximately 5 seconds. The younger subjects' responses were edited so that a 5-second strip of timed leader tape separated each production, so as to facilitate capture of the images on the oscilloscope. Productions in which the adult's stress patterns were not reproduced by the child were eliminated since stress can significantly influence stop closure durations. Productions which were whispered, marred by ambient noise, where clearcut phonemic substitutions involving place- or manner-of-articulation occurred, or where no response was obtained were also omitted from the analysis. A total of 202 ie. 7.5% of syllables were rejected, leaving 2,678 available for analysis.

The same two judges were used as for experiment one and the judging

procedures remained the same. Two measures were taken from each production of each syllable - a measure of whole syllable duration and a measure of the duration of the closure phase of the medial stop plosive, whether voiced or voiceless.

Voiceless stop closure duration was characterized by a 'quiescent' speech wave ie. zero sound pressure, or 'silent interval'. The silent closure phase followed the quasiperiodic waveform of the initial vowel. In some instances of stops, following supraglottal closure and prior to the onset of voicing, gradually decreasing low amplitude glottal pulses were observed in the closure interval (Fig.12). These may be attributed to residual vocal fold vibration accompanying the devoicing gesture of the posterior cricoarytenoid muscle contraction (Lindquist 1972; Lofquist 1976) and are included by some workers in the closure interval (Weismer and Fromm 1983). Since these low-amplitude pulses do not show up on spectrography, most studies make no reference to this matter. It is thus also questionable whether data from spectrographic and oscillographic displays are directly comparable, but emphasizes the need for consistent, operationally defined criteria. While validity may be jeopardized to some extent by arbitrary, operational segment boundary choices, reliability is enhanced, an important factor when internal control groups are used in a study such as the present one. Due caution must be observed, however, in comparing specific durational values, rather than trends, with reported values in the literature, where different segmentation criteria may have been used.

Voiced stop closure consisted of a characteristic wave form illustrated in Fig.13 indicating voicing during closure or a quiescent wave (Fig 14) indicating a voice break. In the case of aspirated stops, the plosive burst was included in the stop closure duration measure, closure being considered to end with the onset of quasiperiodic waves of the final vowel. In the case of unaspirated stops, the stop closure duration ended with the onset of the quasiperiodic waveform of the postconsonantal vowel, whether the closure phase had been voiced throughout or whether it had included a voice break. Figs.12 to 14 illustrate typical oscillographic displays of the VCV syllables, with the areas of interest to be measured.

VII STATISTICAL TREATMENT

1. Multiple box plots were obtained, illustrating,
 - a) the central tendency (median) and range for MM2. It will be recalled that MM2 is the type of mean obtained by summing the maximum and minimum scores for each subject and dividing by 2.
 - b) the central tendency (median) and range for the range of scores.

These dimensions were plotted separately for each syllable and also allowed for comparisons between the eight experimental groups. Separate multiple box plots were obtained for the whole syllable duration measures, for stop closure duration for se, and for the percentage which stop closure duration represented of the whole syllable duration. These multiple box plots are illustrated in Figs.15 to 17.

2. Figs 18a to 18h illustrate multiple box plots separately computed for each experimental group, containing information on the central tendency and range of
 - a) stop closure duration per se and
 - b) percentage stop closure was of whole syllable duration for the eight experimental syllables. These plots facilitate comparisons between stop closure duration in voiced and voiceless stops as well as in /a/ compared with /i/ vowel environments.
3. The results of the Spearman's correlations performed on each production of each syllable by each group are illustrated in Figs. 19a to 19h in the Appendix.
4. Interjudge reliability coefficients are illustrated in Figs. 20a to 20h.
5. Table XV summarizes mean stop closure durations and ranges for the eight syllables for all groups.
6. Table XVI gives the mean closure duration values and the mean differences between voiced and voiceless cognates.

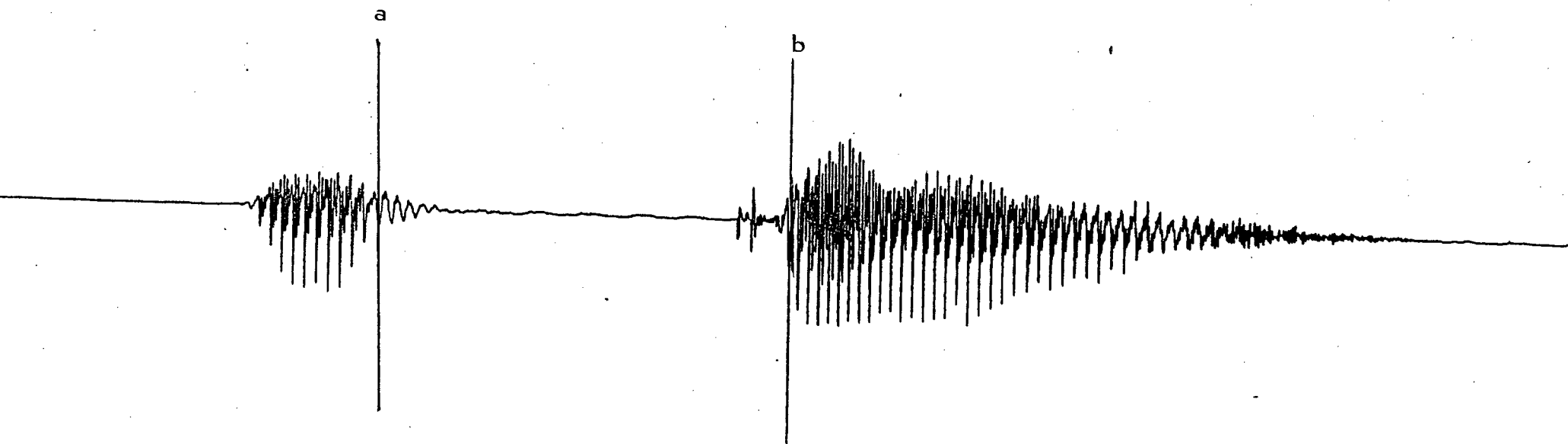
VIII RESULTS

A Interjudge reliability

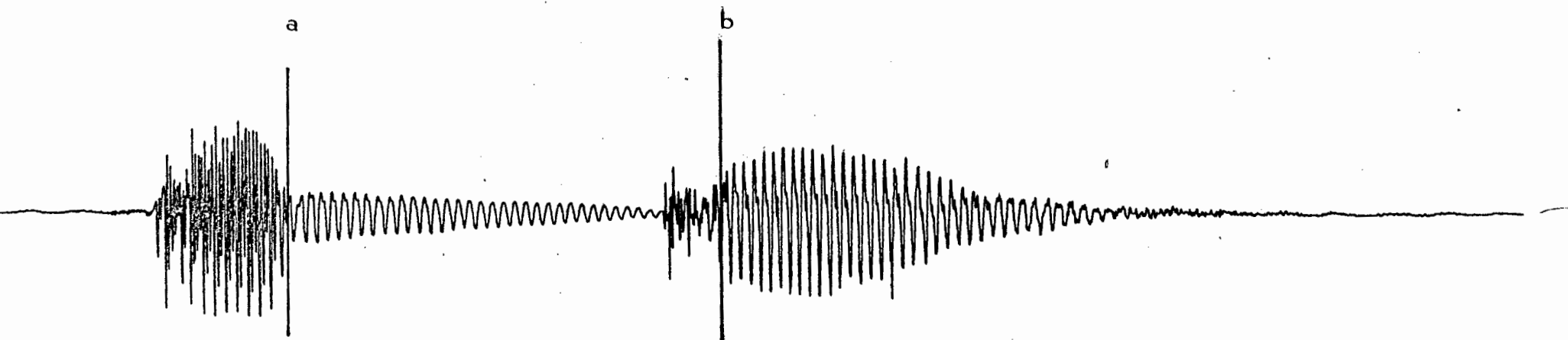
As can be seen on Figs. 20a to 20h, interjudge agreement for syllable and whole word durations was very high, with the exception of one observation of /ipi/. With such close agreement, it was felt to be justified for one judge to complete the measurements alone.

B Spearman's correlations

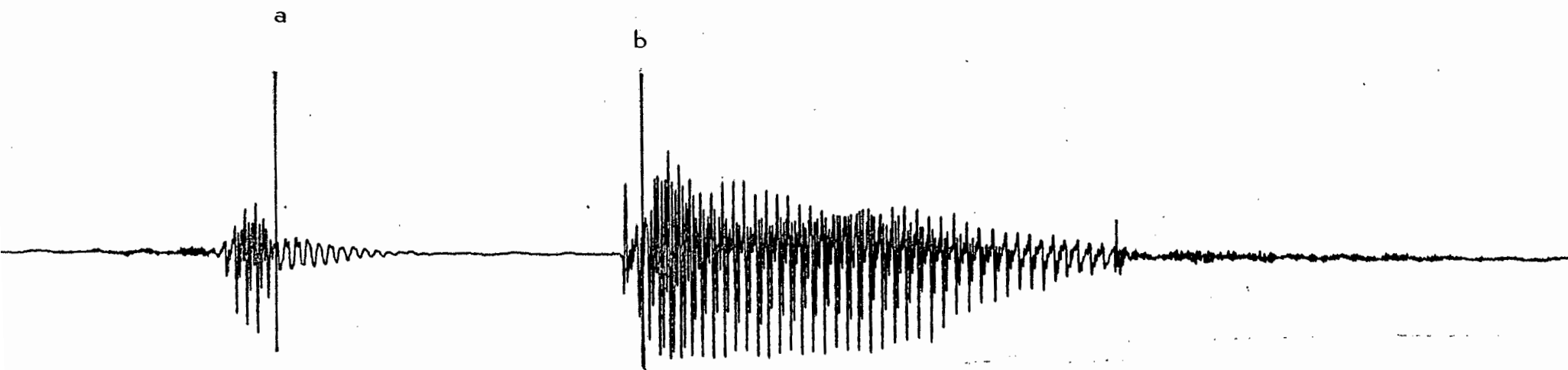
The results of the Spearman's correlations, while they contained numerous instances of positive correlations between given productions of the experimental syllables, did not fall into any patterns which could be said to characterize the groups.



ig. 12 Production of /apa/ by Subject 70 illustrating low amplitude pulses intruding into the closure phase of the medial stop. This is followed by a quiescent wave indicating a voice break, after which a short voice onset transition precedes the quasiperiodic vowel activity. Lines a and b indicate the boundaries of the closure period.



g. 13 Production of /idi/ by Subject 70 illustrating the continuation of voicing during the closure phase of the voiced stop. Lines a and b indicate the boundaries of the closure segment.



g. 14 Production of /aba/ by Subject 70 showing a voicing break during the closure phase of a "voiced" medial stop. The closure interval boundaries are indicated by lines a and b. In practice, boundary placement was easier on memory oscilloscopic display which permitted magnification of the waveform.

TABLE XV Mean stop closure durations and ranges for prestressed medial stops in VCV nonsense syllables for the eight experimental groups

	apa	ipi	aba	ibi	ata	iti	ada	idi
Group 1. Older English Nonstutterers	<u>$\bar{x}$ duration</u> 105.73 <u>Range</u> 54-112	106.77 63-138	99.44 54-144	102.82 30-156	104.29 54-162	109.91 54-162	95.51 48-150	101.91 48-162
Group 2. Older Afrikaans Nonstutterers	<u>$\bar{x}$ duration</u> 104.66 <u>Range</u> 36-162	116.10 36-180	91.88 30-228	105.17 36-192	108.51 24-180	119.42 42-180	83.3 18-144	101.60 30-192
Group 3. Older English Stutterers	<u>$\bar{x}$ duration</u> 89.91 <u>Range</u> 18-144	89.14 54-132	87.93 34-174	79.93 42-114	84.78 42-168	79.57 45-156	77.79 18-132	86.55 36-144
Group 4. Older Afrikaans Stutterers	<u>$\bar{x}$ duration</u> 113.89 <u>Range</u> 66-168	124.26 48-192	92.93 60-216	94.69 54-168	118.64 60-216	119.12 42-180	88.30 30-156	101.39 48-162
Group 5. Younger English Nonstutterers	<u>$\bar{x}$ duration</u> 129.32 <u>Range</u> 60-222	121.91 54-201	106.00 51-192	117.15 24-186	120.29 45-186	126.98 66-204	94.03 18-162	114.54 36-170
Group 6. Younger Afrikaans Nonstutterers	<u>$\bar{x}$ duration</u> 149.94 <u>Range</u> 90-246	137.94 72-216	120.54 48-270	122.67 60-204	137.46 54-252	150.10 90-276	99.51 54-186	116.02 48-198
Group 7. Younger English Stutterers	<u>$\bar{x}$ duration</u> 107.05 <u>Range</u> 54-234	98.93 24-150	89.22 42-126	104.85 48-276	97.17 36-174	111.55 54-186	84.32 24-150	89.60 48-180
Group 8. Younger Afrikaans Stutterers	<u>$\bar{x}$ duration</u> 124.69 <u>Range</u> 54-198	127.28 84-306	90.66 54-192	108.81 48-198	122.24 54-162	121.72 72-183	87.43 48-162	139-92 84-246

Note: All durations are expressed in milliseconds

TABLE XVI Mean stop closure durations for the four experimental phonemes and mean differences between voiced and voiceless cognates for the eight experimental groups

	Mean closure				Mean differences	
	/p/	/b/	/t/	/d/	p-b	t-d
Group 1. Older English Nonstutterers	106.25	101.13	107.10	98.71	5.12	8.39
Group 2. Older Afrikaans Nonstutterers	110.38	98.53	113.97	92.45	11.85	21.52
Group 3. Older English Stutterers	89.53	83.93	82.18	82.17	5.6	.01
Group 4. Older Afrikaans Stutterers	119.08	93.81	118.88	94.85	25.27	24.03
Group 5. Younger English Nonstutterers	125.62	111.58	123.64	104.29	14.04	19.35
Group 6. Younger Afrikaans Nonstutterers	143.94	121.61	143.78	107.77	22.33	36.01
Group 7. Younger English Stutterers	102.99	97.04	104.36	86.96	5.95	17.40
Group 8. Younger Afrikaans Stutterers	125.99	99.74	121.98	113.68	26.25	8.30

Note: values are expressed in milliseconds.

Experimental Groups

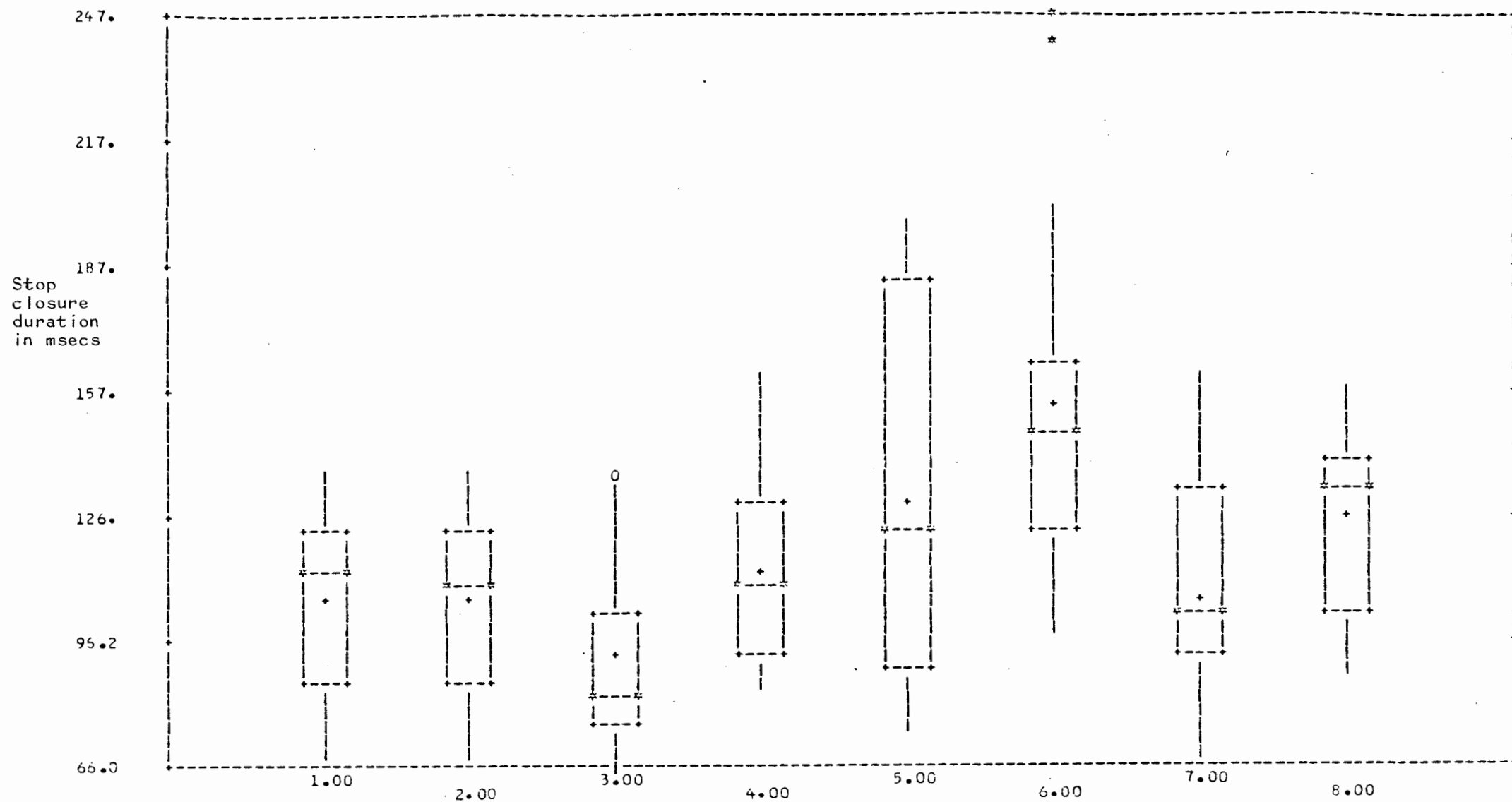


Fig. 15a(i) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /apa/

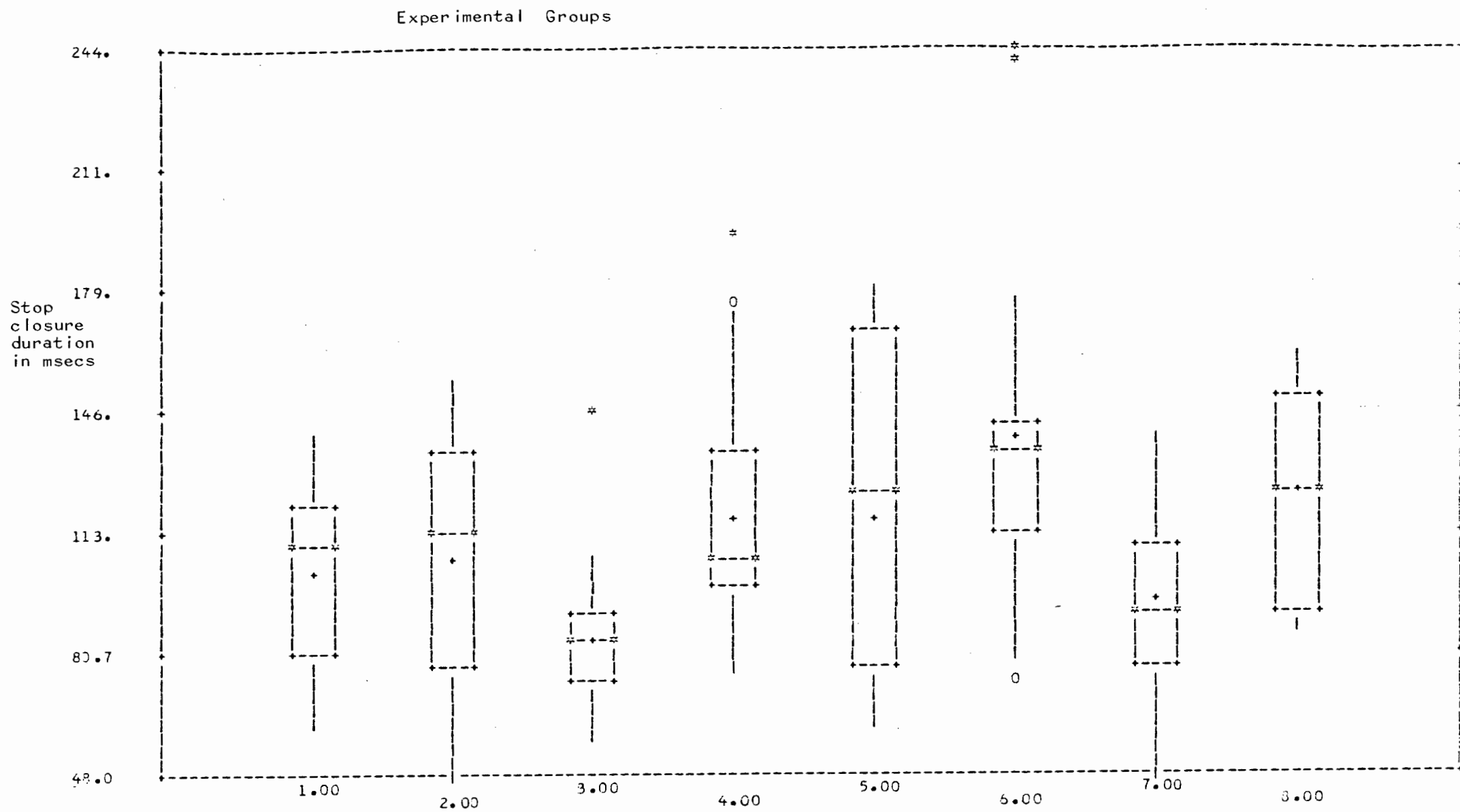


Fig. 15a(iii) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /ata/

Experimental Groups

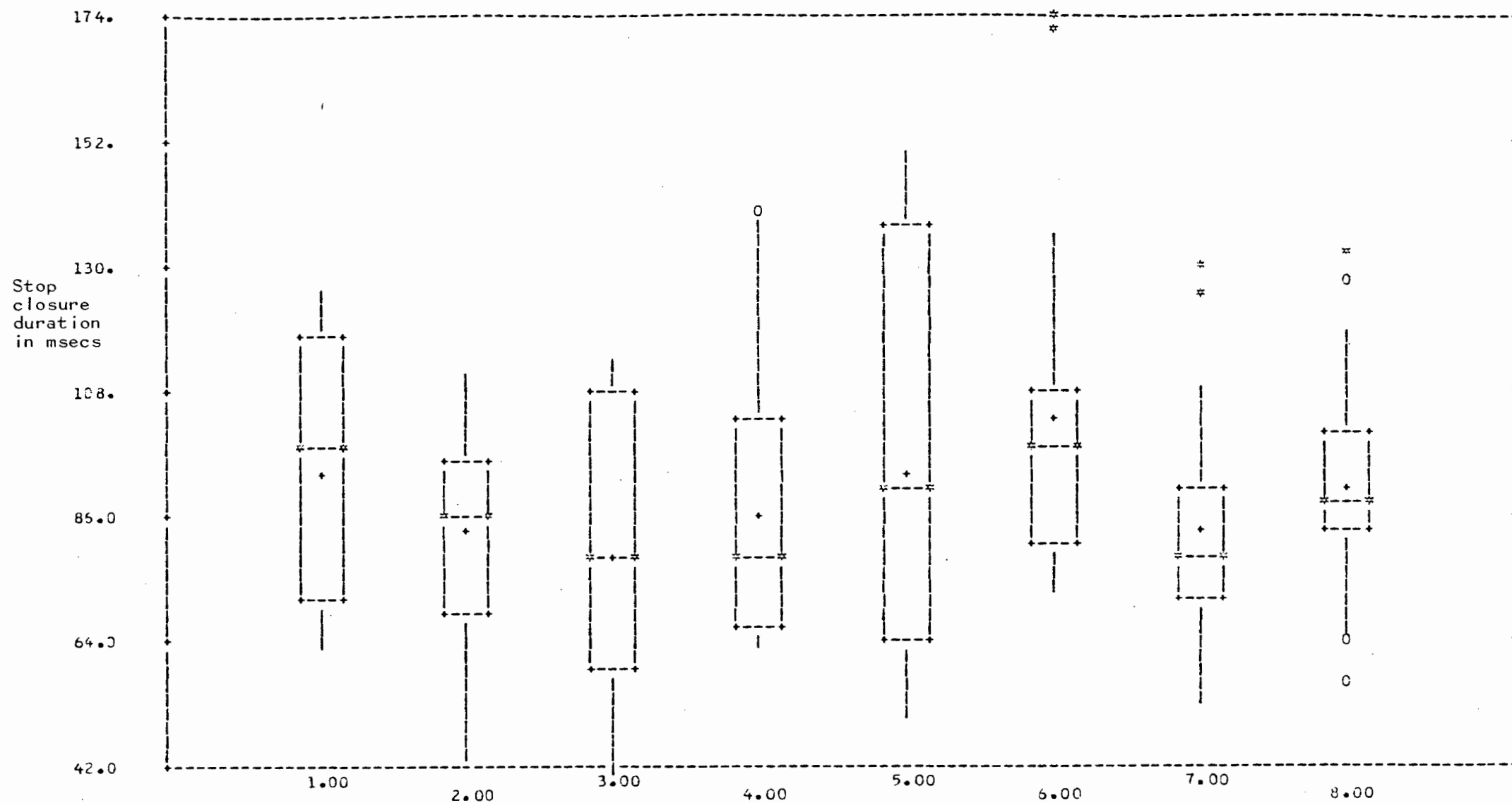


Fig. 15a(iv) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /ada/

Experimental Groups

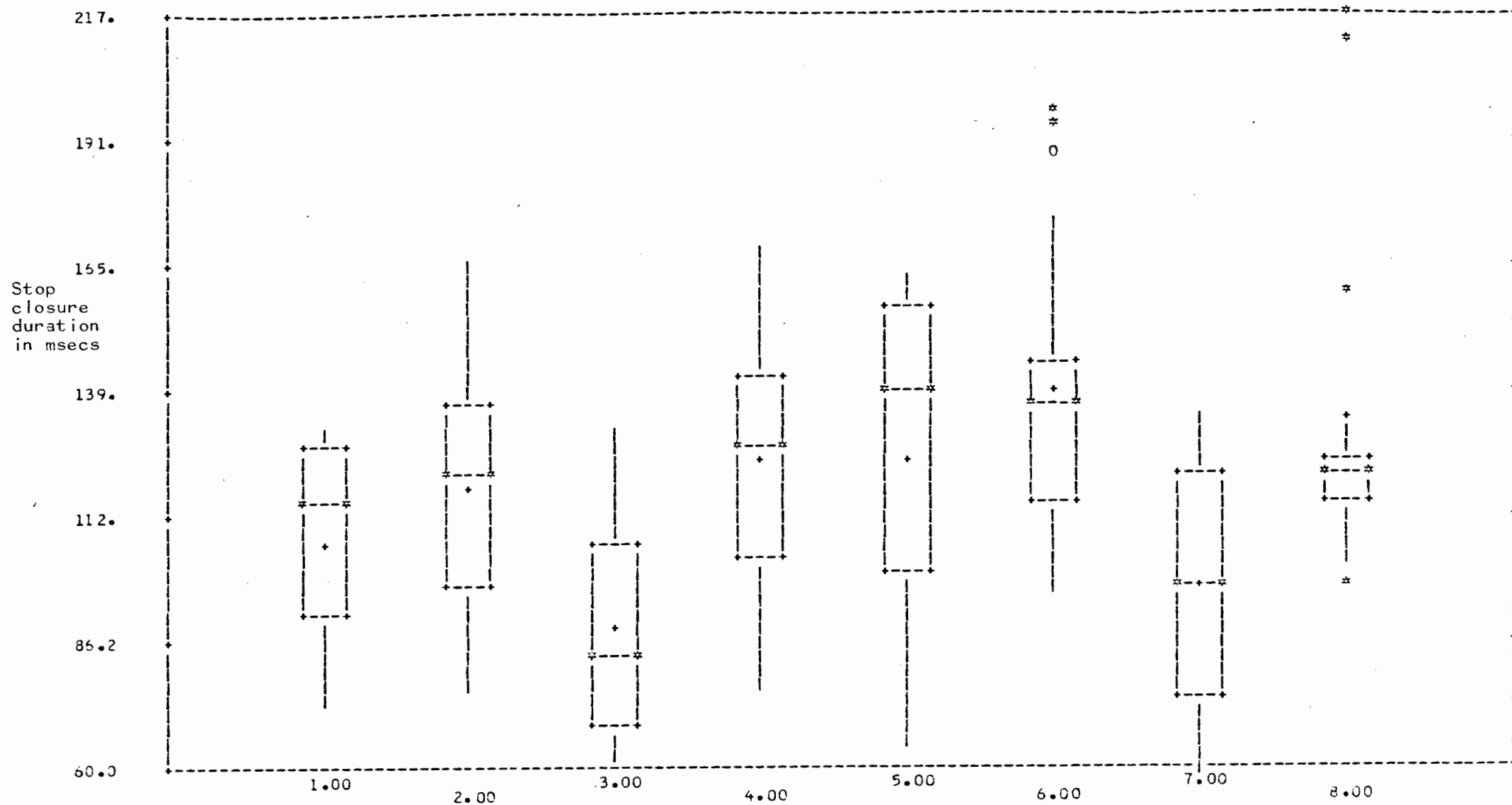


Fig. 15a(v) Multiple box plots showing central tendency and distribution of MM2 for stop duration in /ipi/

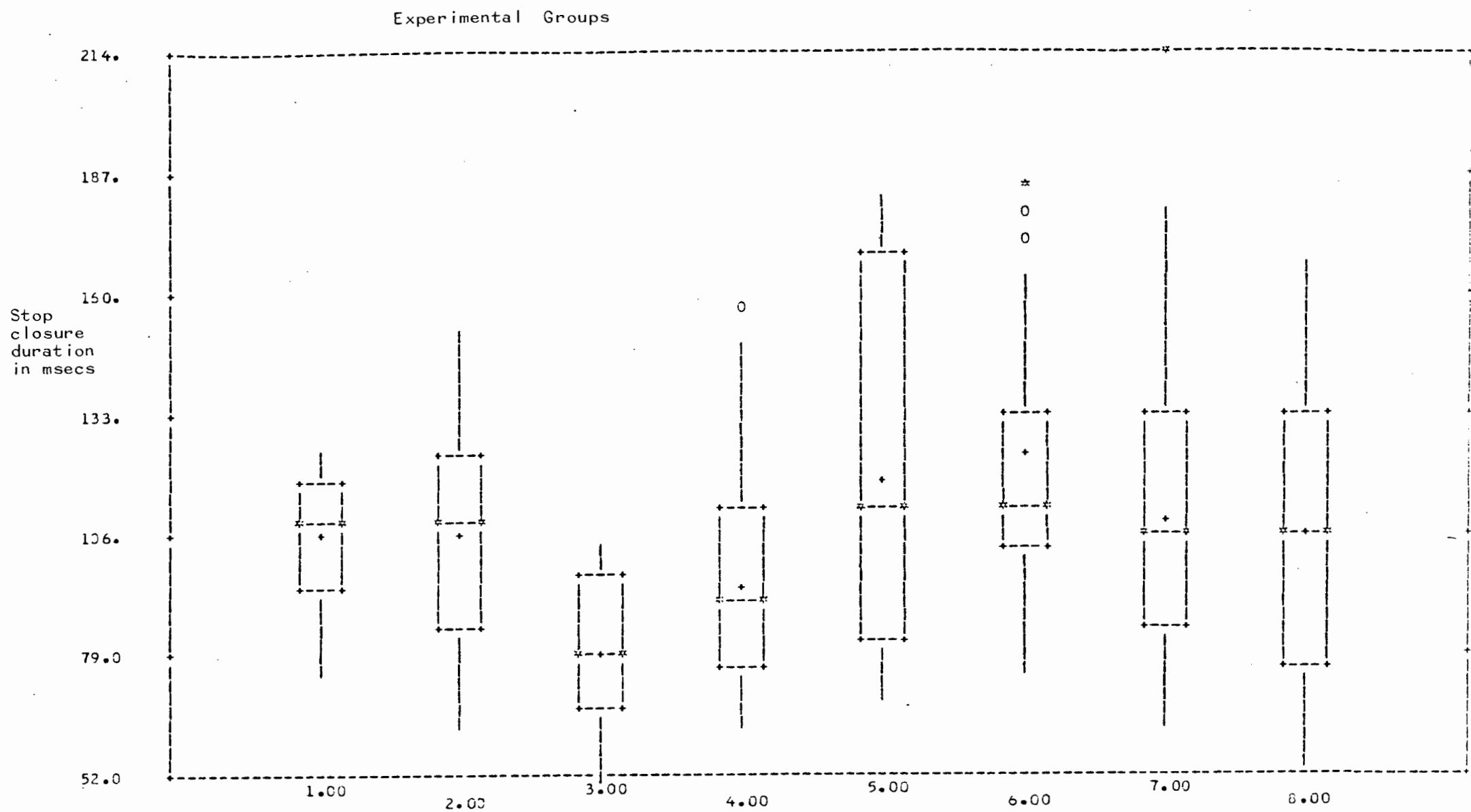


Fig. 15a(vi) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /ibi/

Experimental Groups

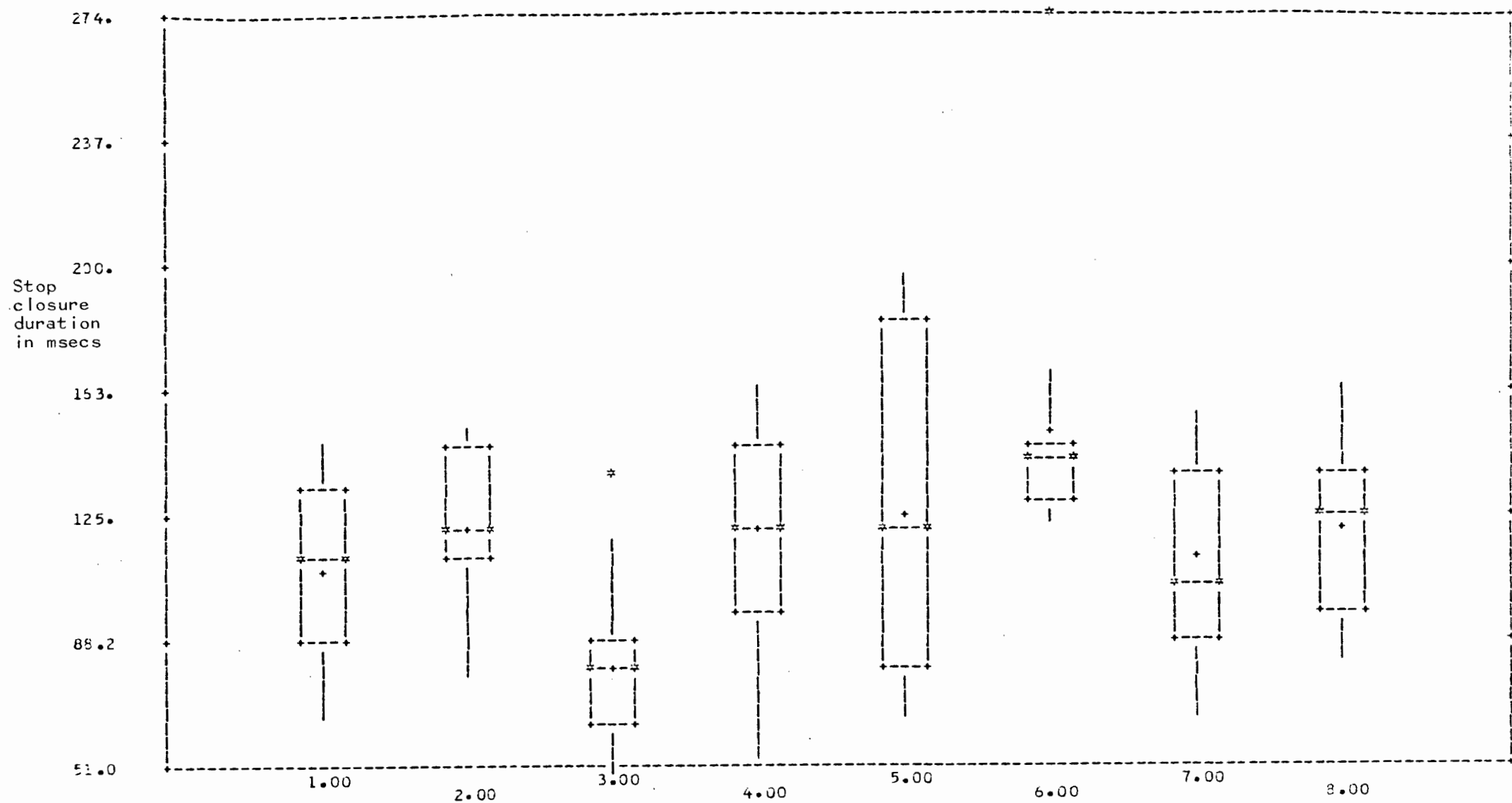


Fig. 15a(vii) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /iti/

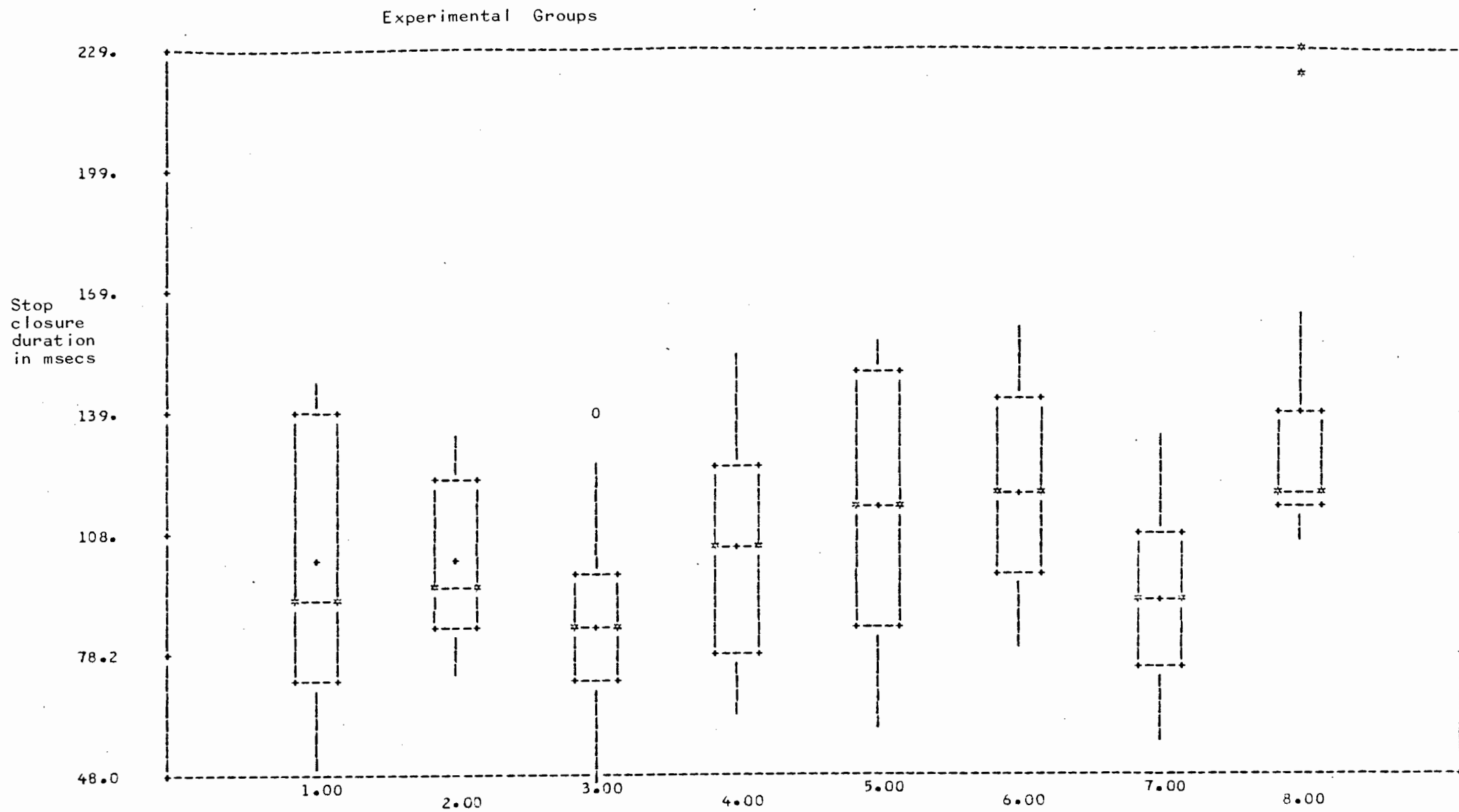


Fig. 15a(viii) Multiple box plots showing central tendency and distribution of MM2 for stop closure duration in /idi/

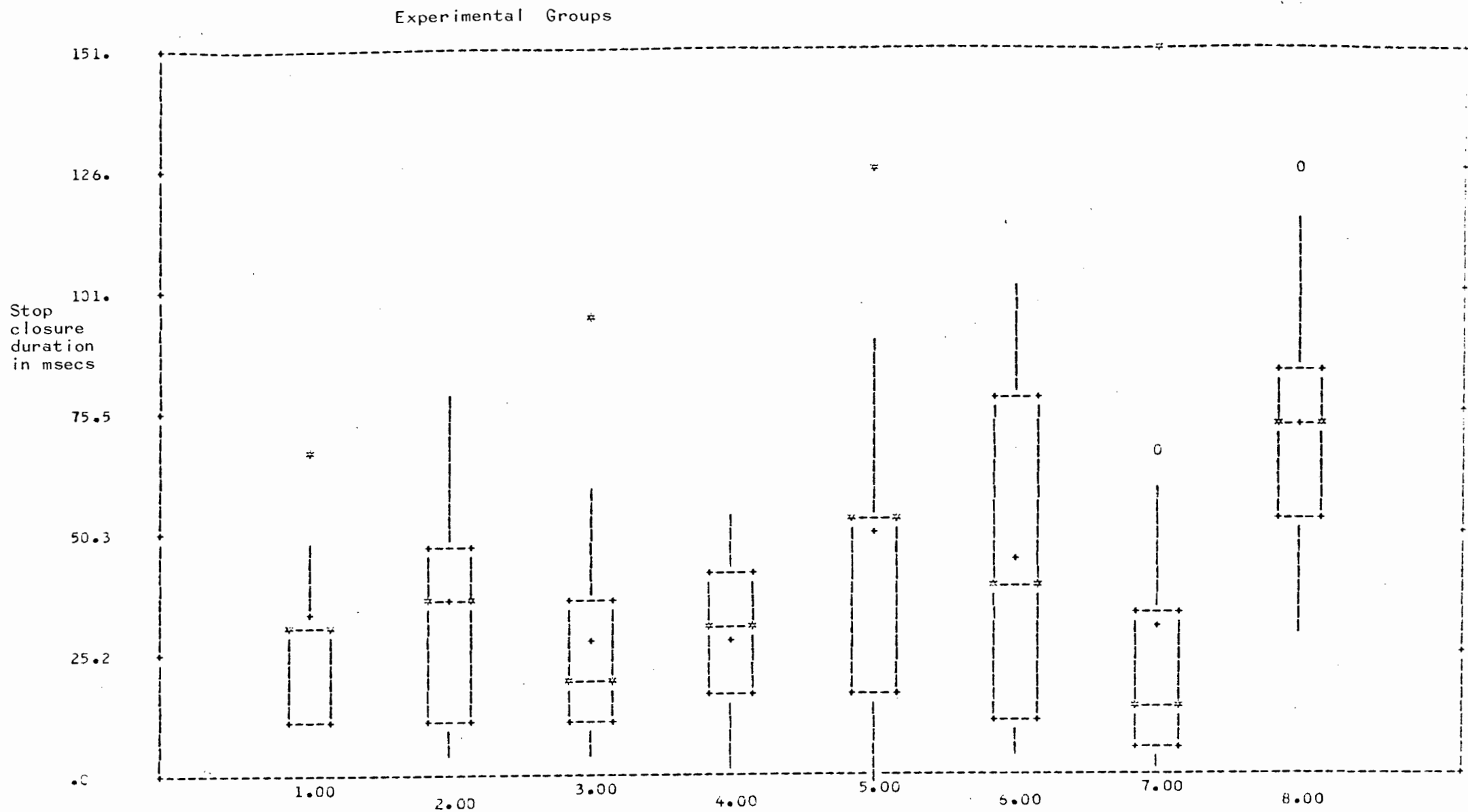


Fig. 15b(i) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /apa/

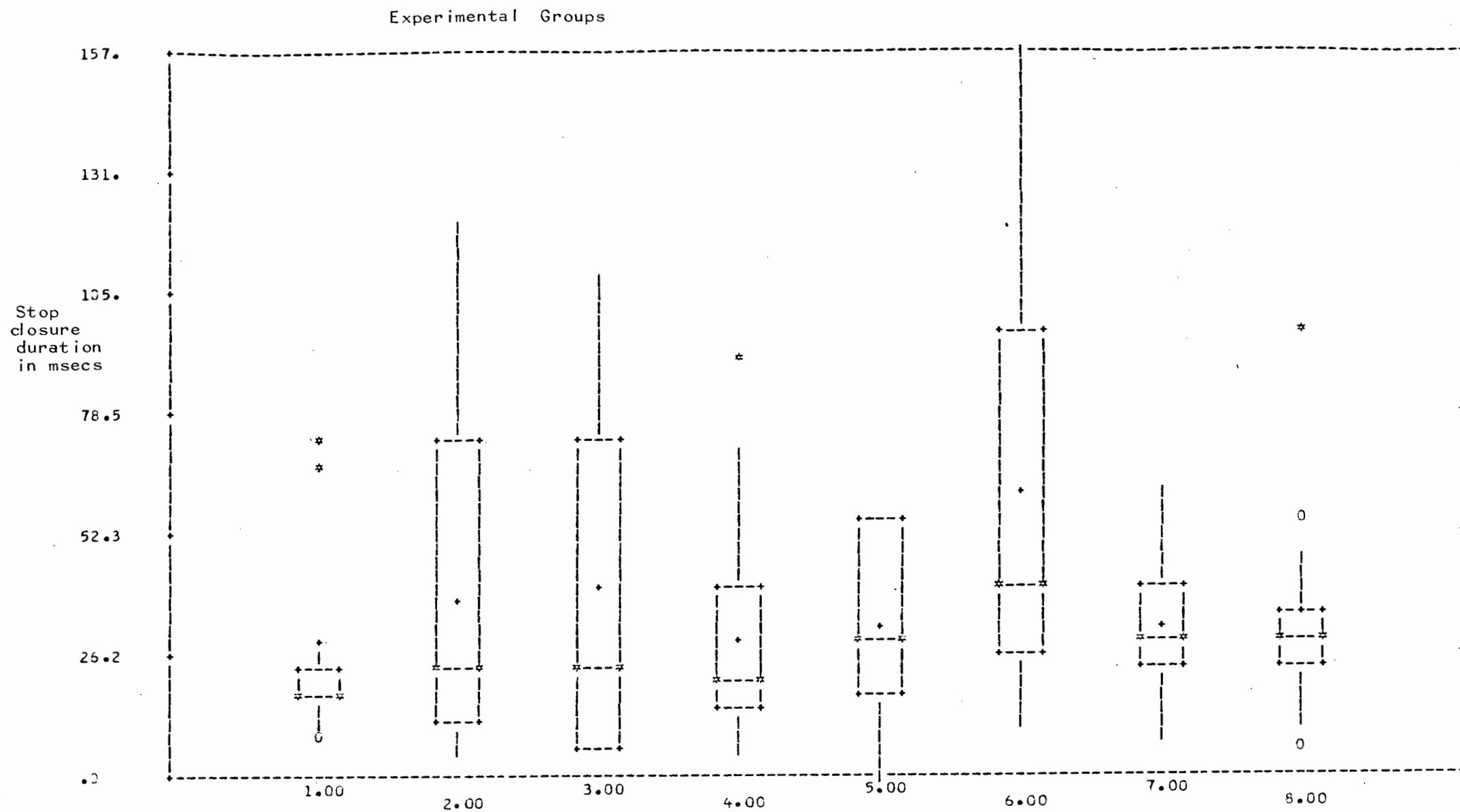


Fig. 15b(ii) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /aba/

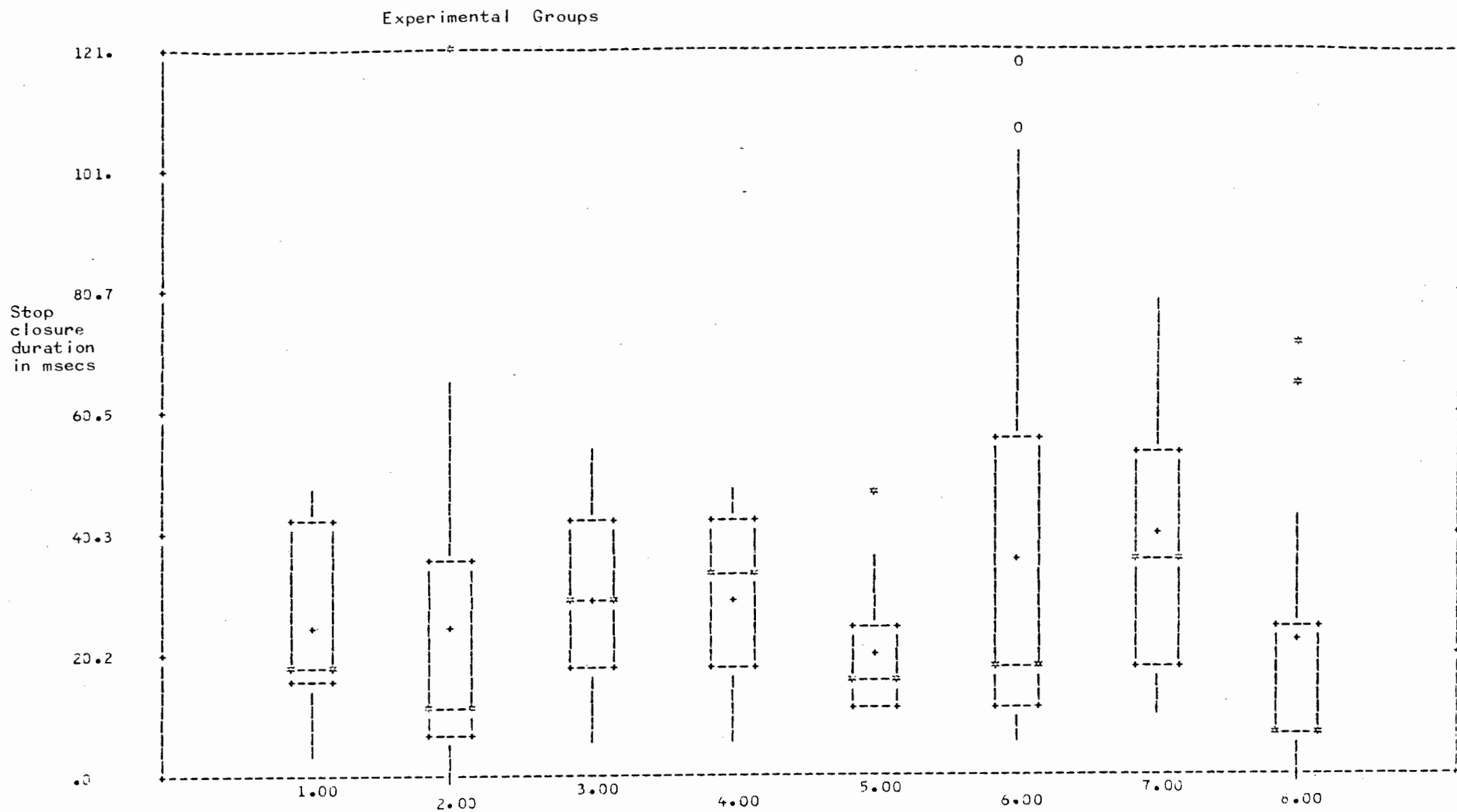


Fig. 15b(iii) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /ata/

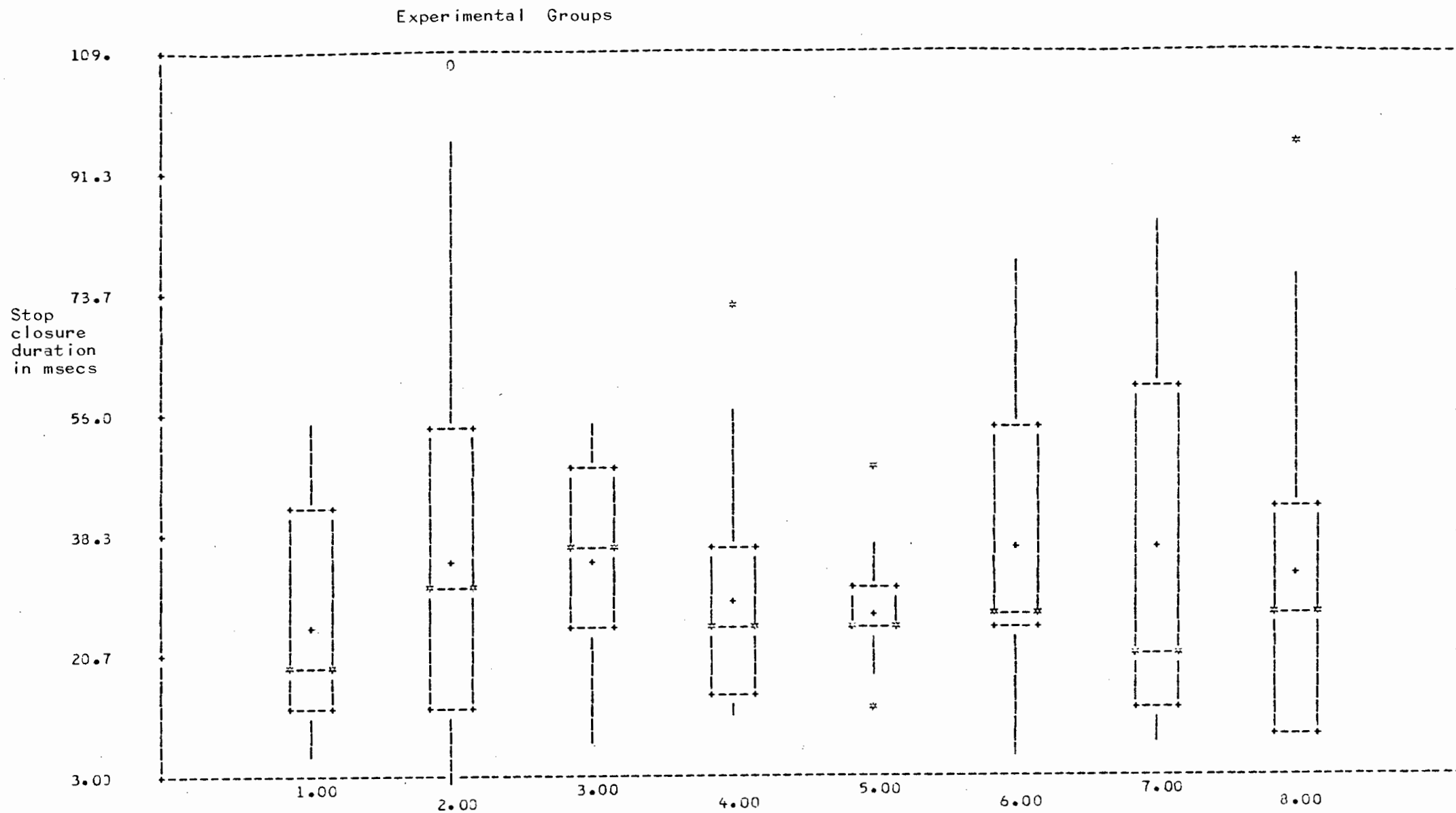


Fig. 15b(iv) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /ada/

Experimental Groups

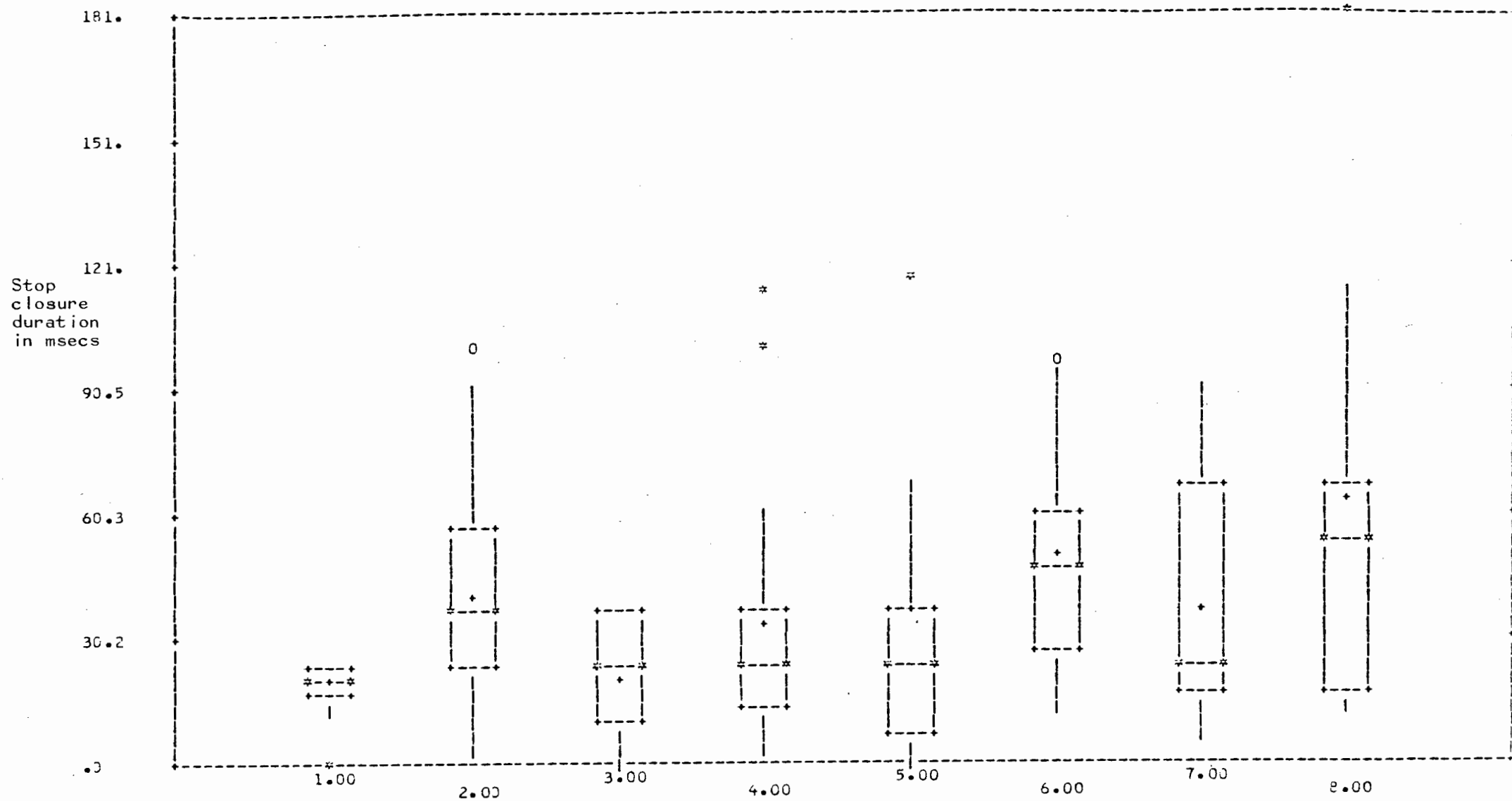


Fig. 15b(v) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /ipi/

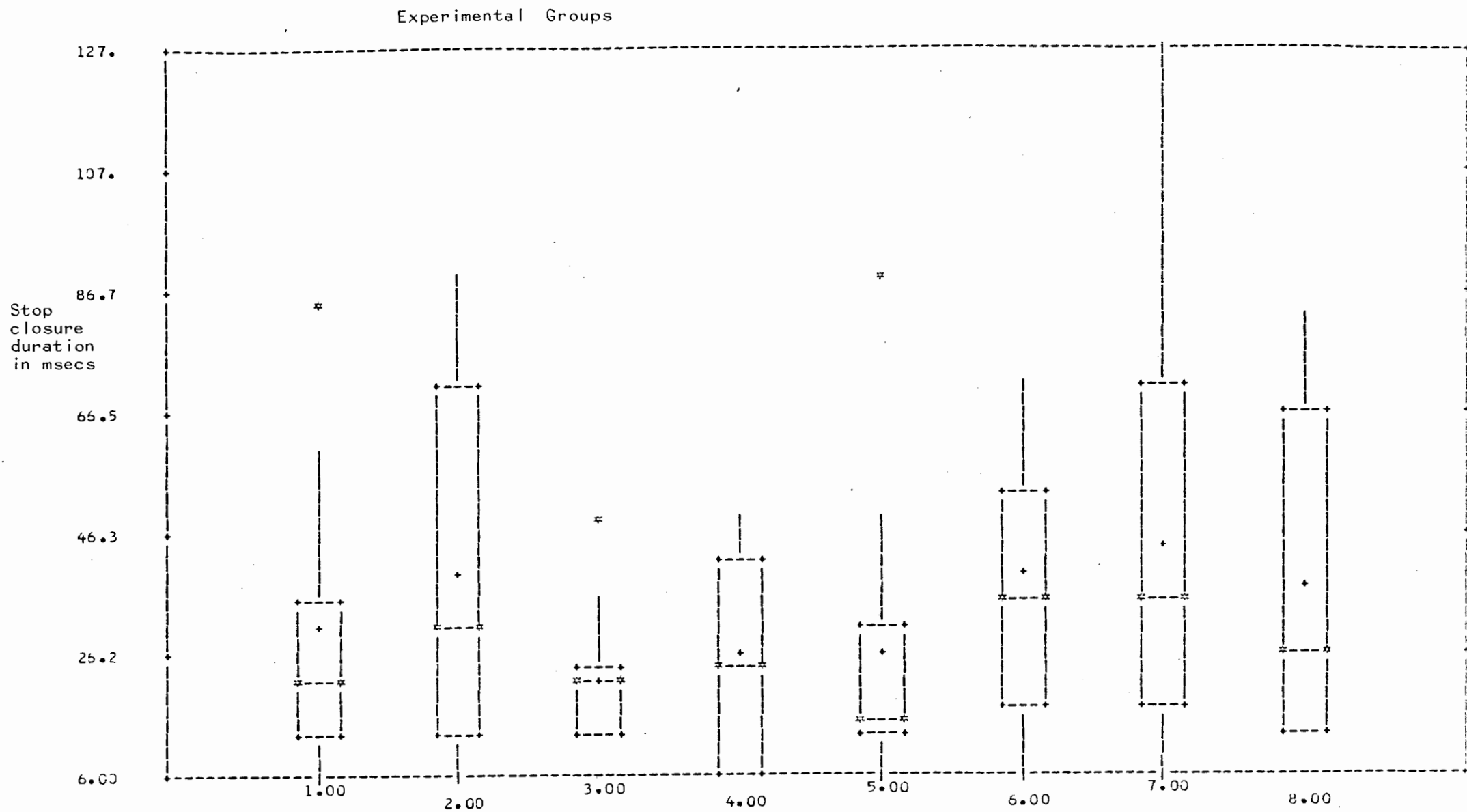


Fig. 15b(vi) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /ibi/

Experimental Groups

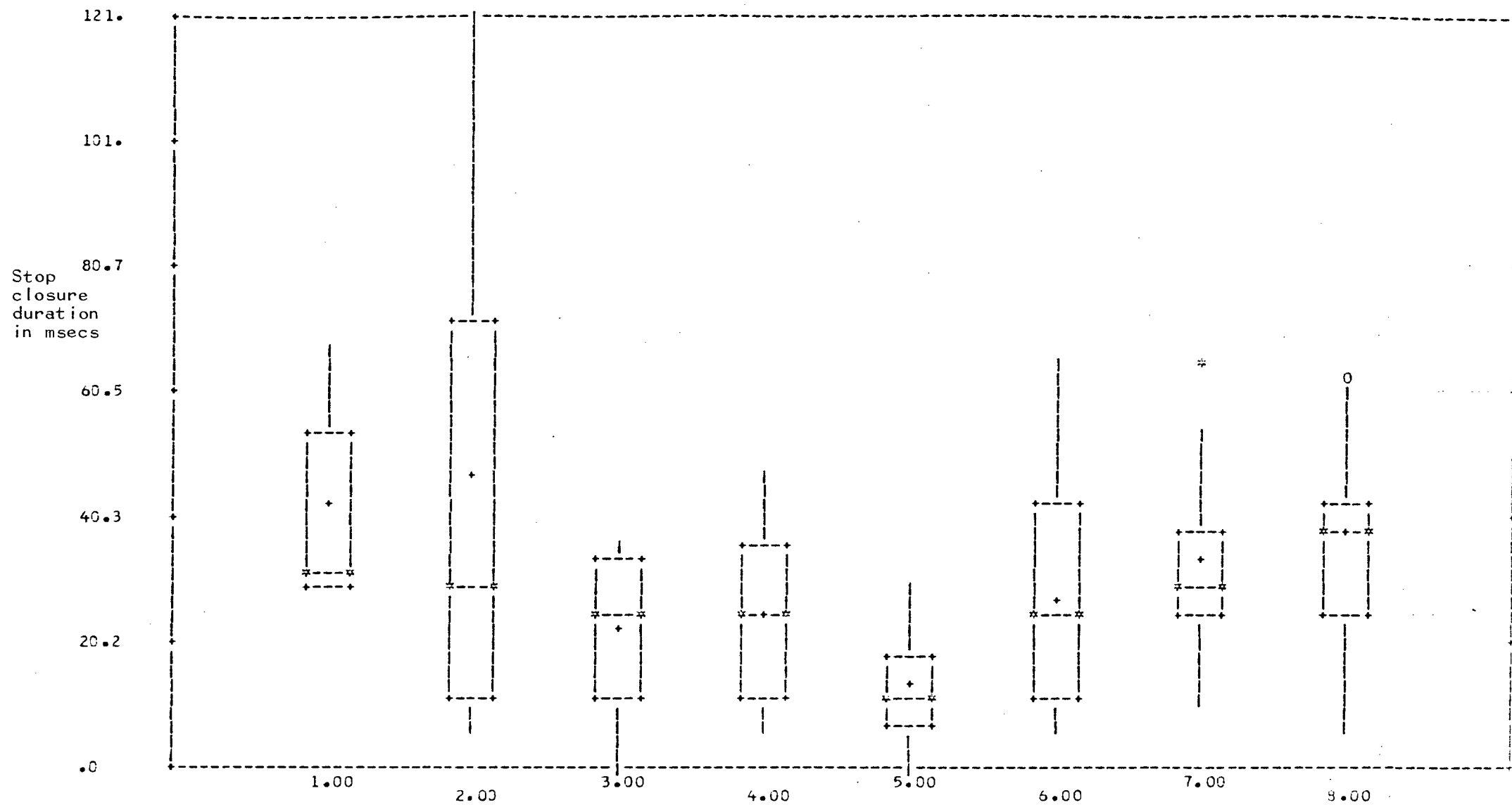


Fig. 15b(vii) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /iti/

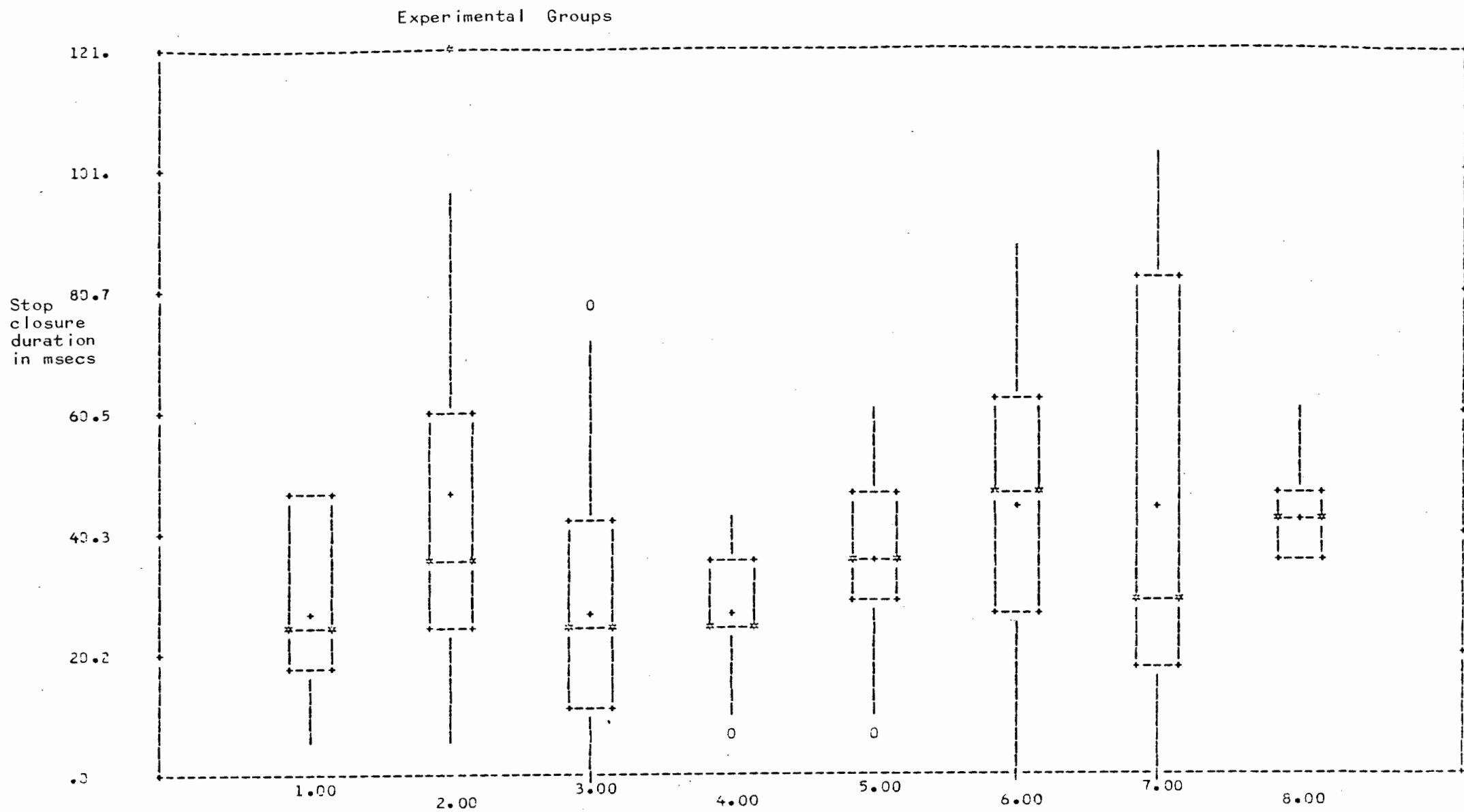


Fig. 15b(viii) Multiple box plots showing central tendency and distribution of the range for stop closure duration in /idi/

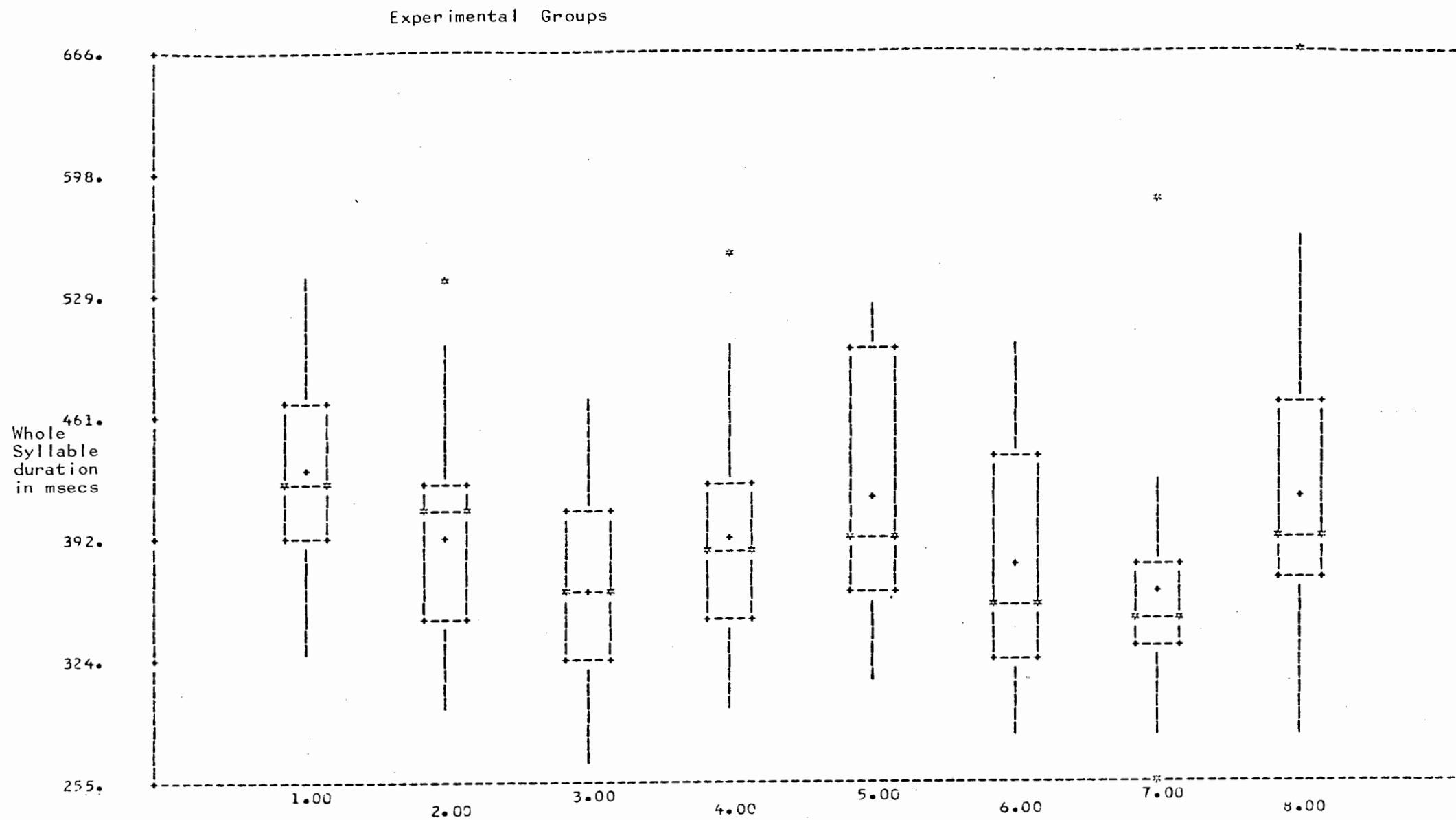


Fig. 16a(i) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /apa/

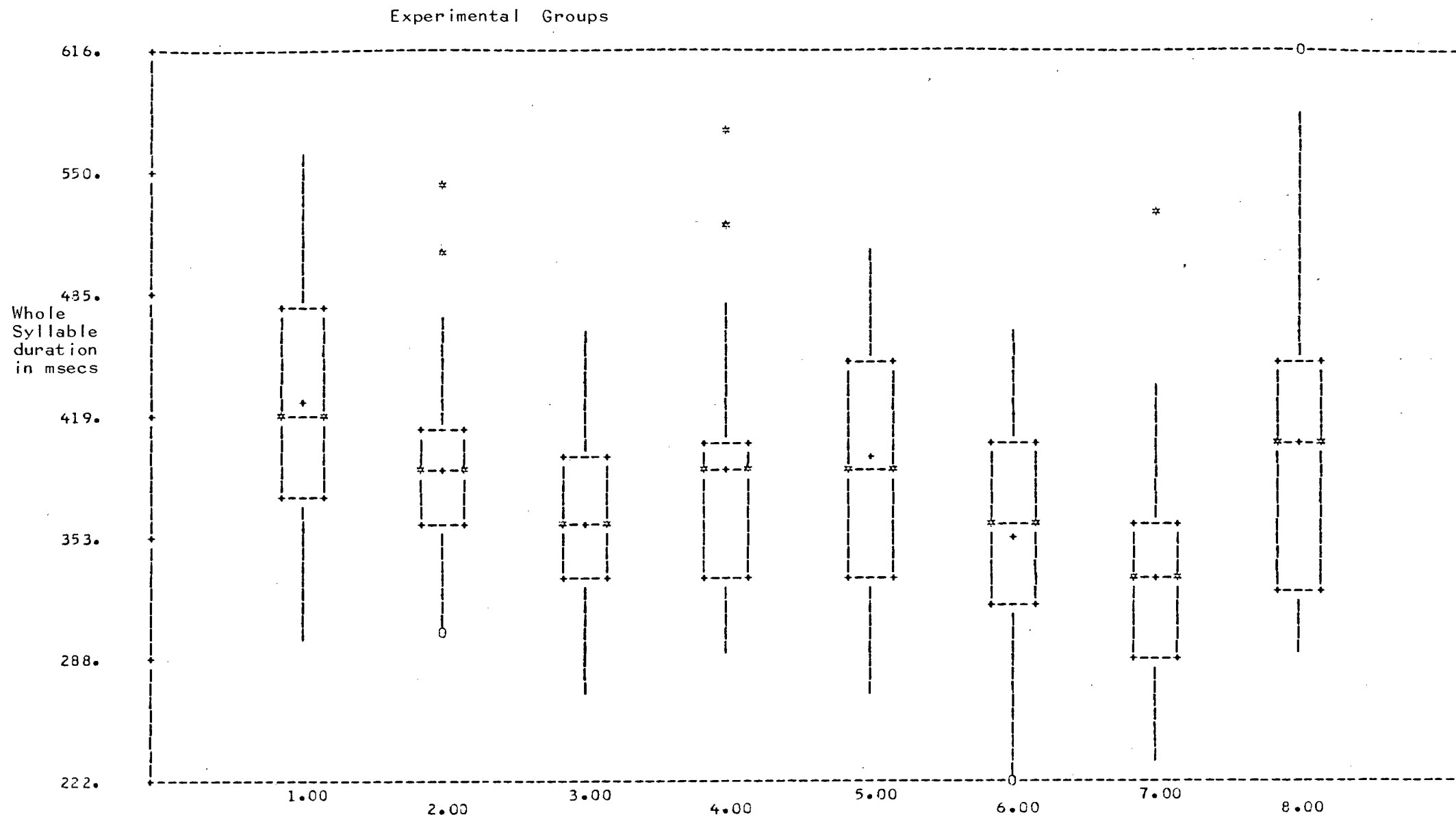


Fig. 16a(ii) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /aba/

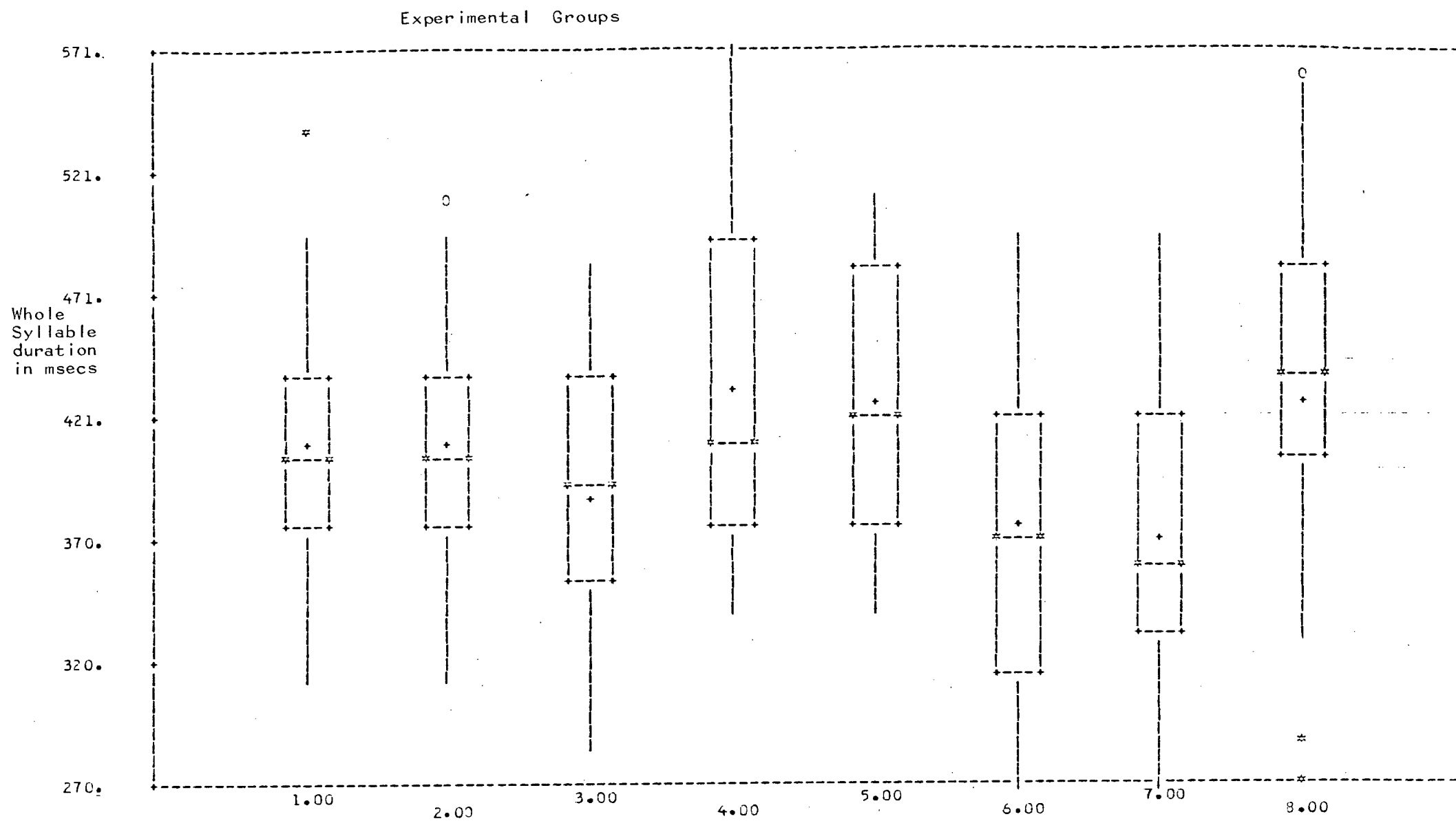


Fig. 16a(iii) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /ata/

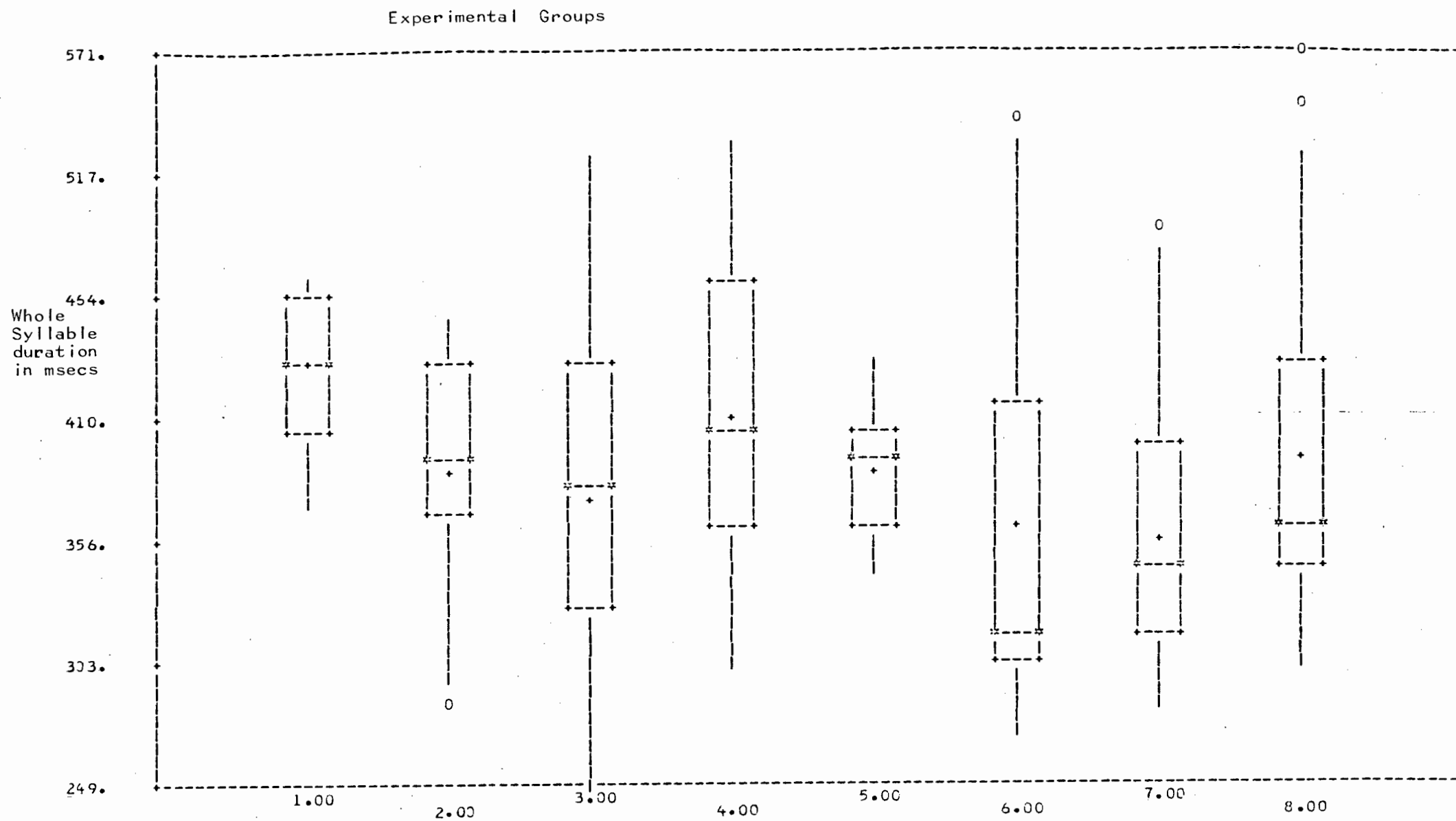


Fig. 16a(iv) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /ada/

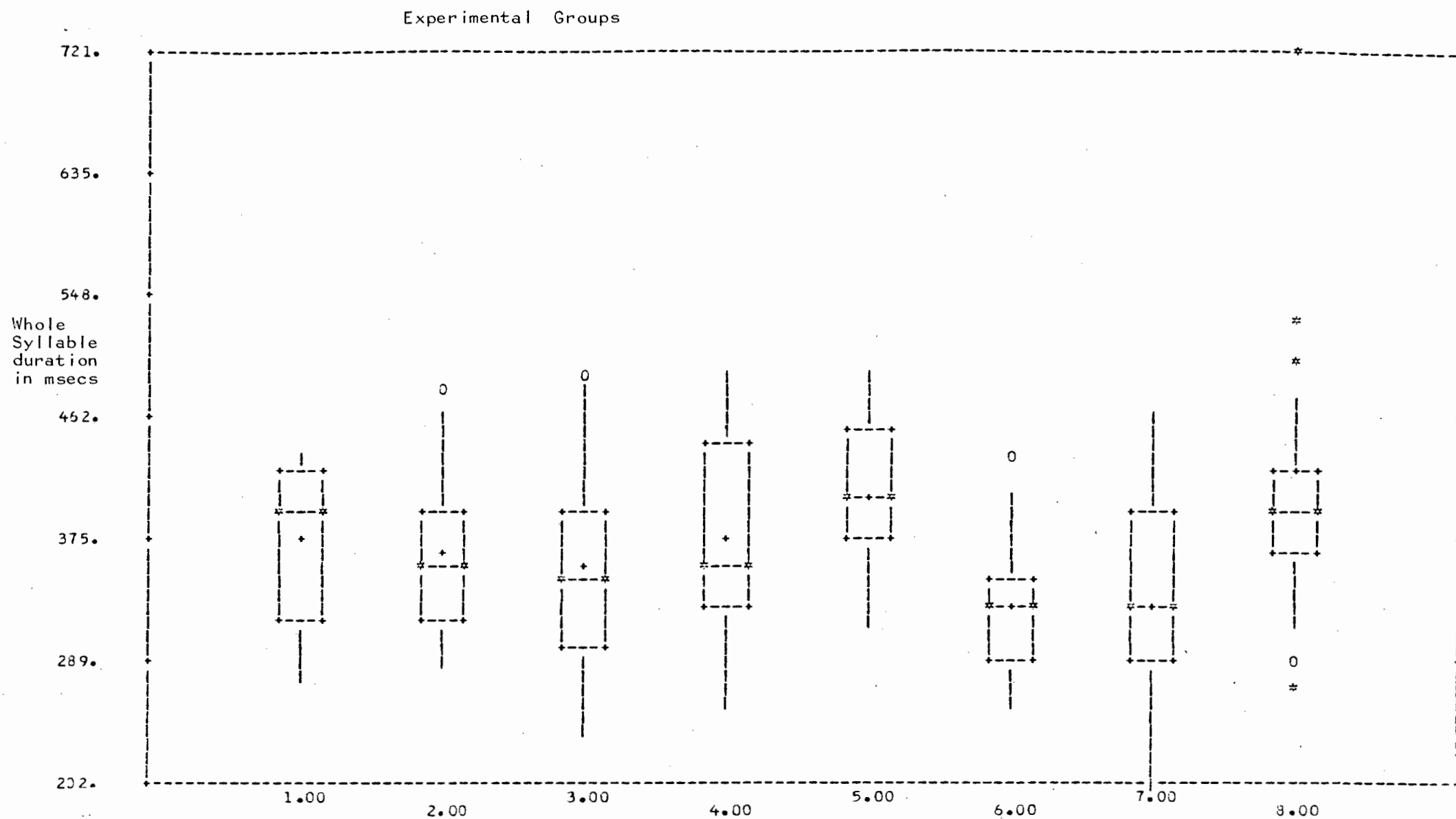


Fig. 16a(v) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /ipi/

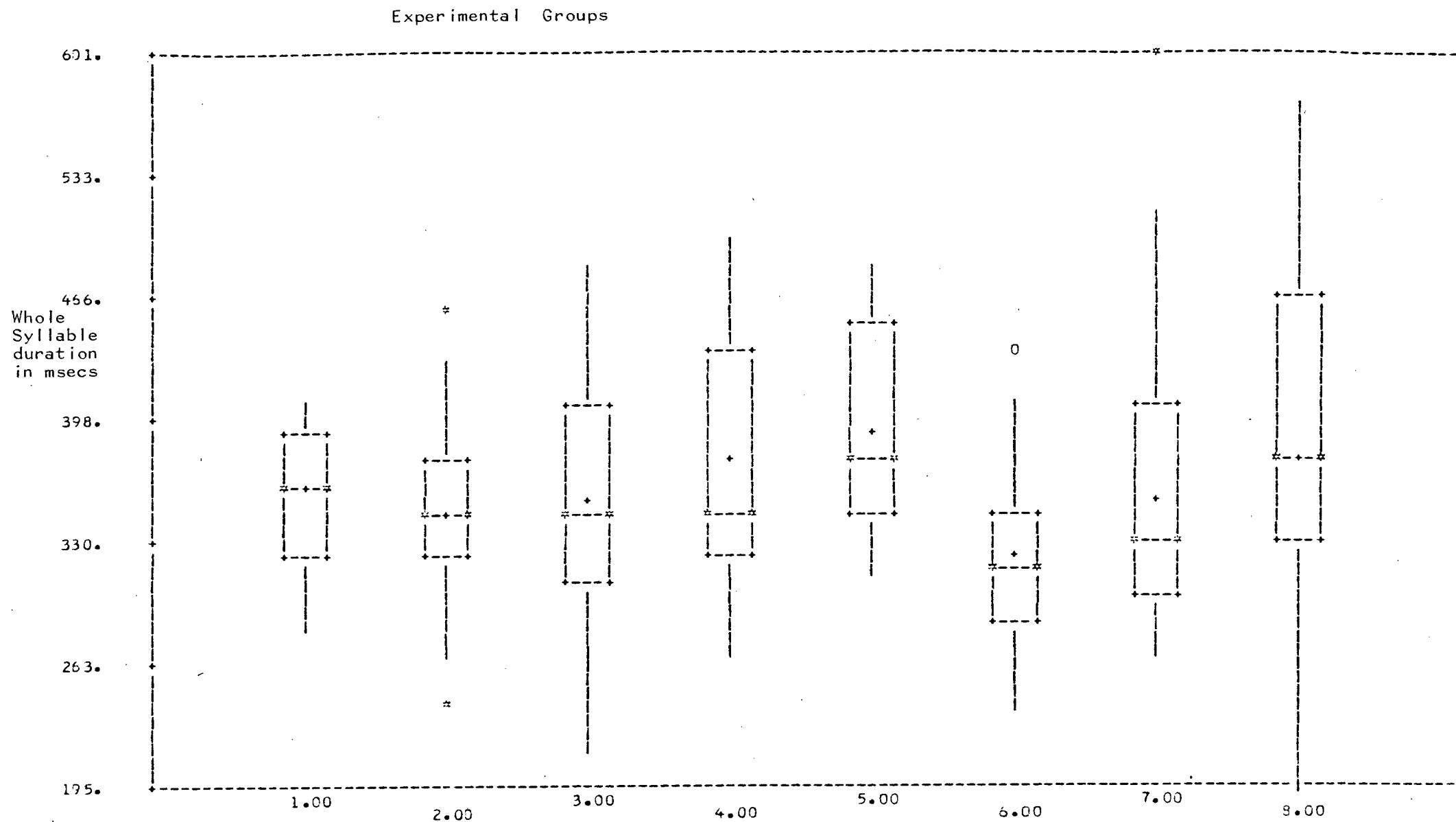


Fig. 16a(vi) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /ibi/

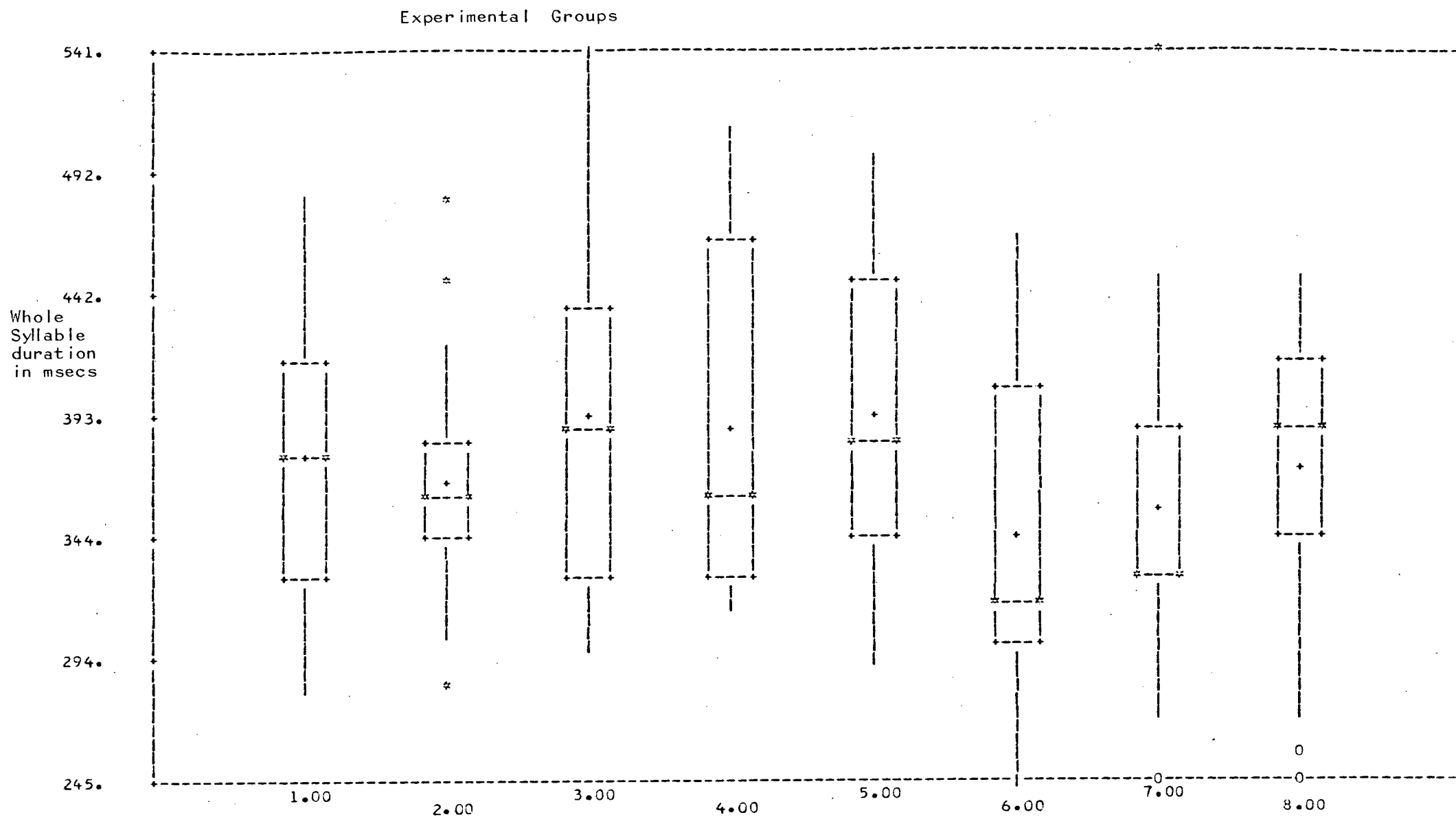


Fig. 16a(vii) Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /iti/

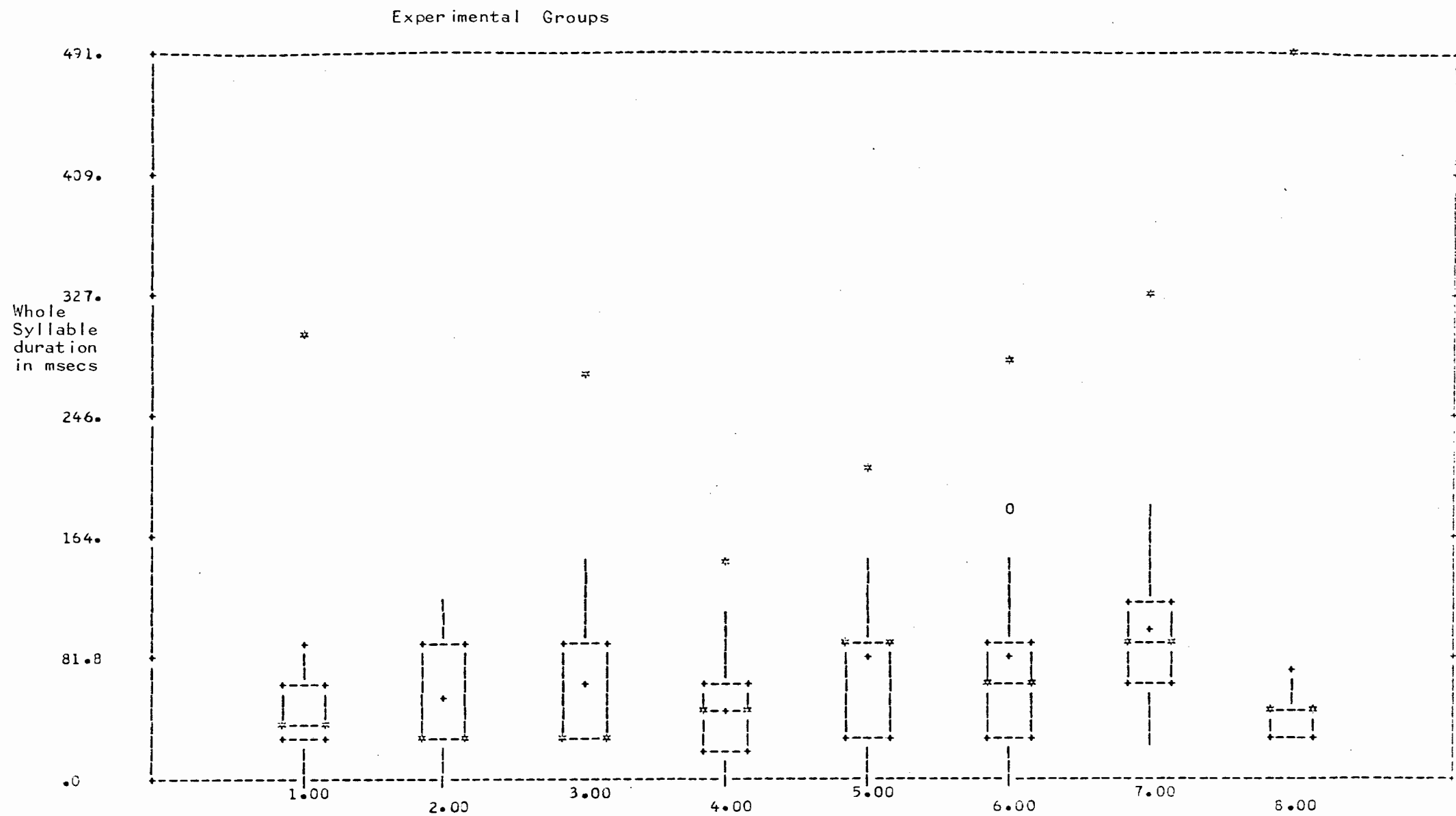


Fig. 16b(i) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /apa/

Experimental Groups

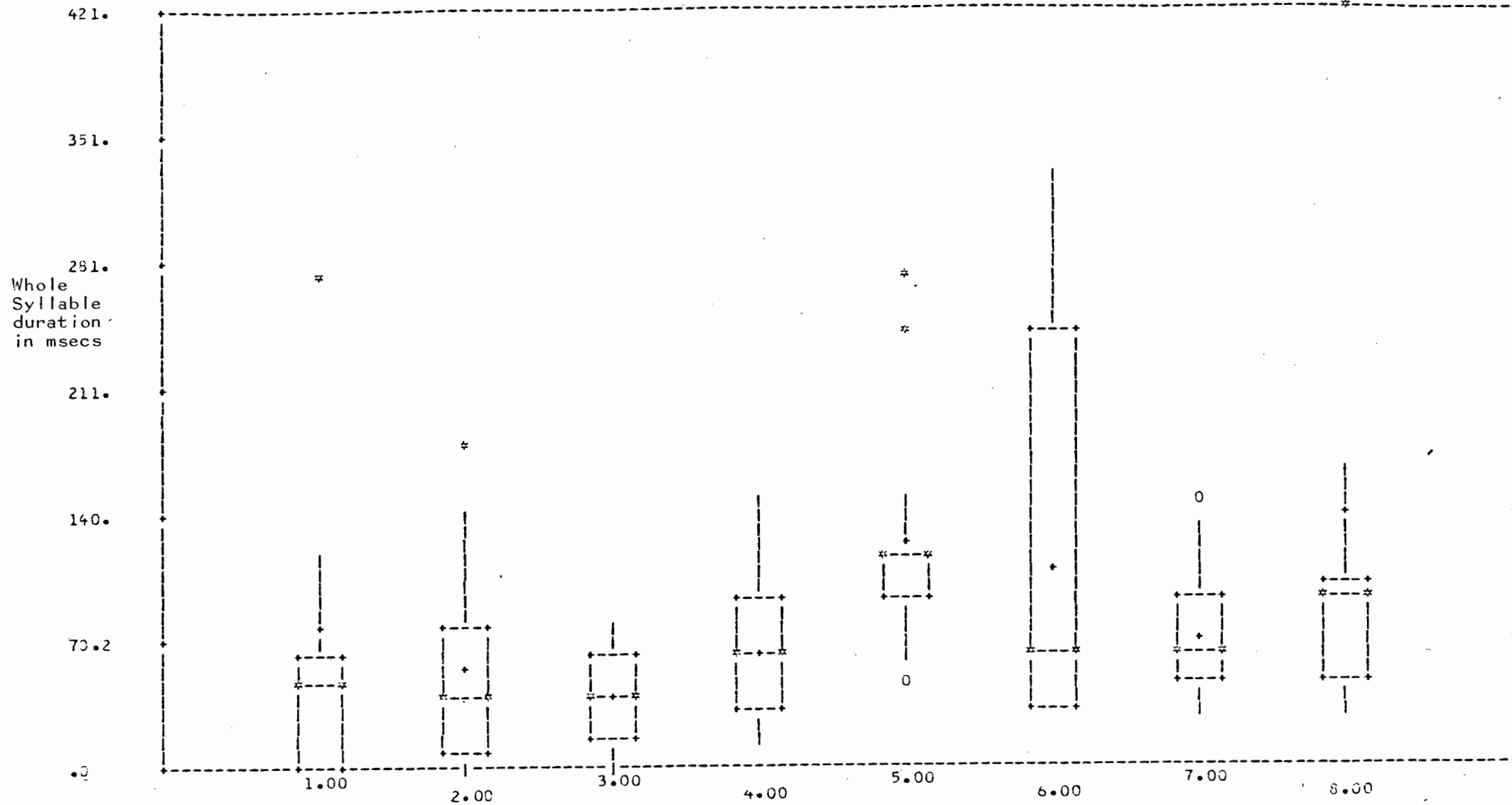


Fig. 16b(ii) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /aba/

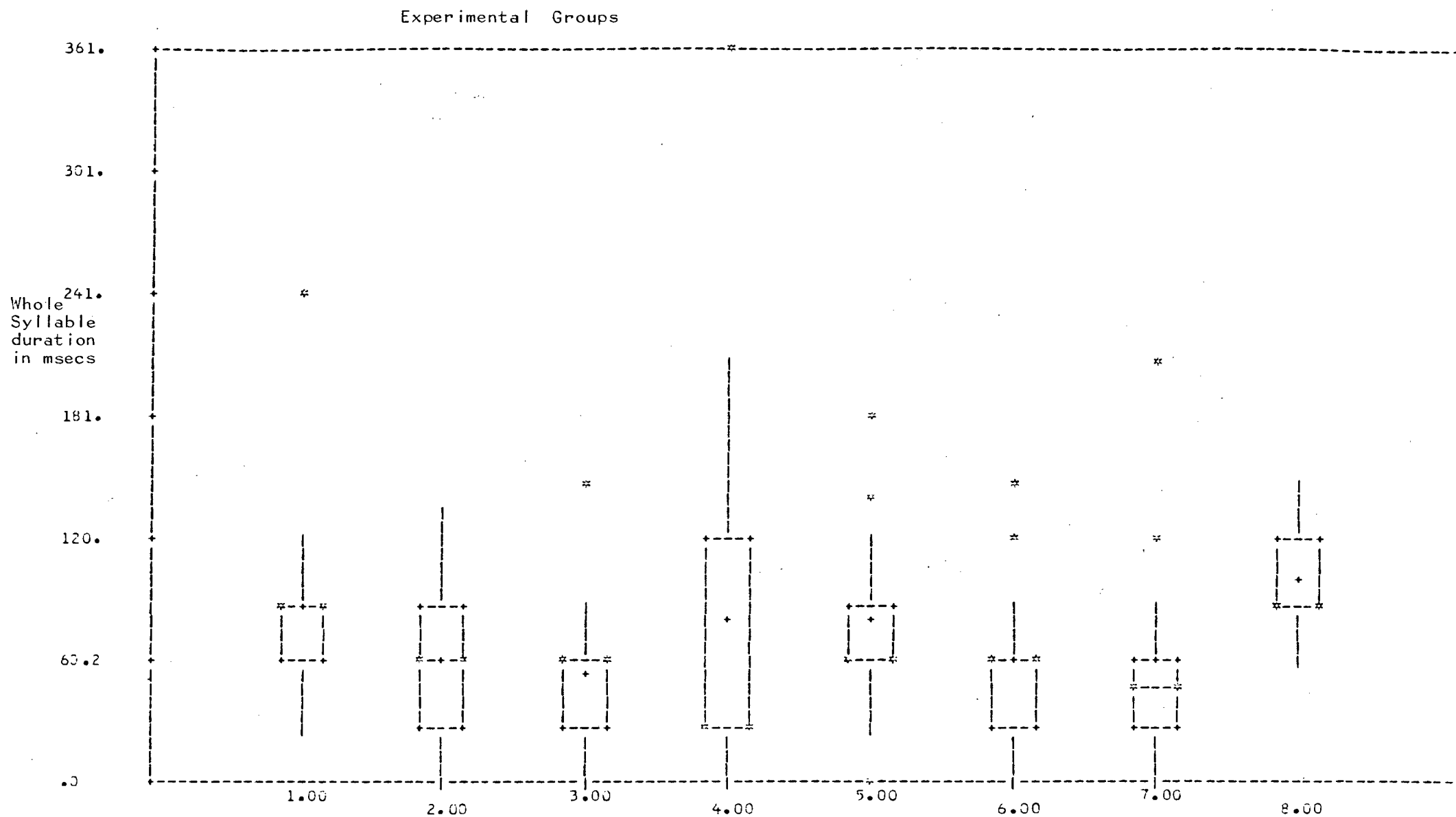


Fig. 16b(iii) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /ata/

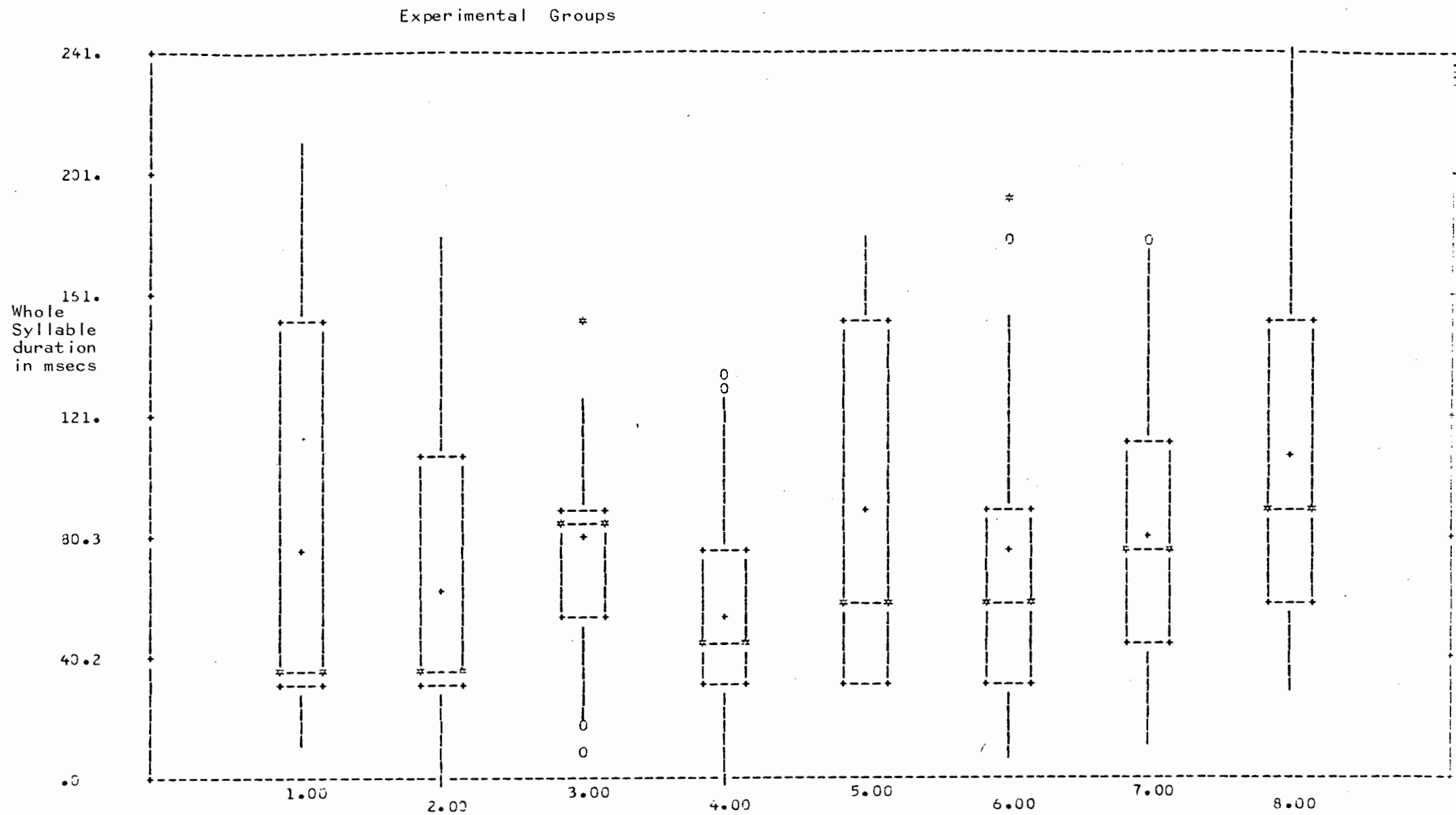


Fig. 16 (iv) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /ada/

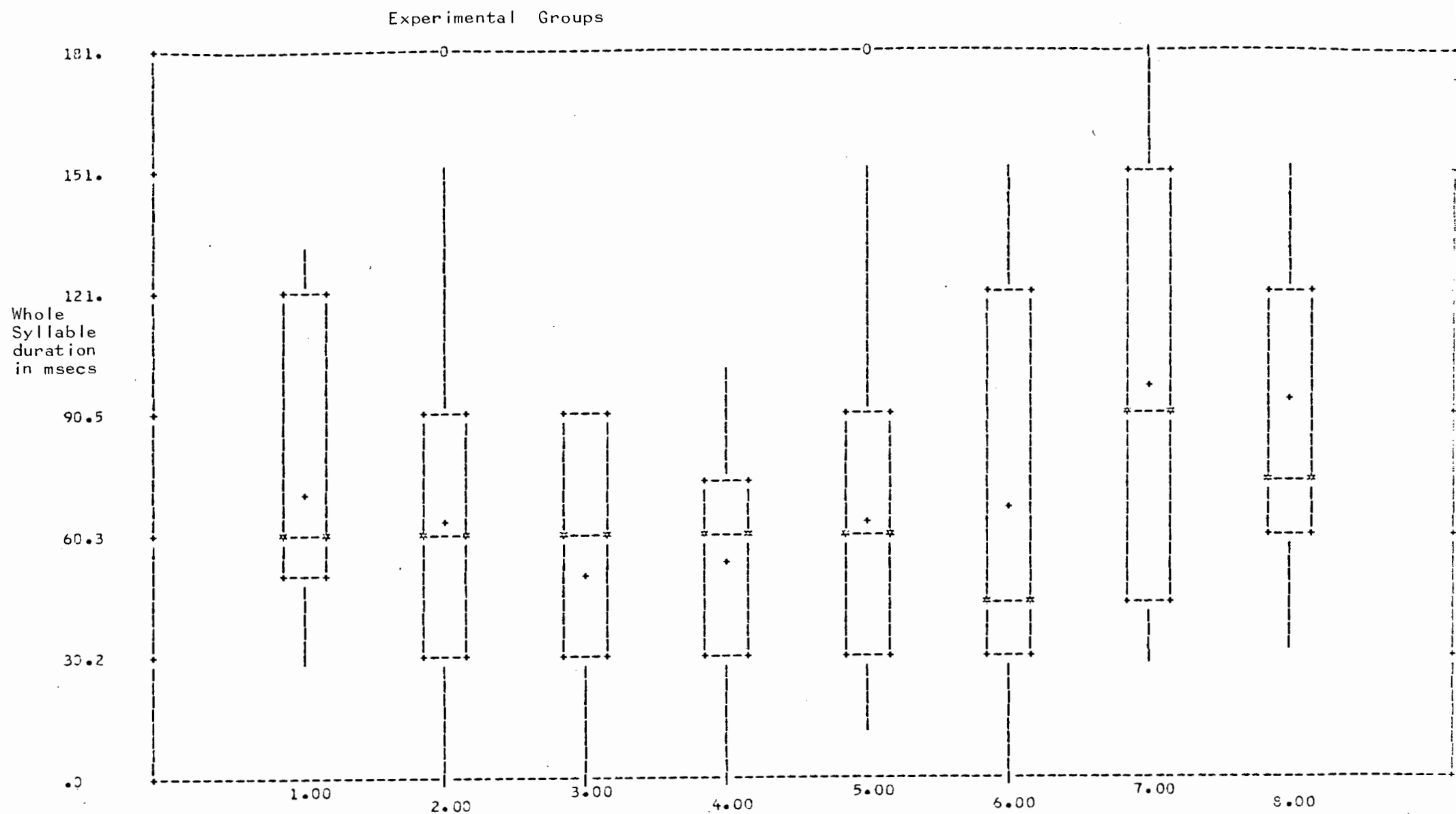


Fig. 16b(v) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /ipi/

Experimental Groups

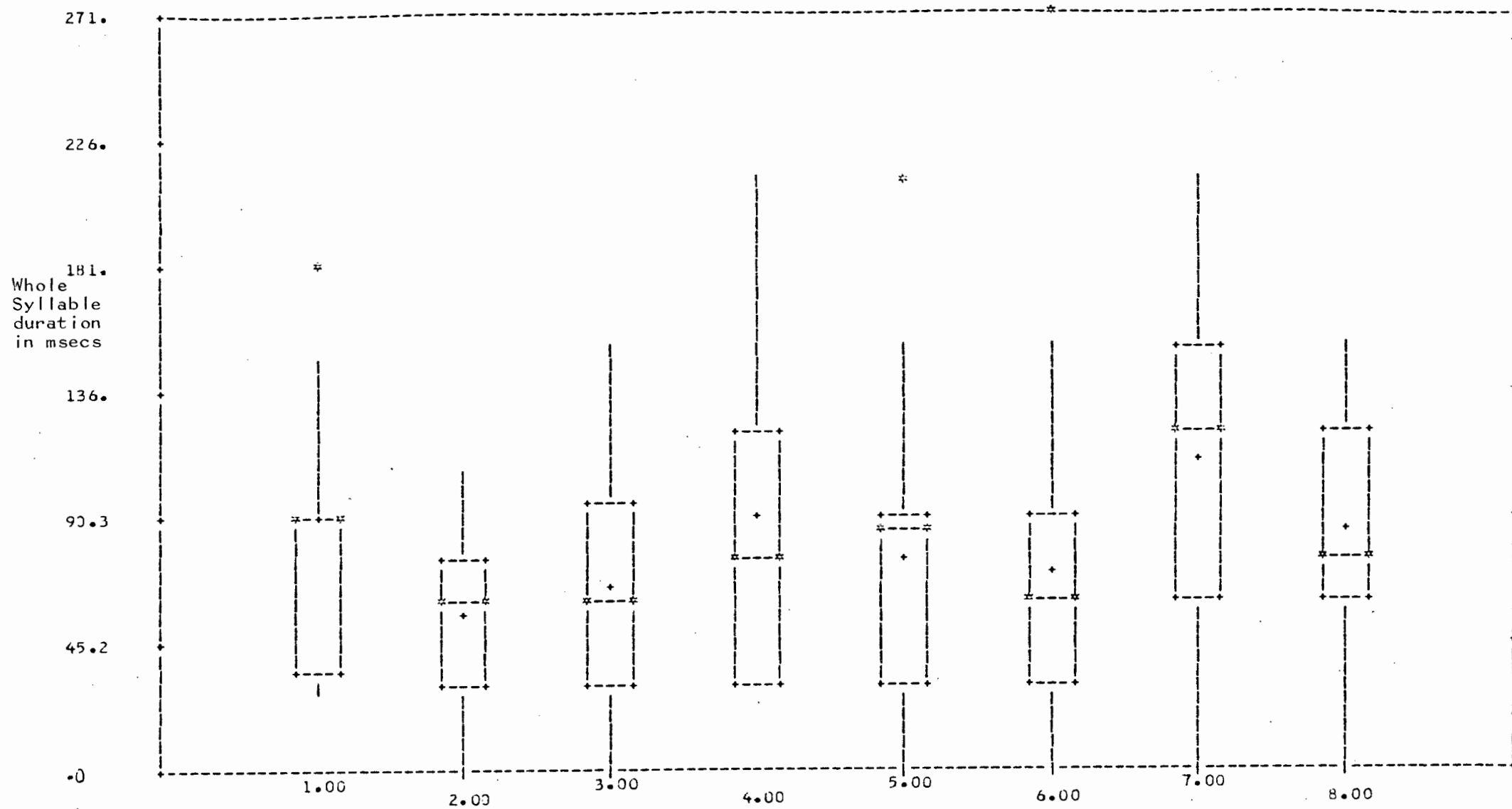


Fig. 16b(vi) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /ibi/

Experimental Groups

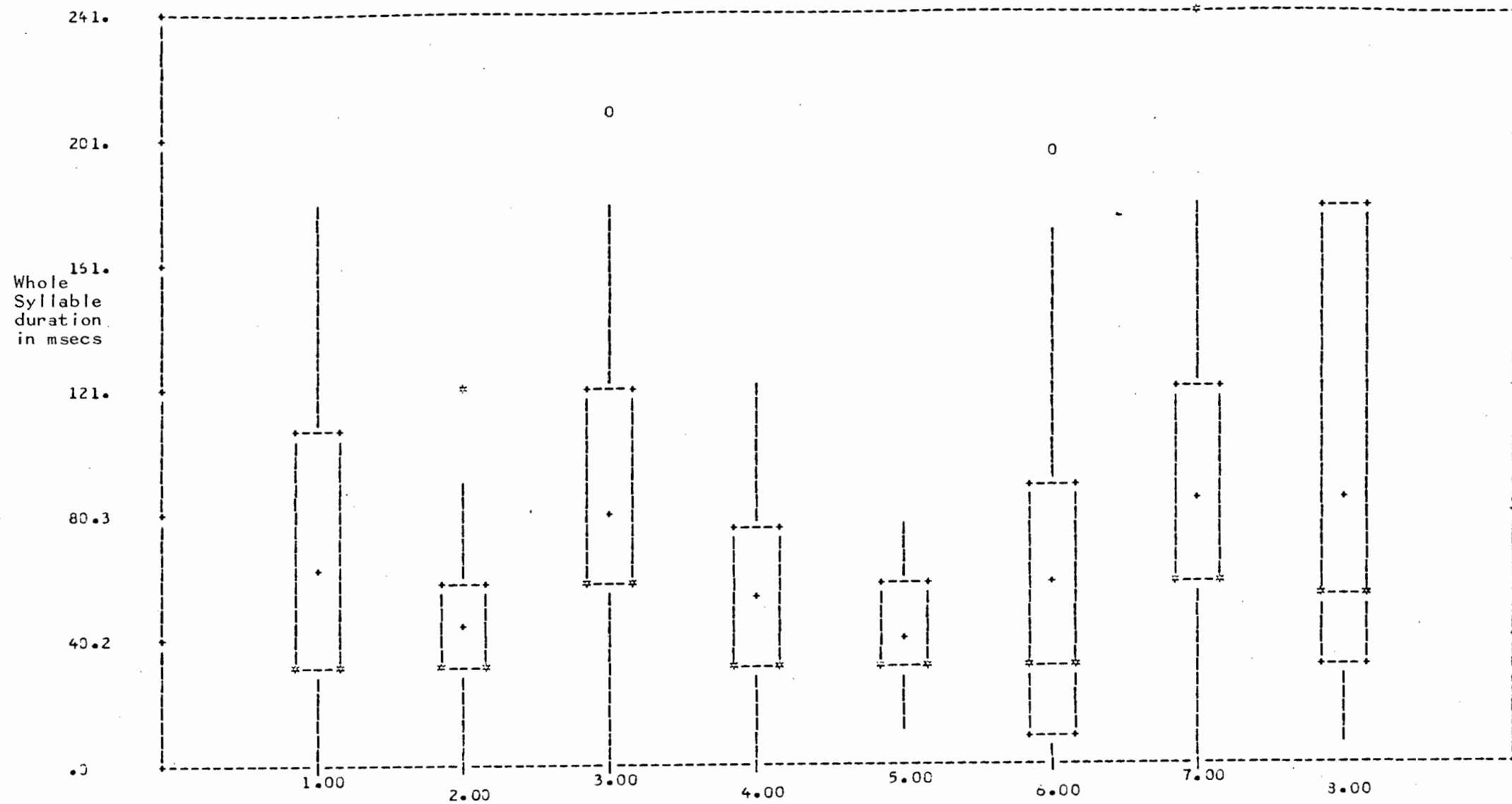


Fig. 16b(vii) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /iti/

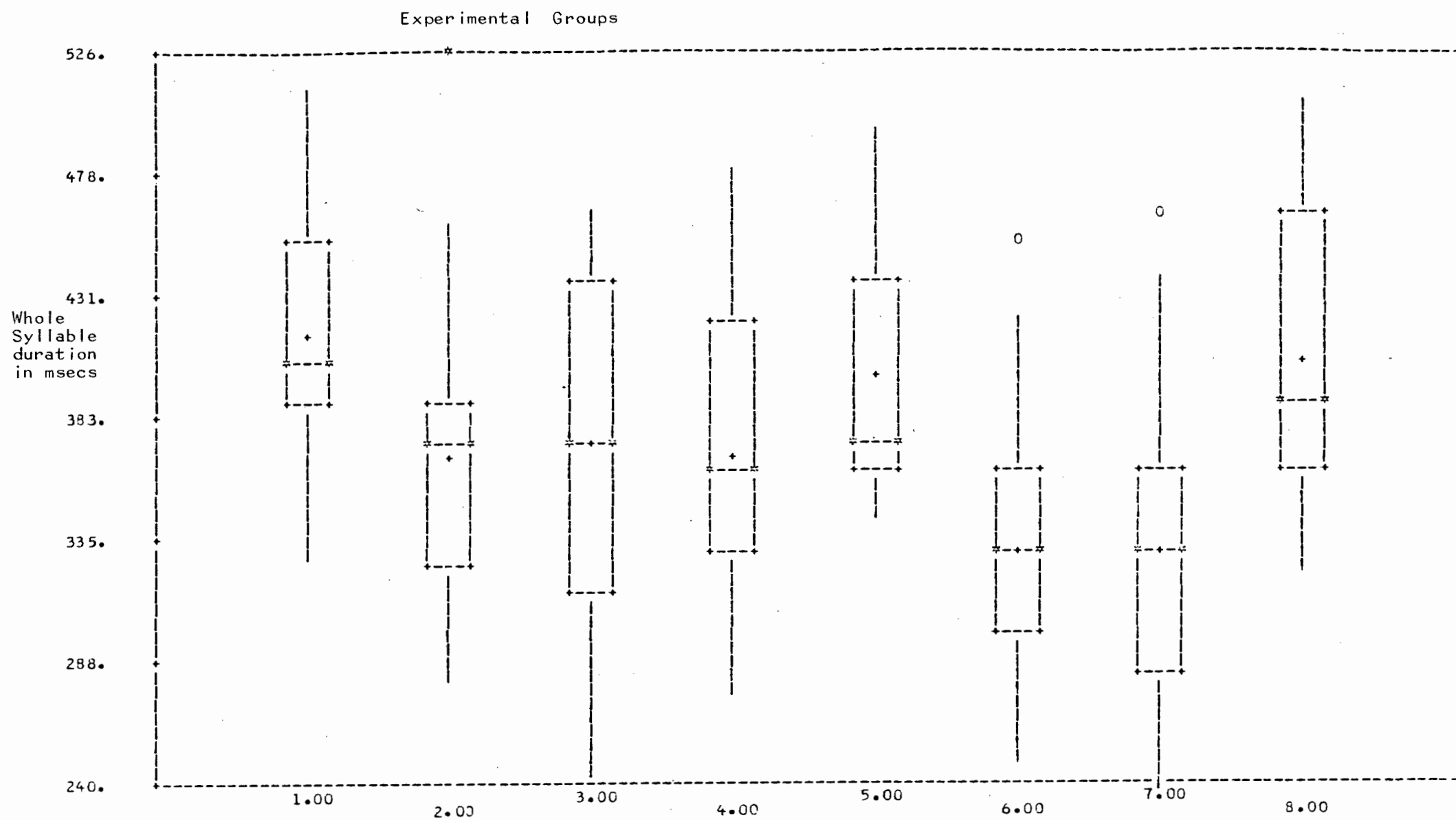


Fig. 16 (viii) Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /idi/

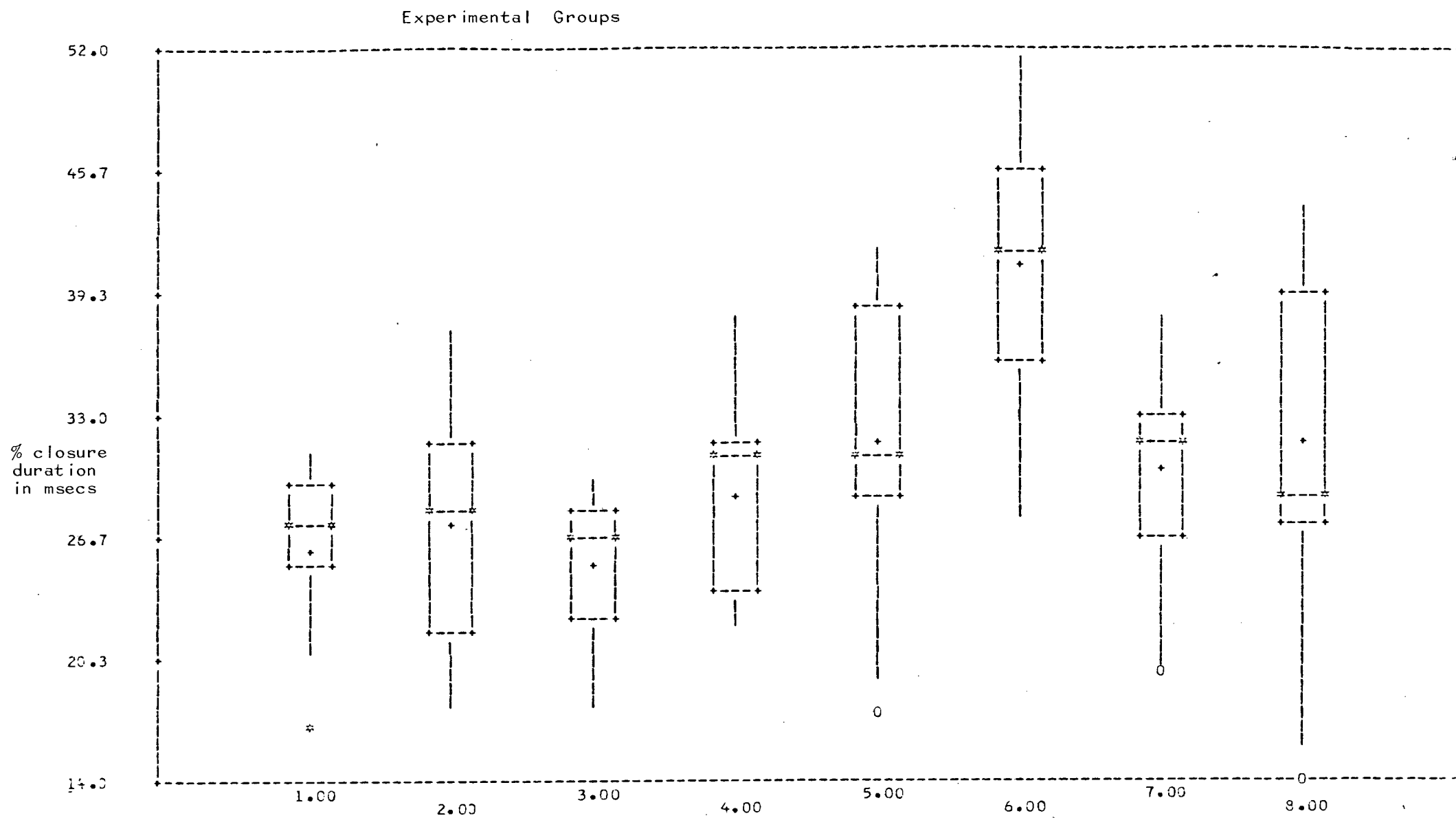


Fig. 17a(i) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /apa/

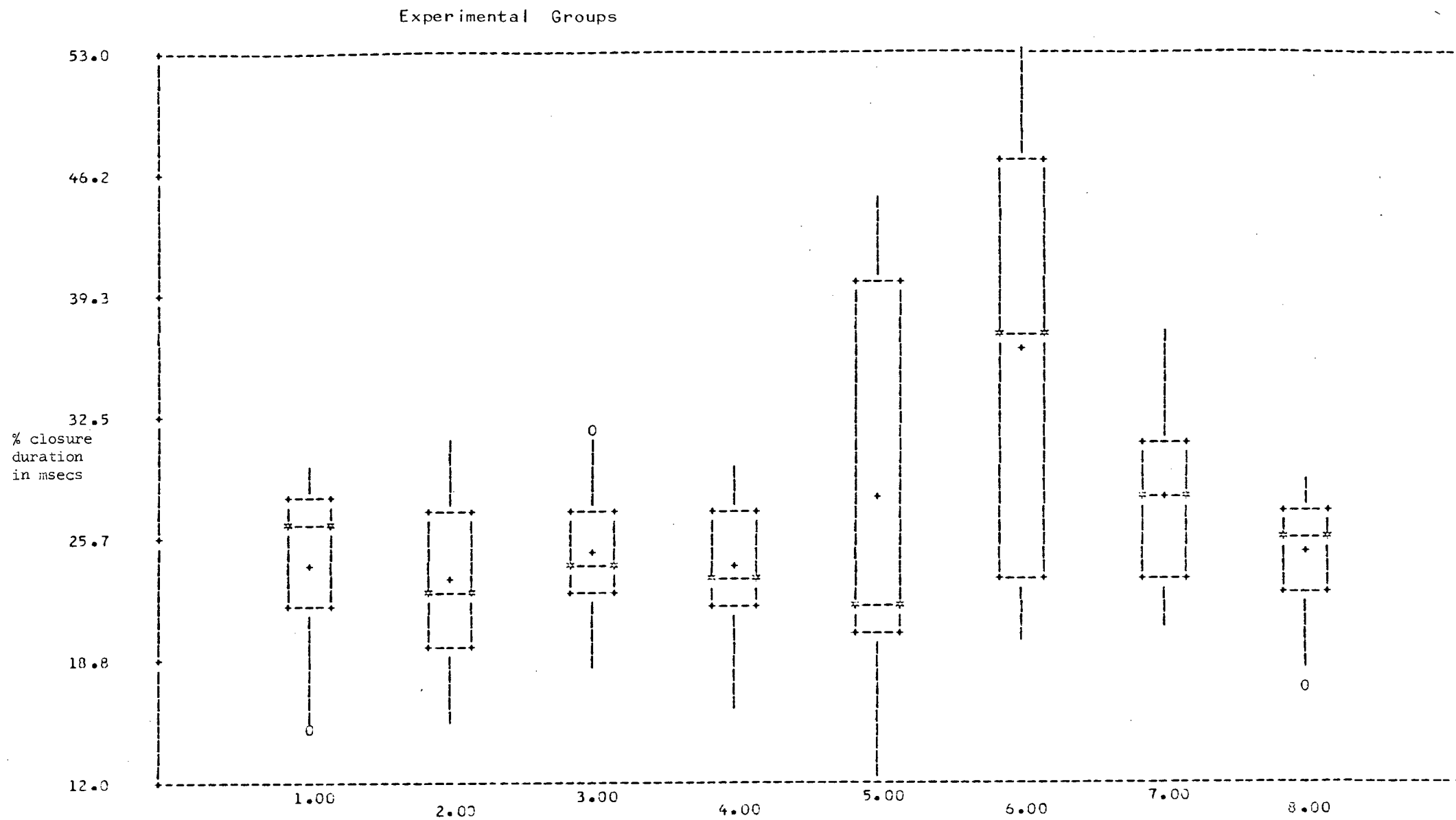


Fig. 17a(ii) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /aba/

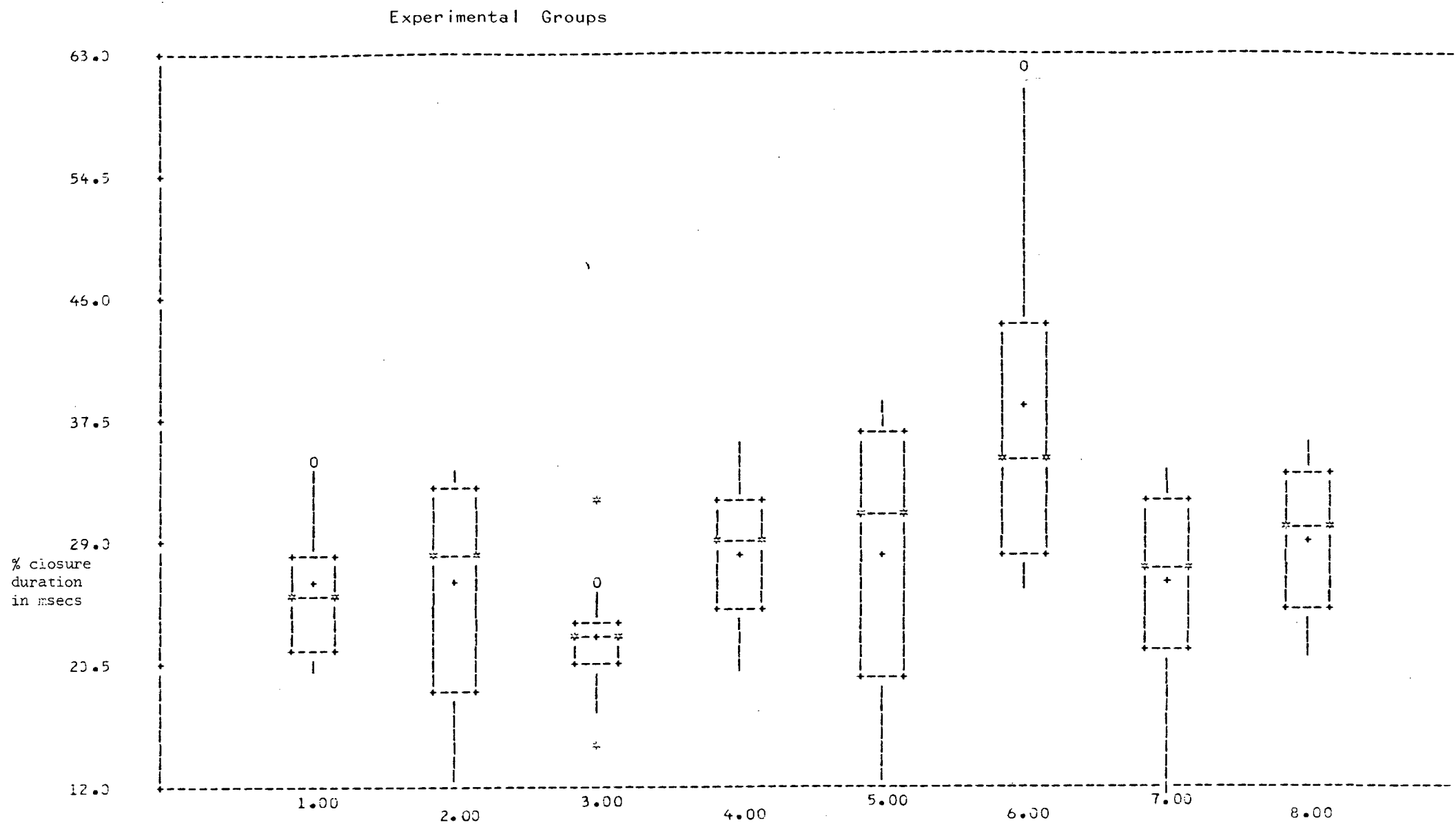


Fig. 17a(iii) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /ata/

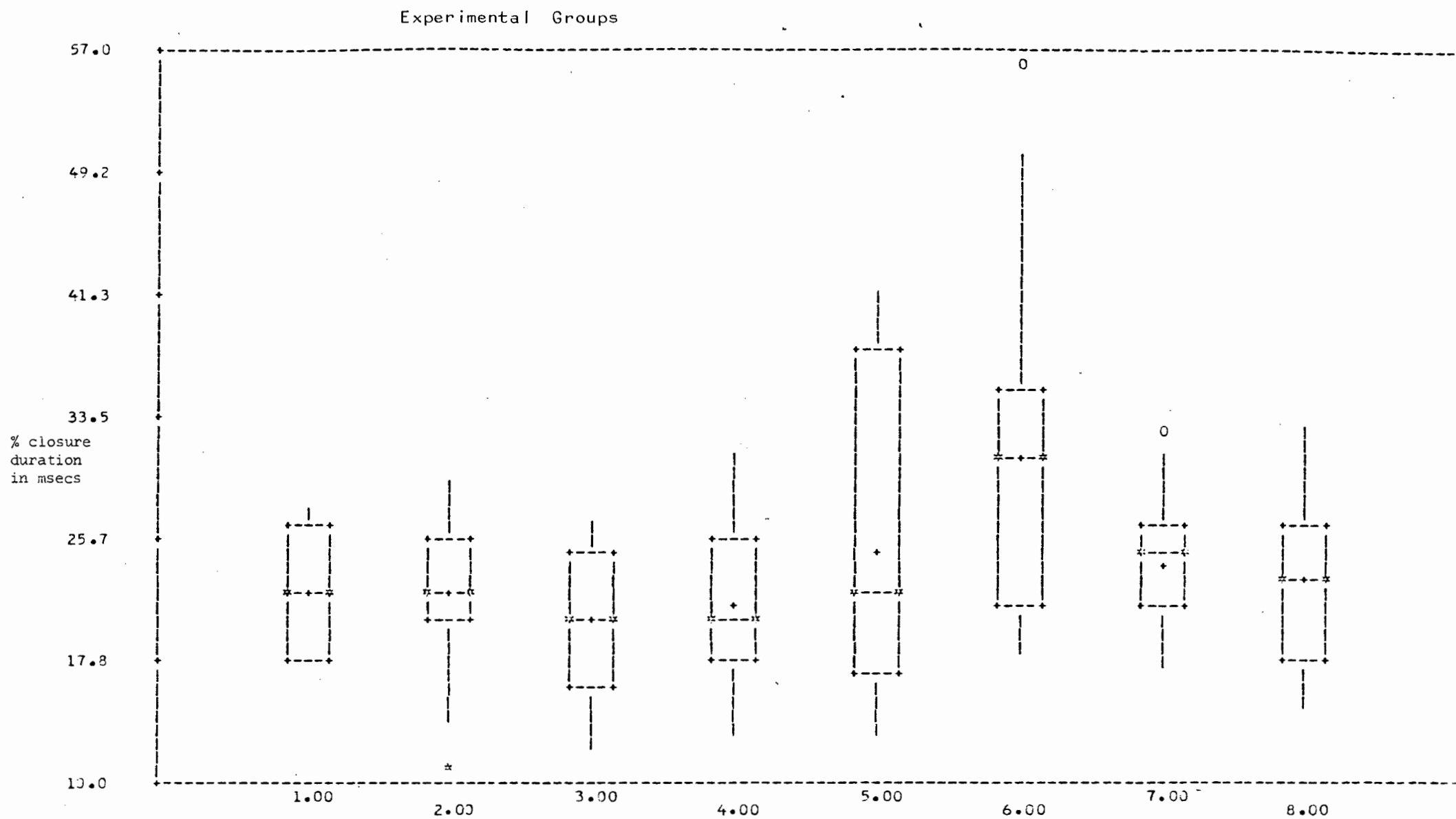


Fig. 17a(iv) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /ada/

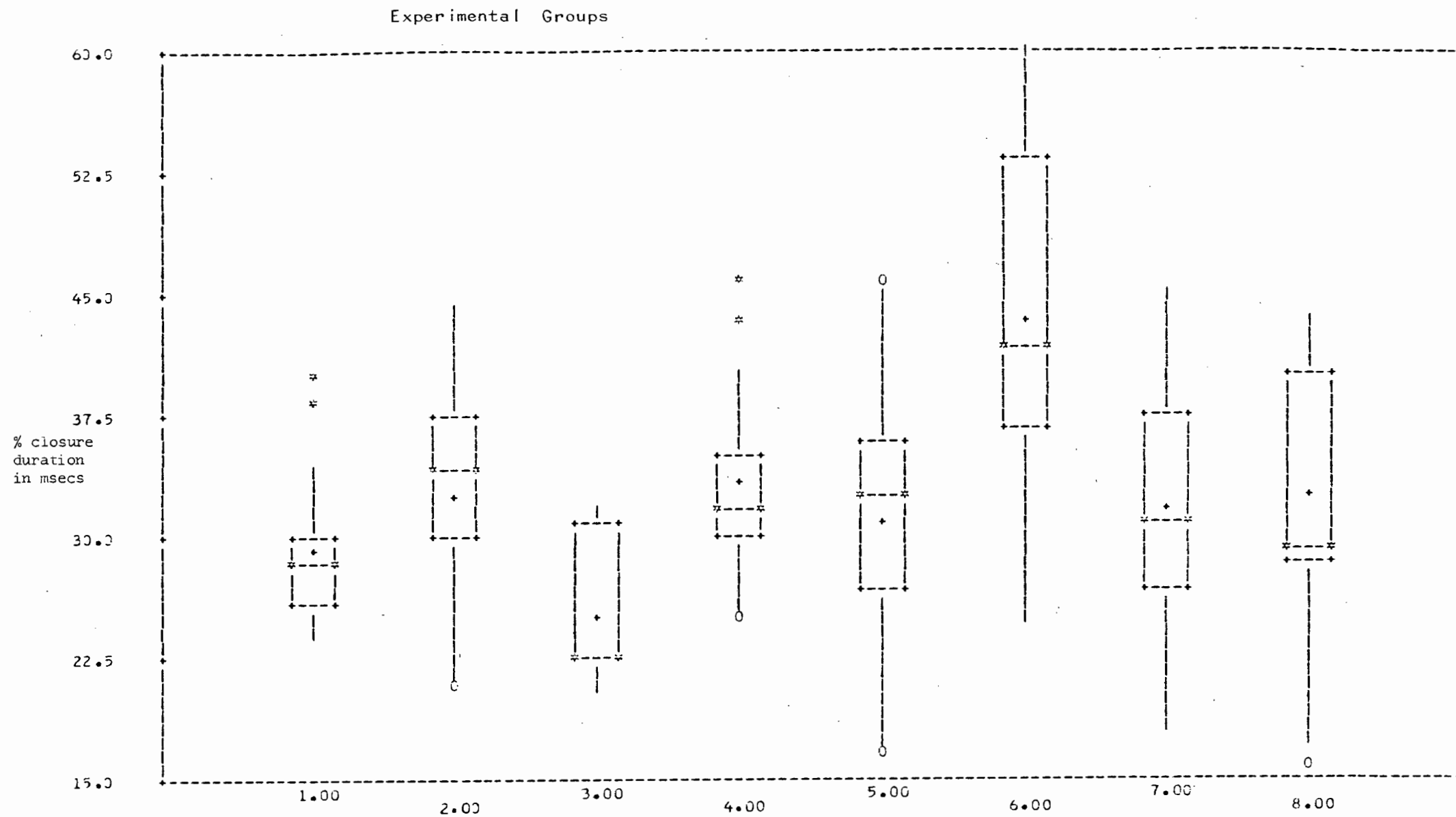


Fig. 17a (v) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /ipi/

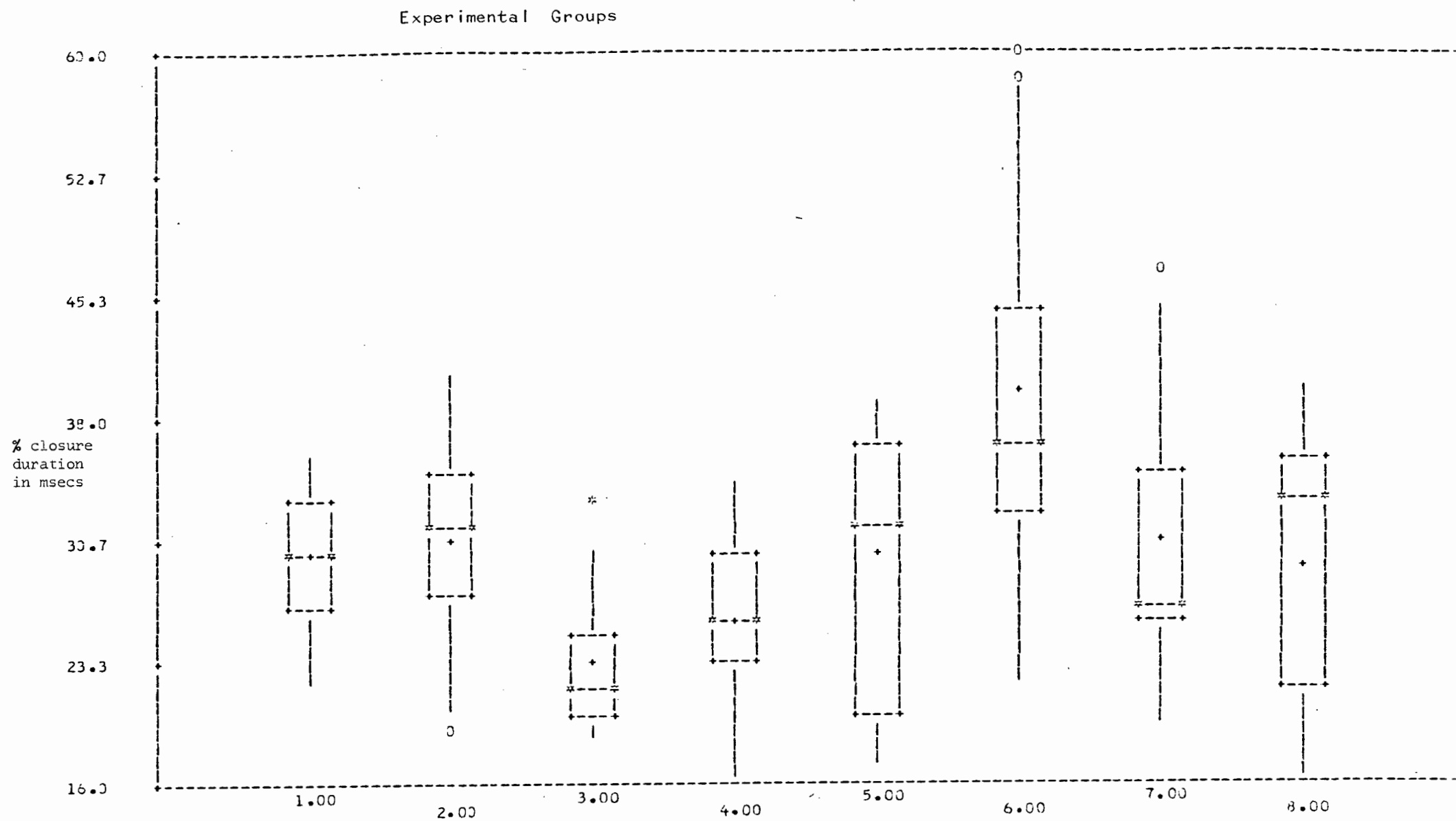


Fig. 17a(vi) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /ibi/

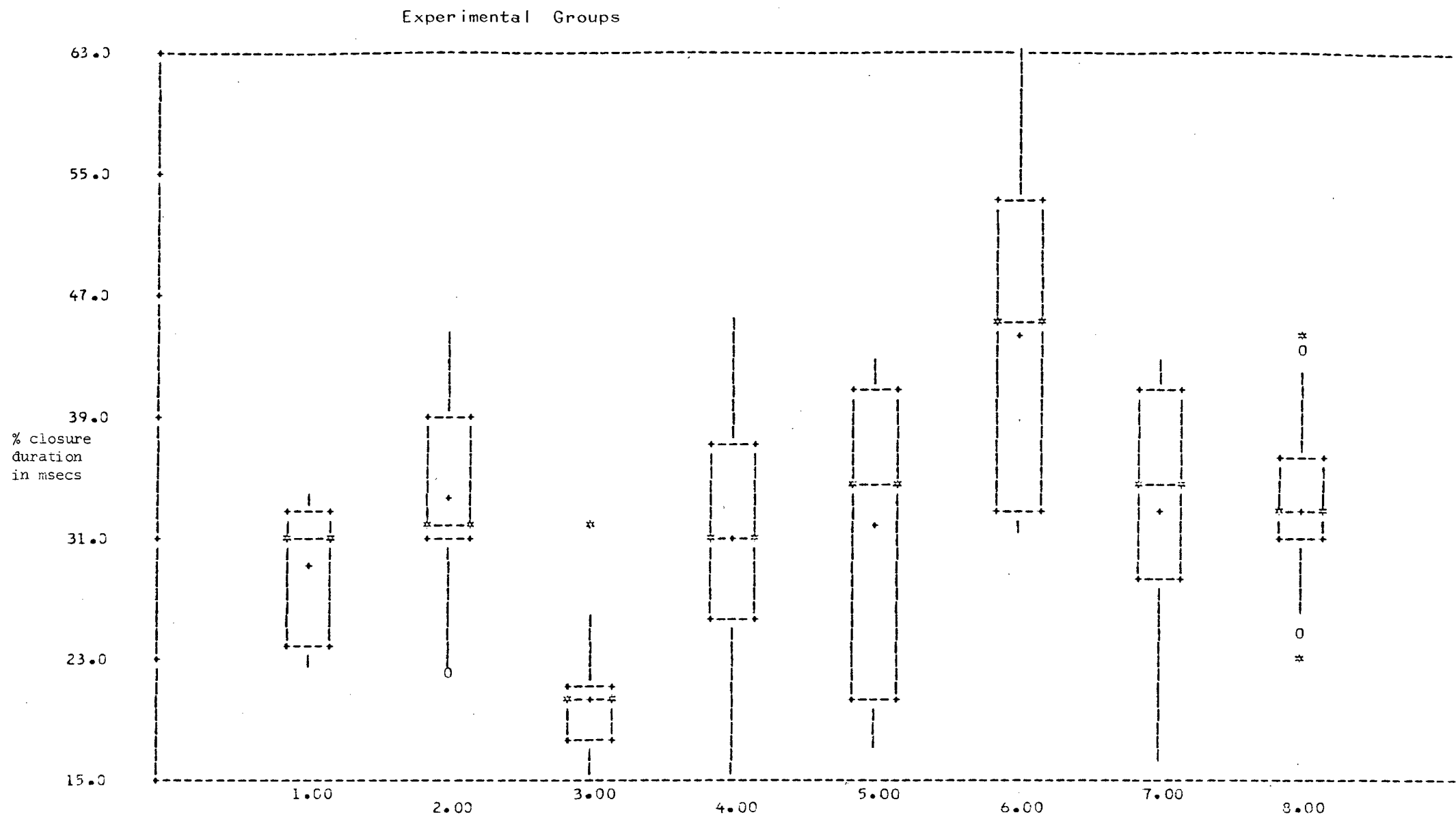


Fig. 17 a(vii) Multiple box plots showing central tendency and distribution of MM2 % closure duration for /iti/

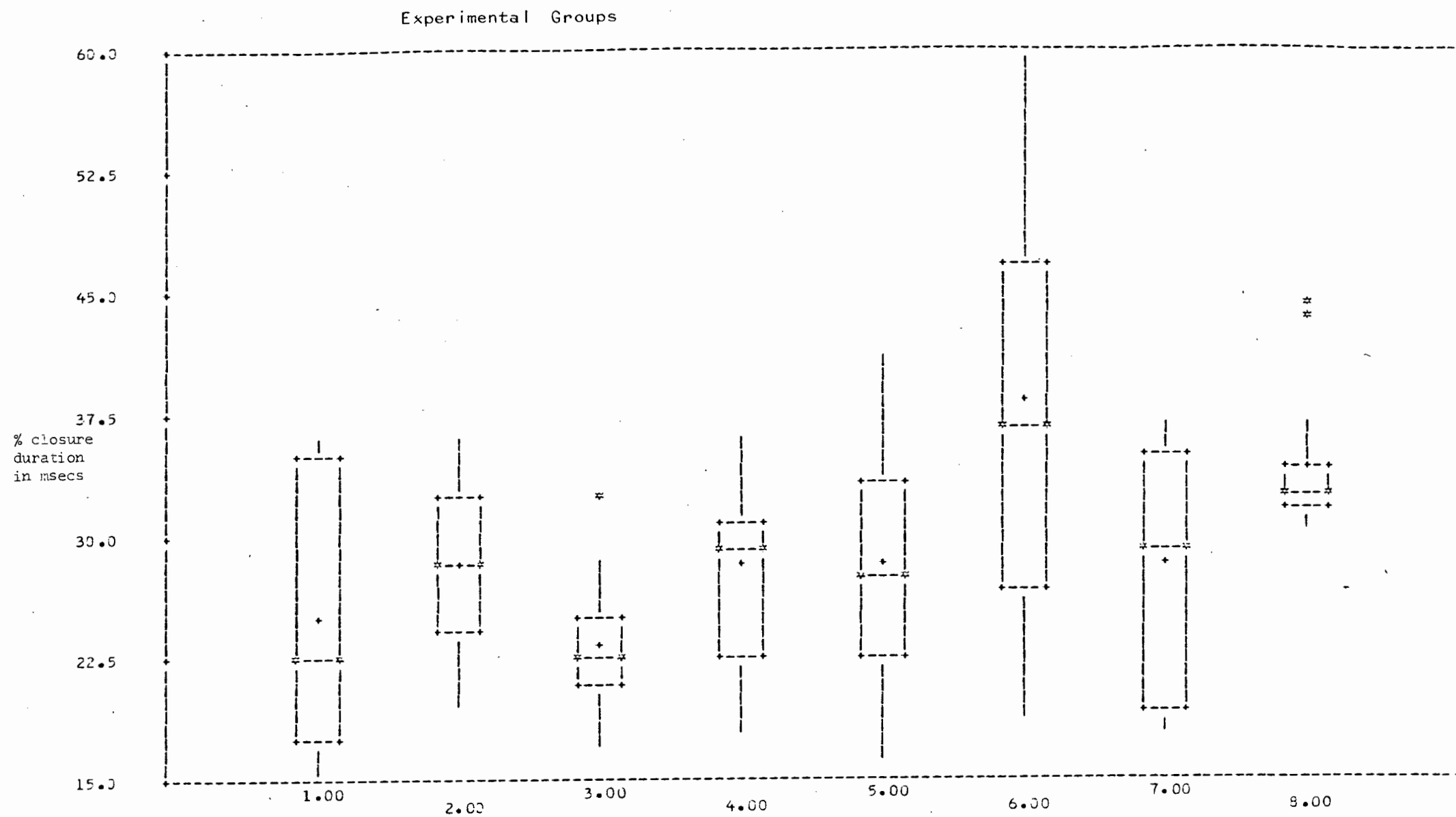


Fig. 17 a(viii) Multiple box plots showing central tendency and distribution of MM2 for % closure duration for /idi/

Experimental Groups

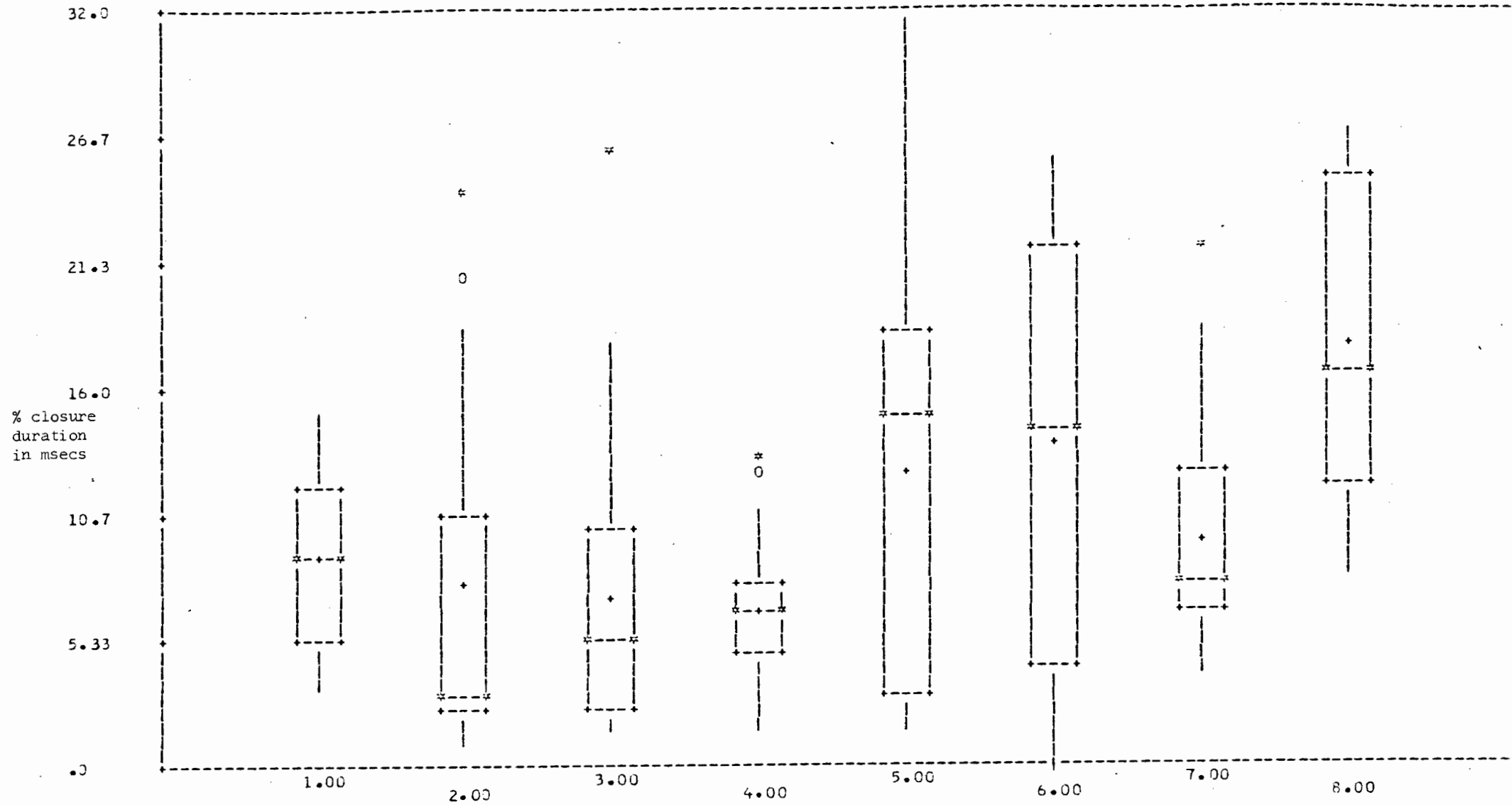


Fig. 17b(i) Multiple box plots showing central tendency and distribution of the range for % closure duration for /apa/

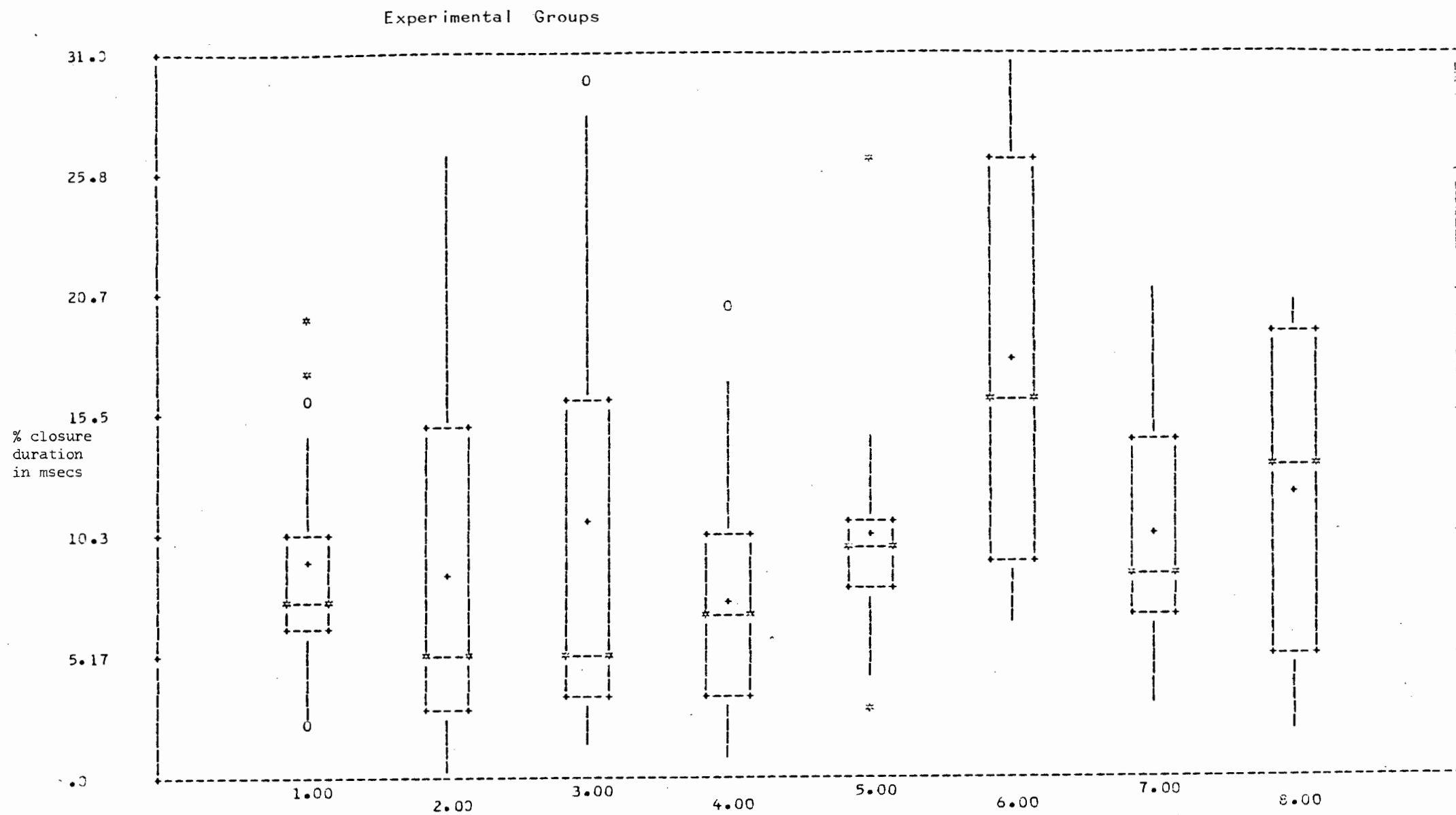


Fig. 17b(ii) Multiple box plots showing central tendency and distribution of the range for % closure duration for /aba/

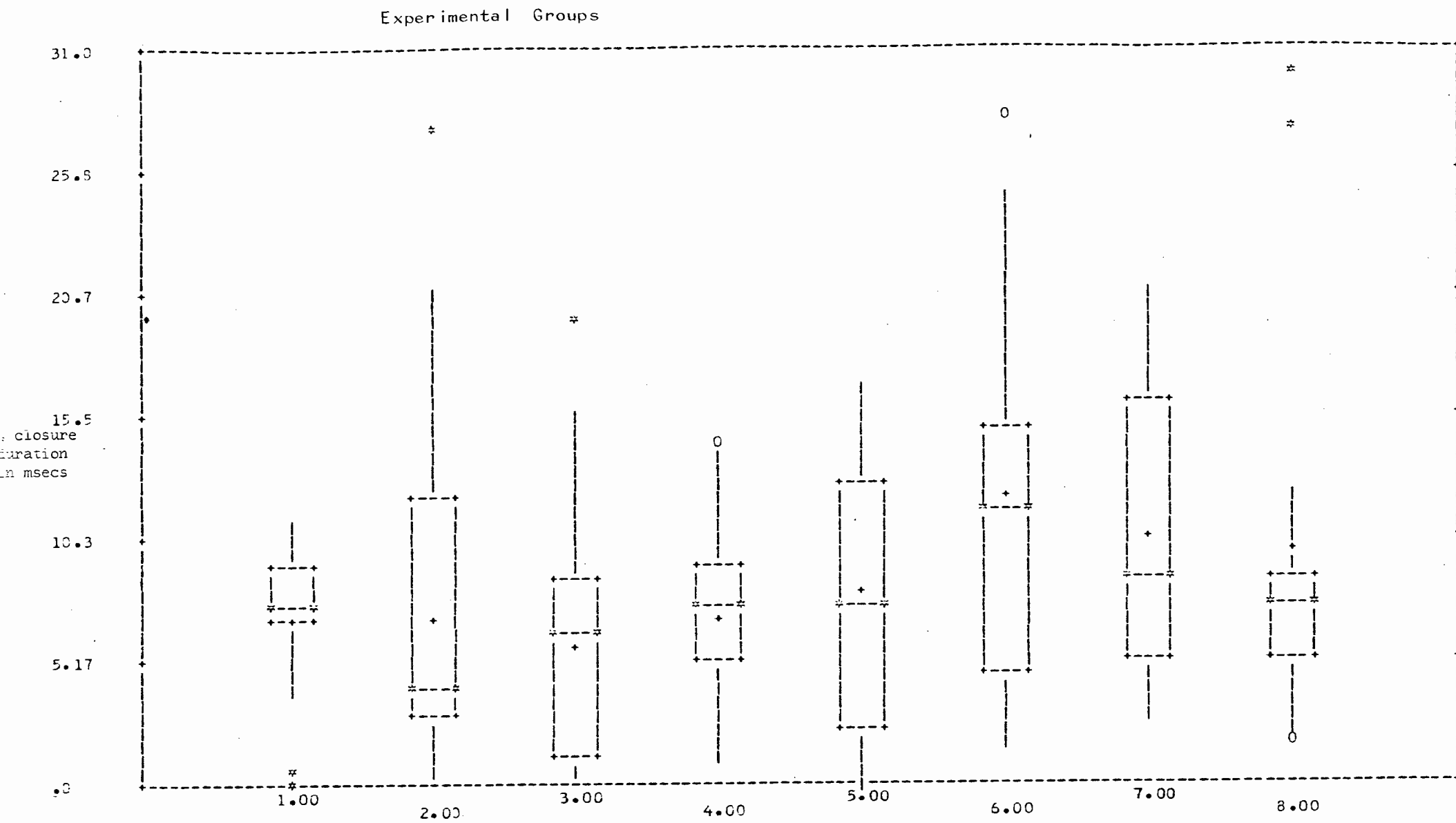


Fig. 17b(iii) Multiple box plots showing central tendency and distribution of the range for % closure duration for /ata/

Experimental Groups

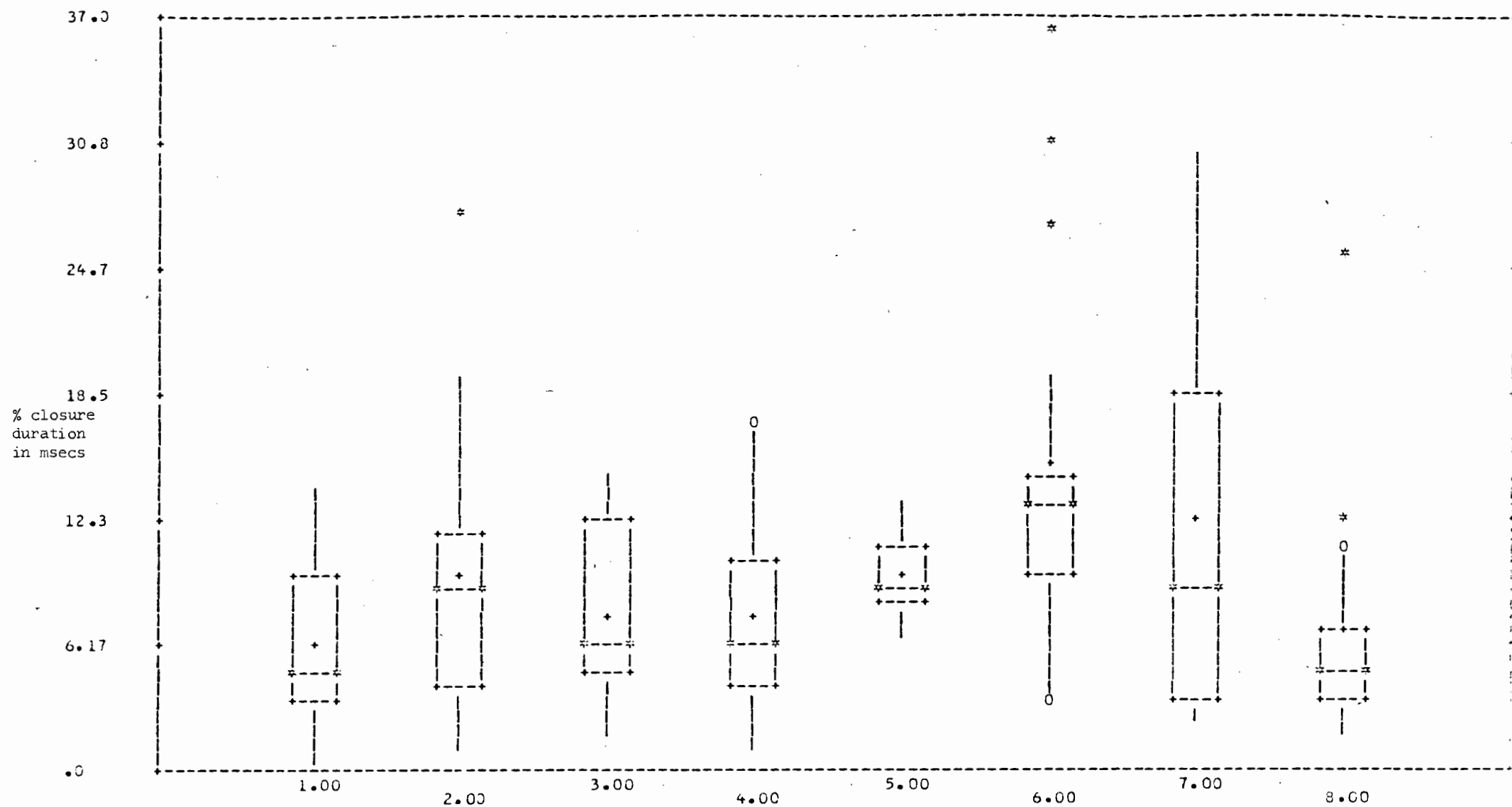


Fig. 17 b(iv) Multiple box plots showing central tendency and distribution of the range for % closure duration for /adā/

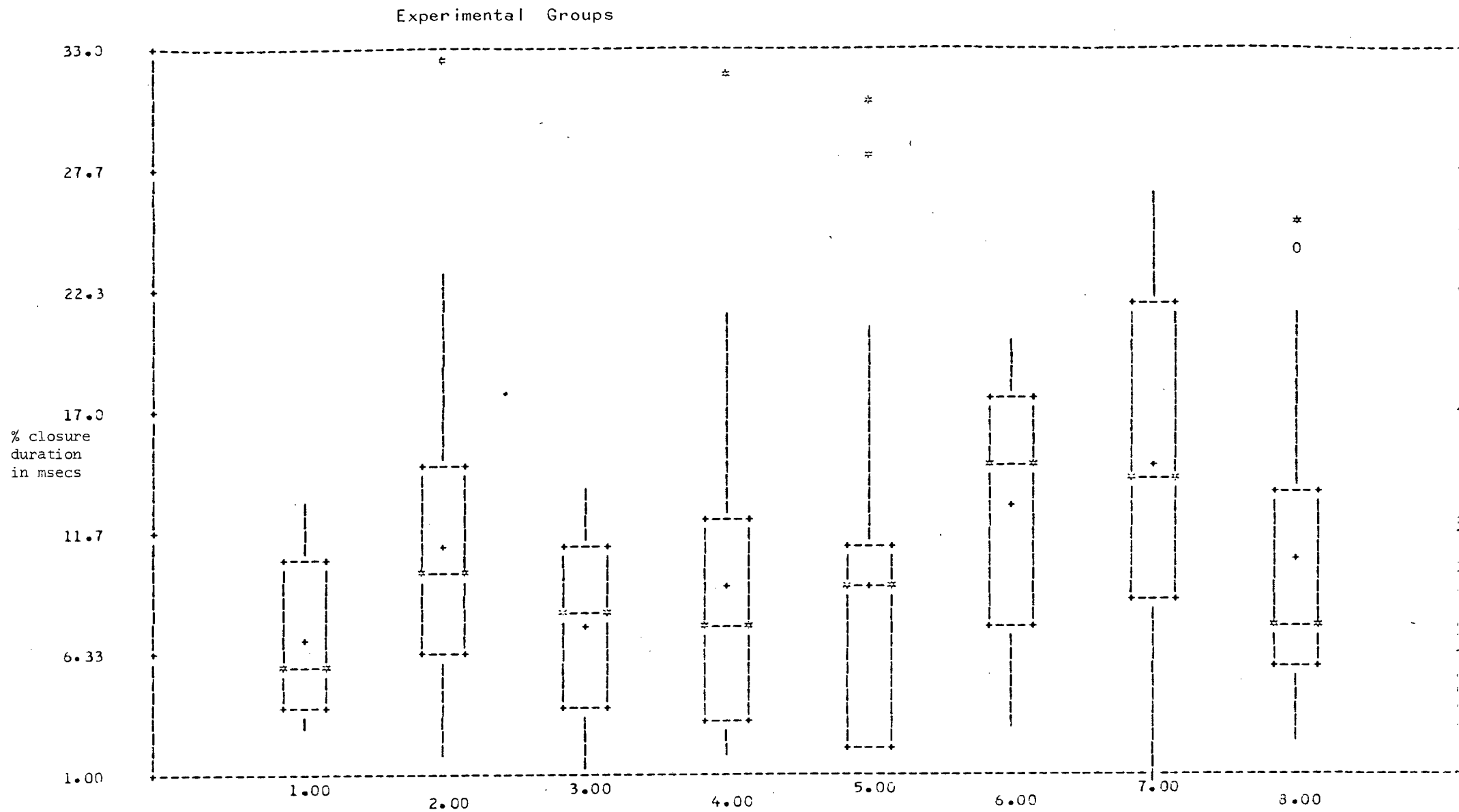


Fig. 17b(v) Multiple box plots showing central tendency and distribution of the range for % closure duration for /ipi/

Experimental Groups

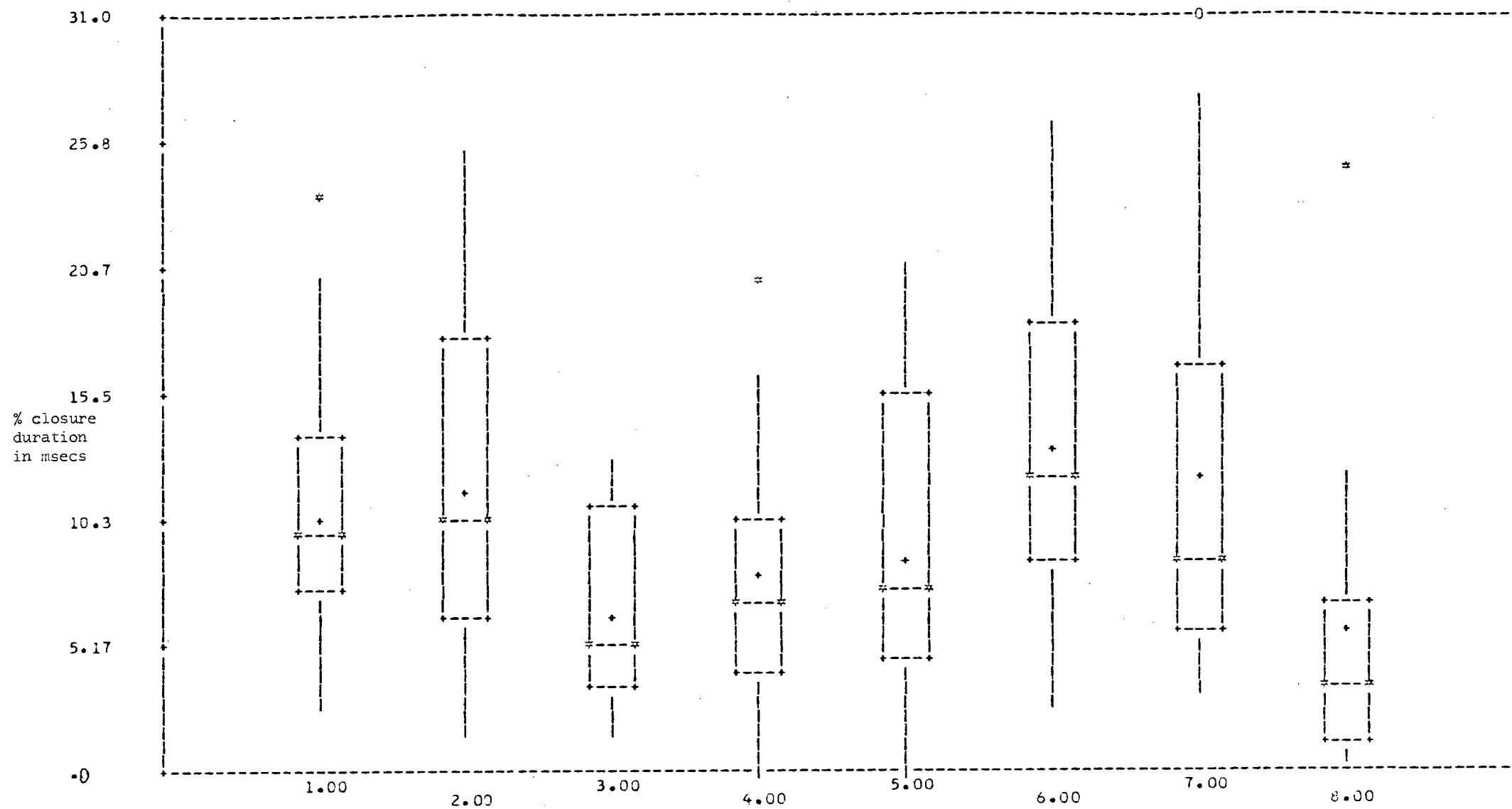


Fig. 17b(vi) Multiple box plots showing central tendency and distribution of the range for % closure duration for /ibi/

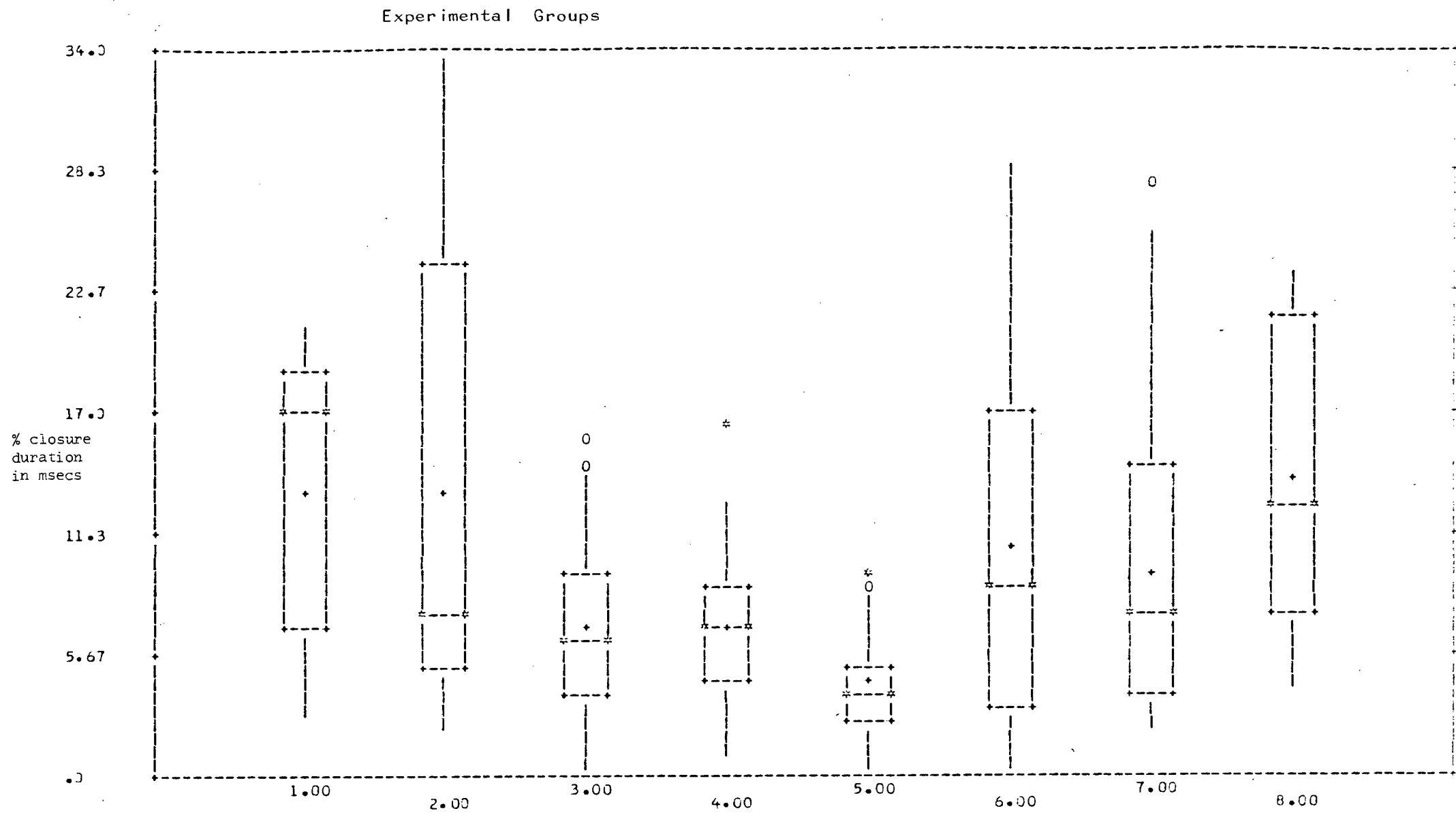


Fig. 17b(vii) Multiple box plots showing central tendency and distribution of the range for % closure duration for /iti/

Experimental Groups

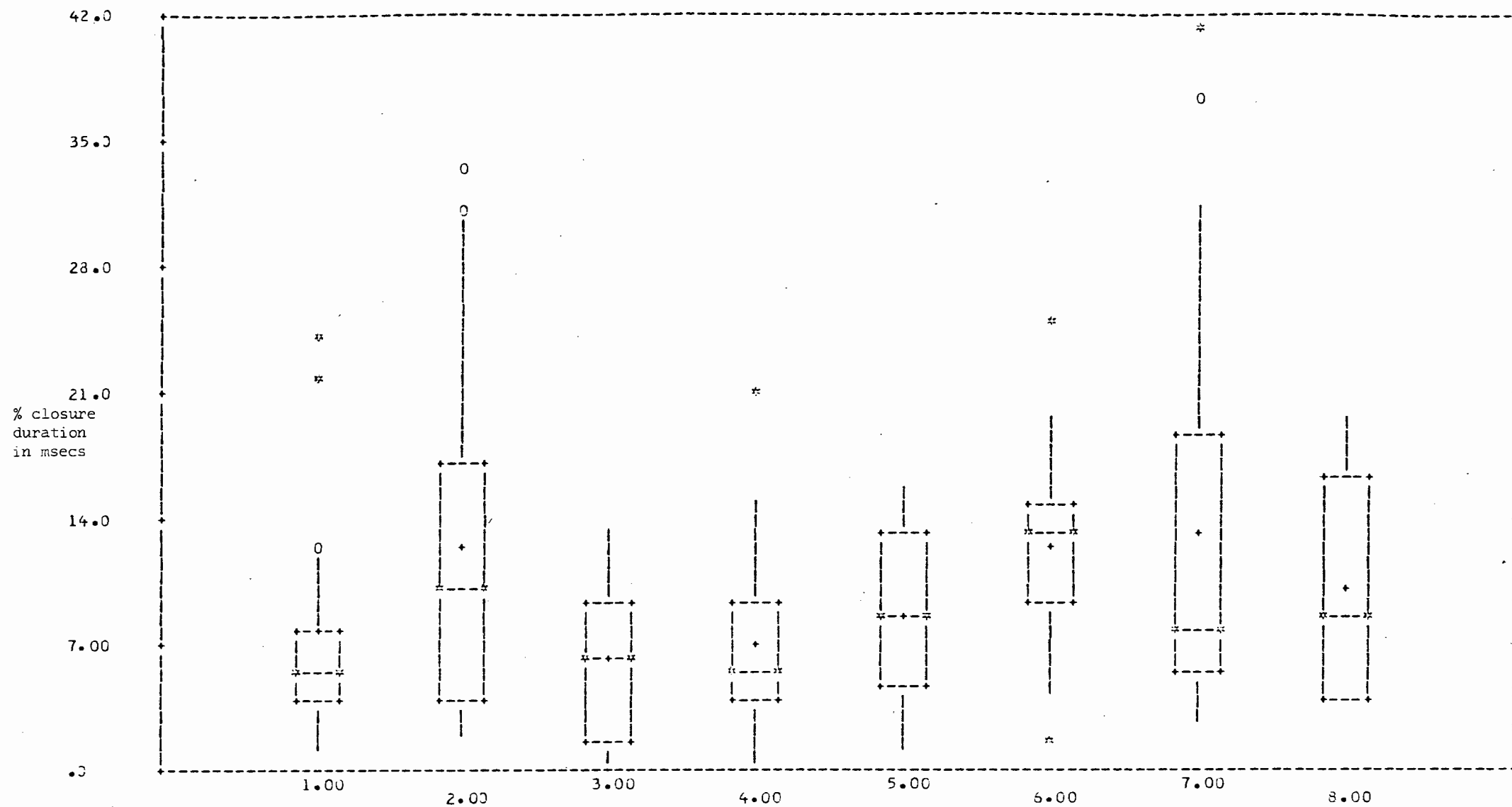


Fig. 17b(viii) Multiple box plots showing central tendency and distribution of the range for % closure duration for /idi/

stop
closure
duration
in msecs

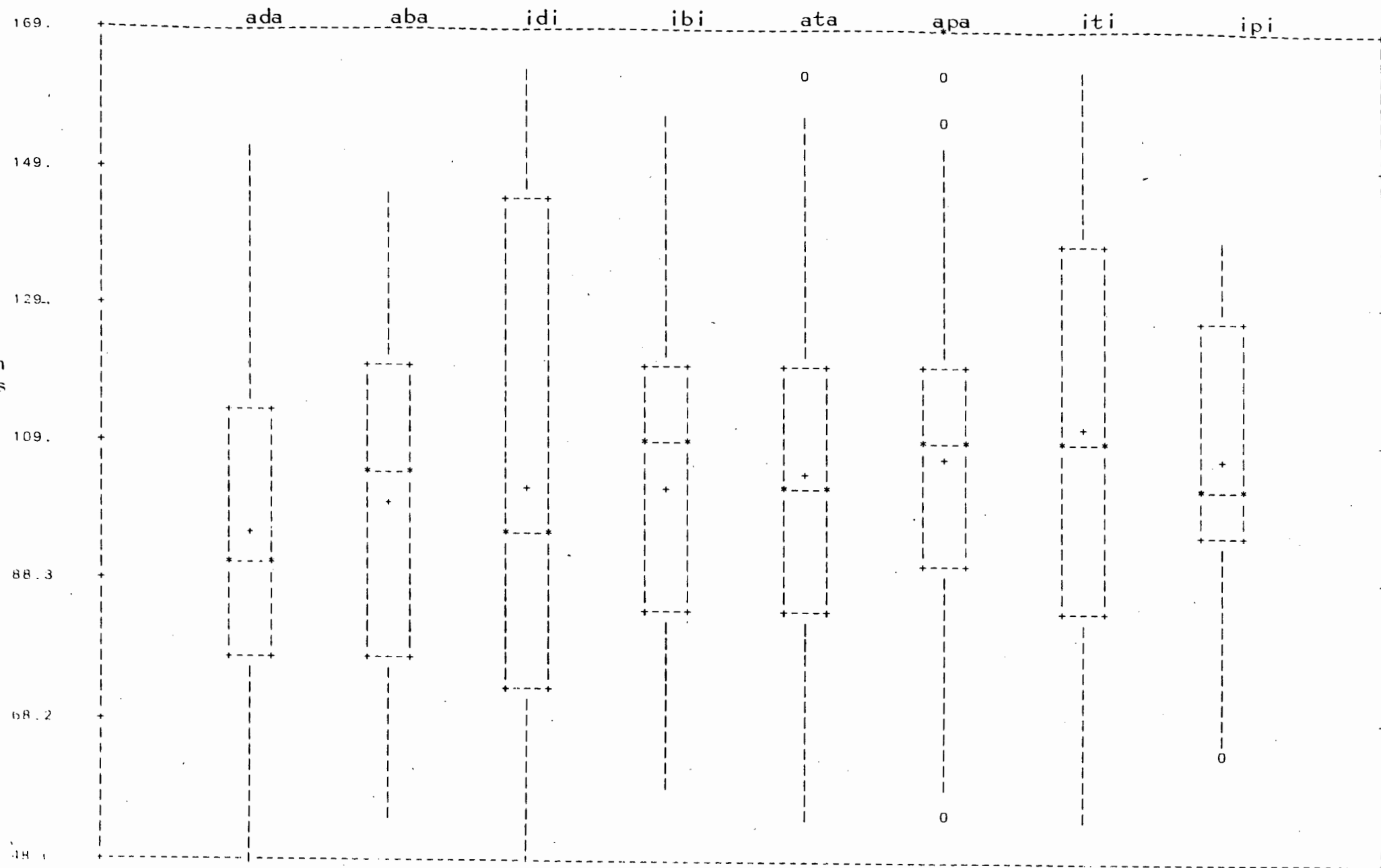


Fig. 18a Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 1.

stop
closure
duration
in msec

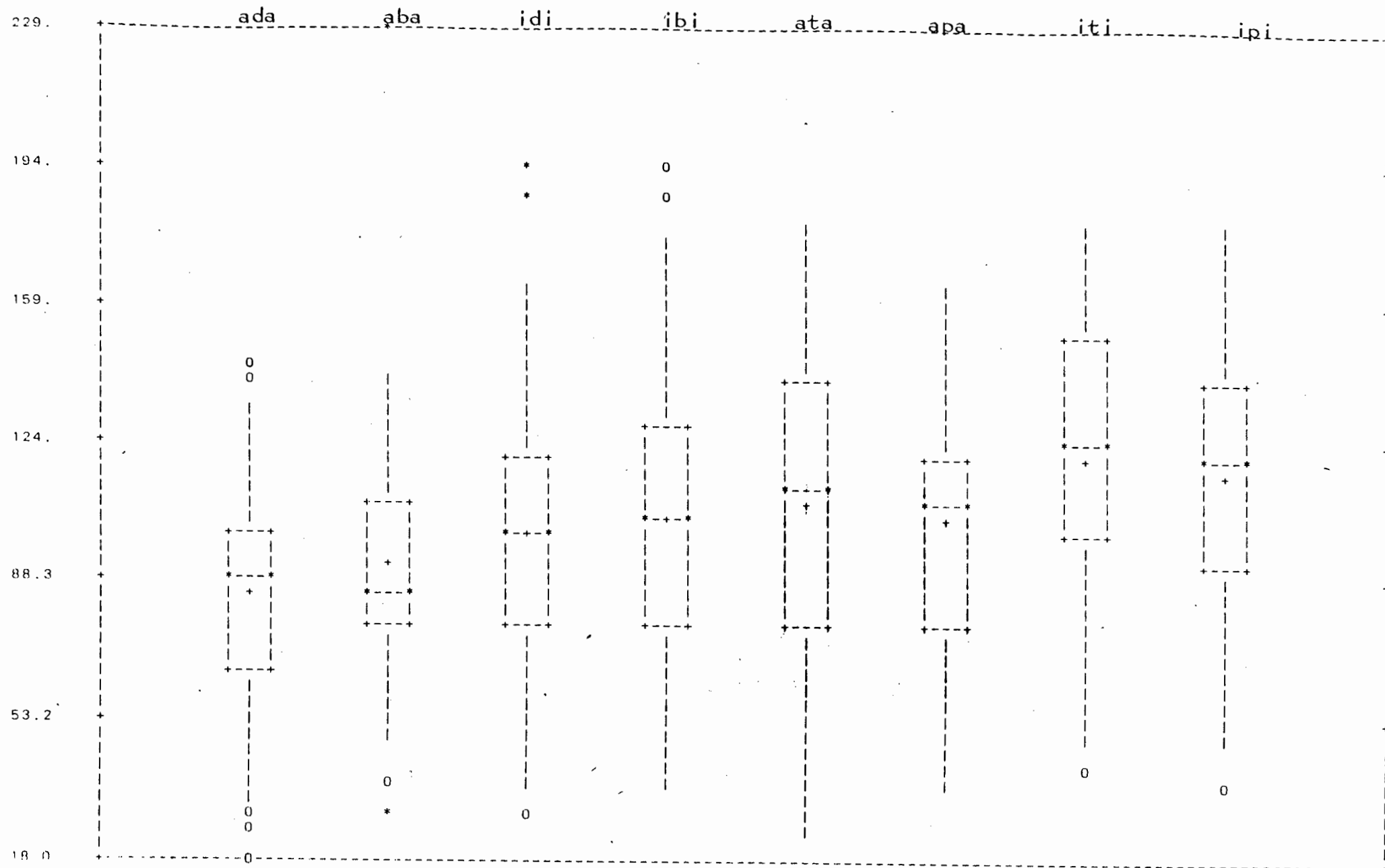


Fig. 18 Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 2.

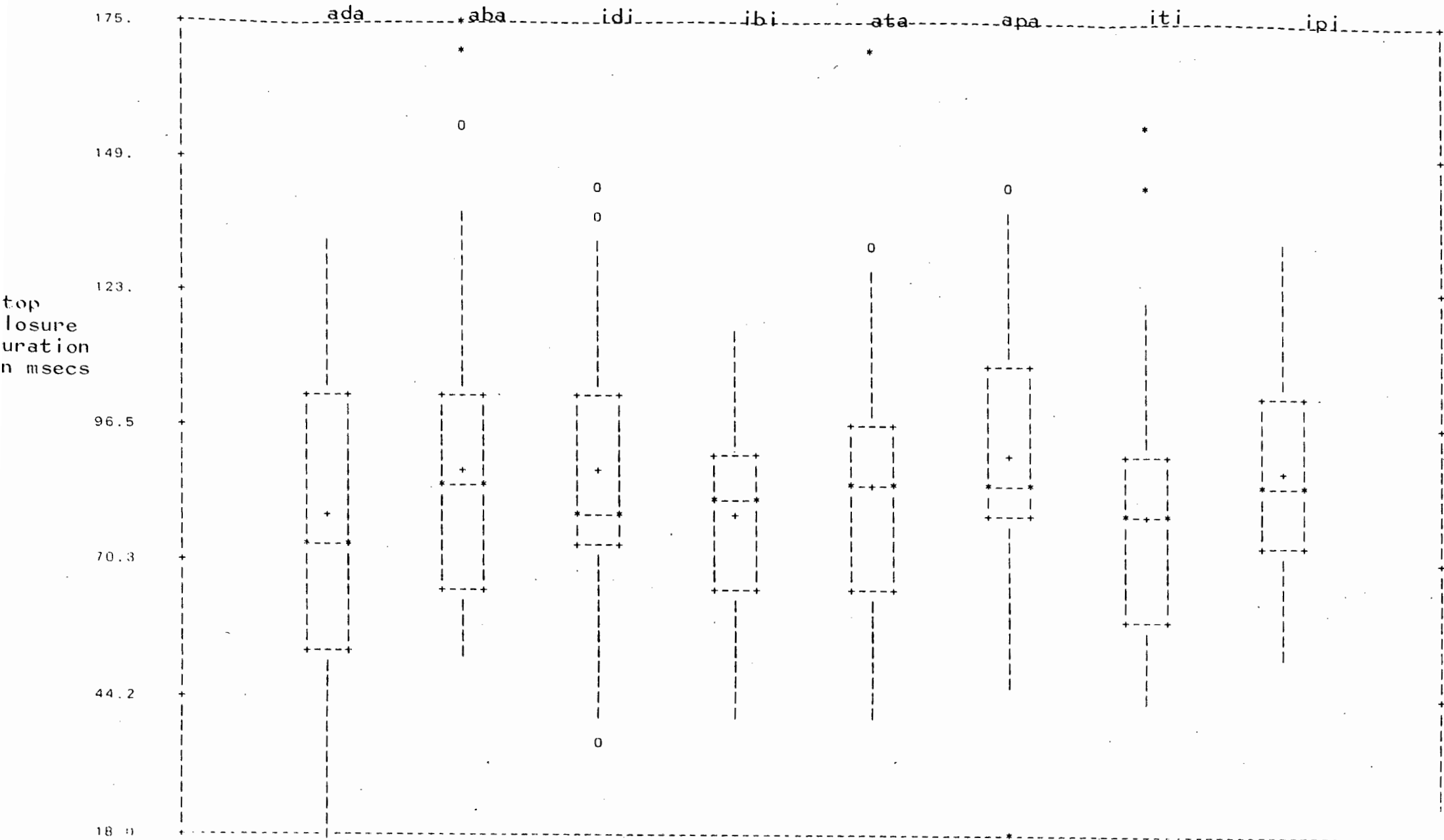


Fig. 18c Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 3.

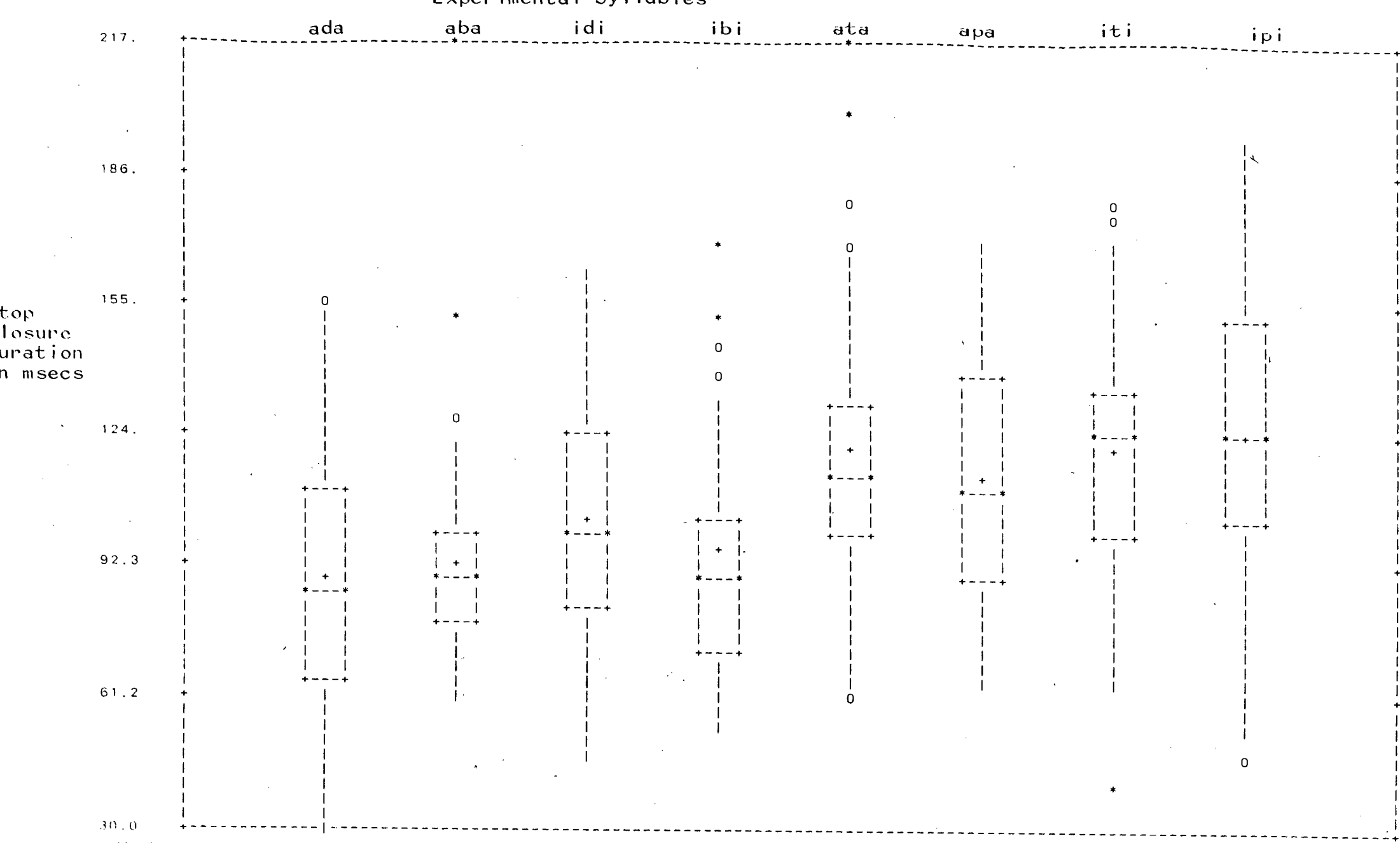


Fig. 18d Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 4.

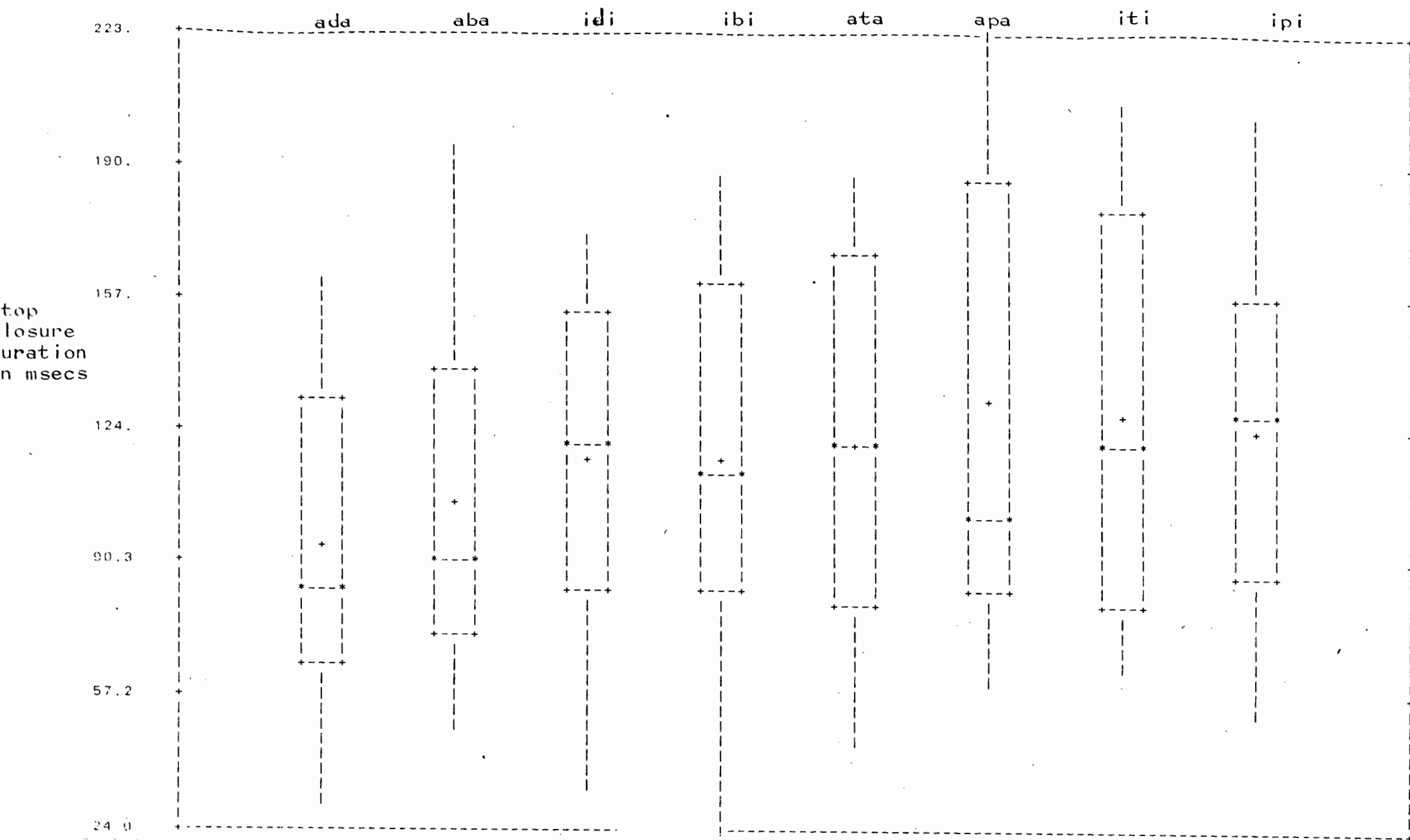


Fig. 18e Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 5.

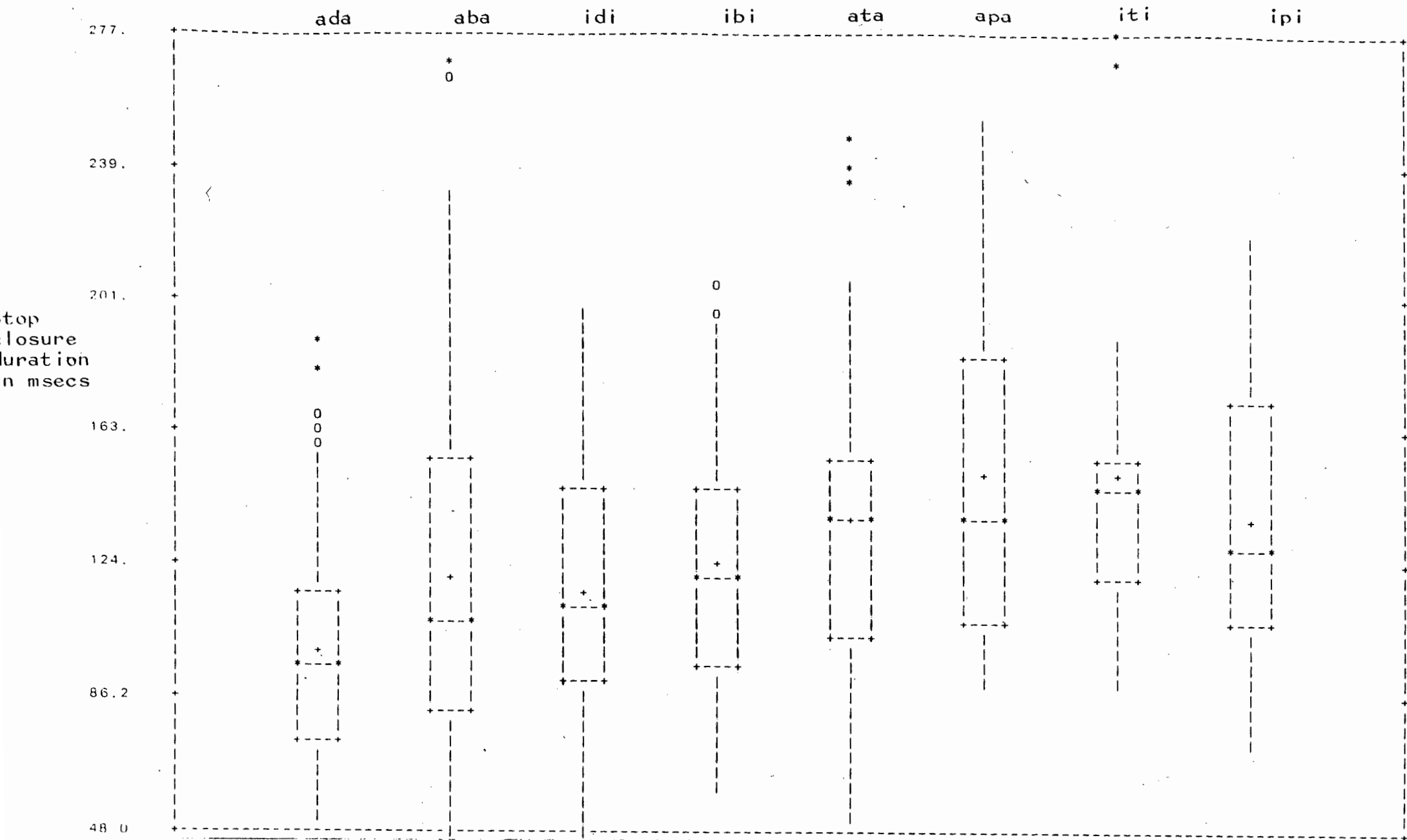


Fig. 18f Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 6.

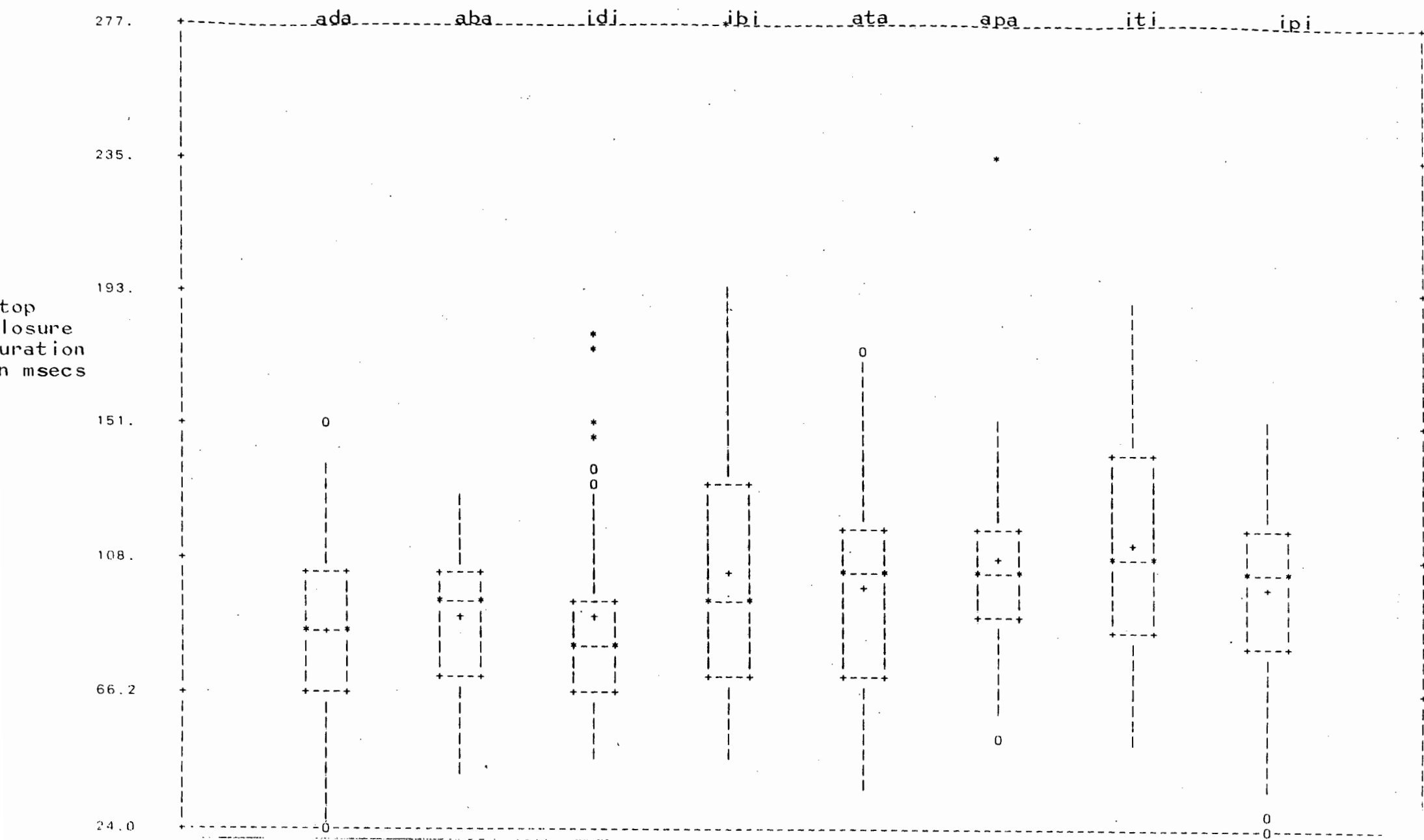


Fig. 18g Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 7.

stop
closure
duration
in msec

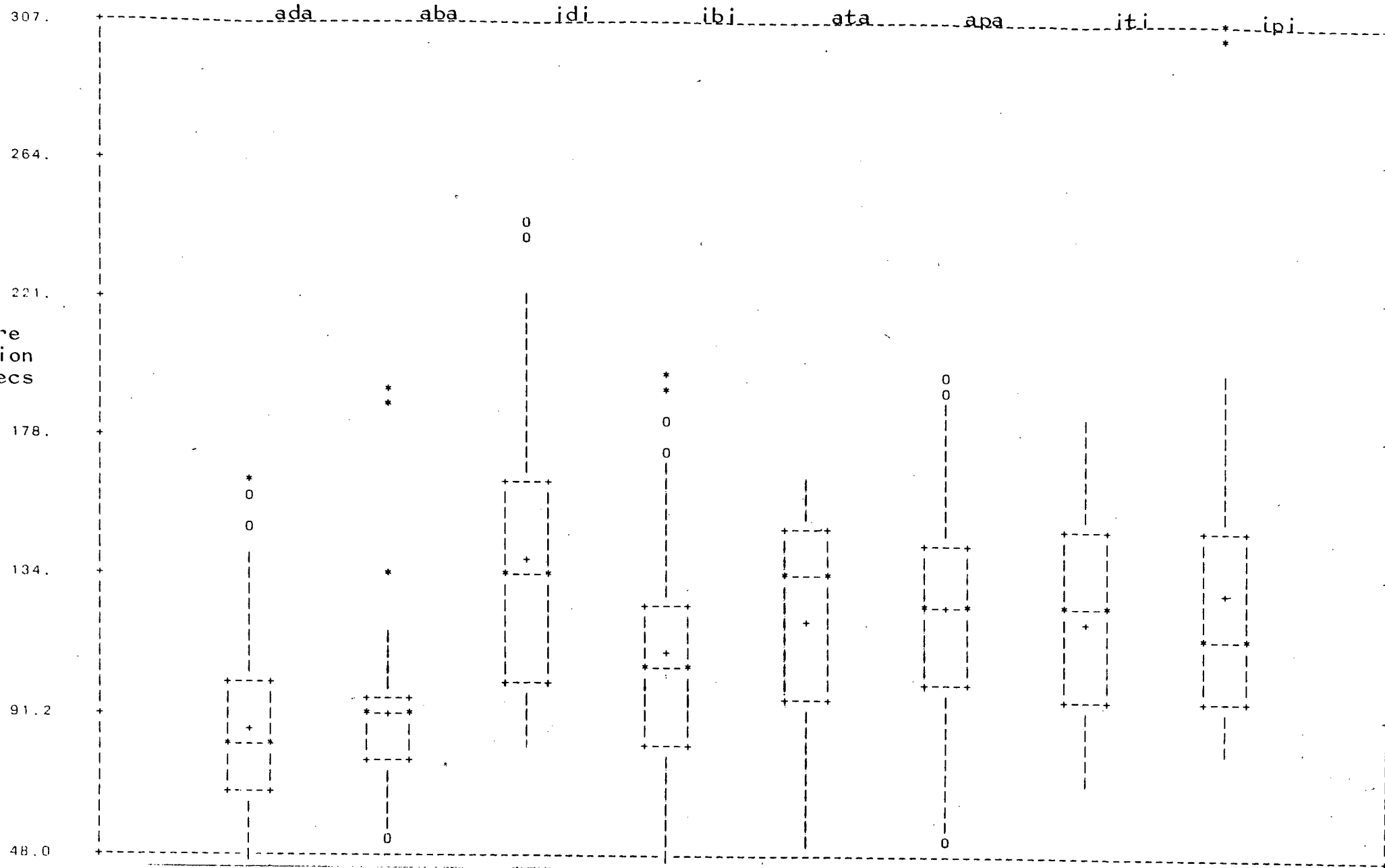


Fig. 18h Multiple box plots showing the central tendency and distributions of stop closure duration scores for the eight experimental syllables in Group 8.

Duration
in msec
(judge 1)

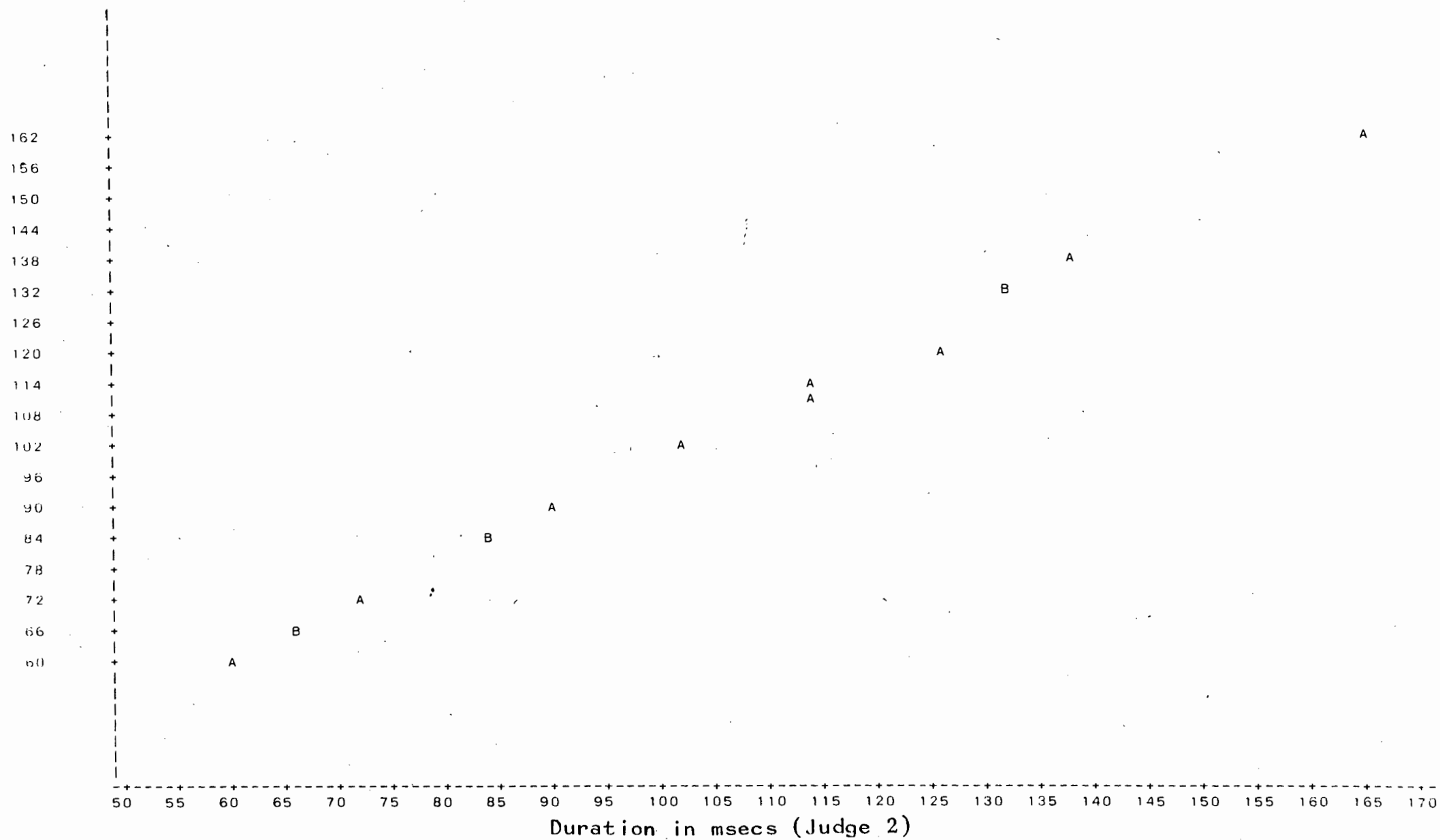


Fig. 20a(i) Plot illustrating interjudge agreement for stop closure duration of /apa/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

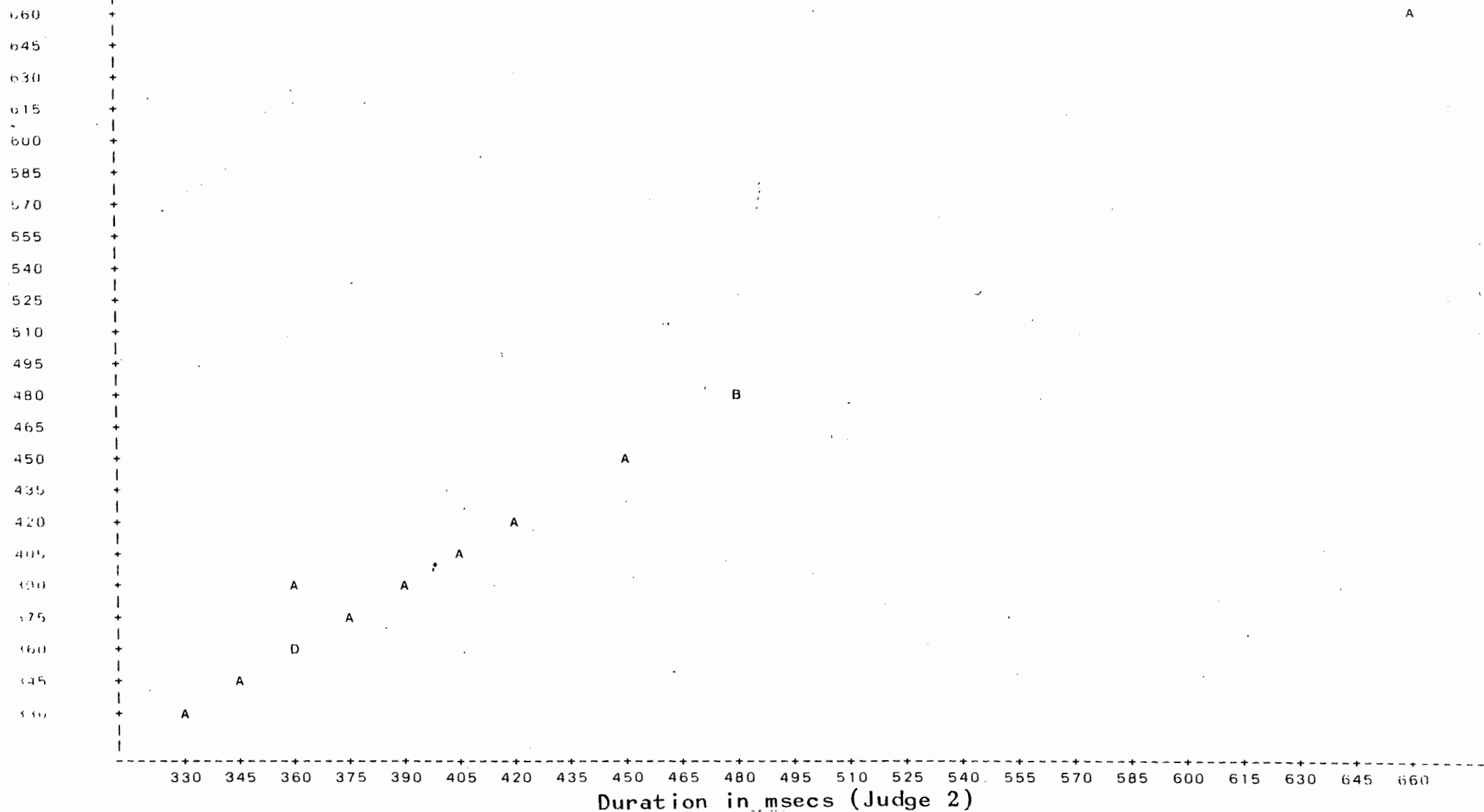


Fig. 20a(ii) Plot illustrating interjudge agreement for whole syllable duration of /apa/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

144
141
138
135
132
129
126
123
120
117
114
111
108
105
102
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54

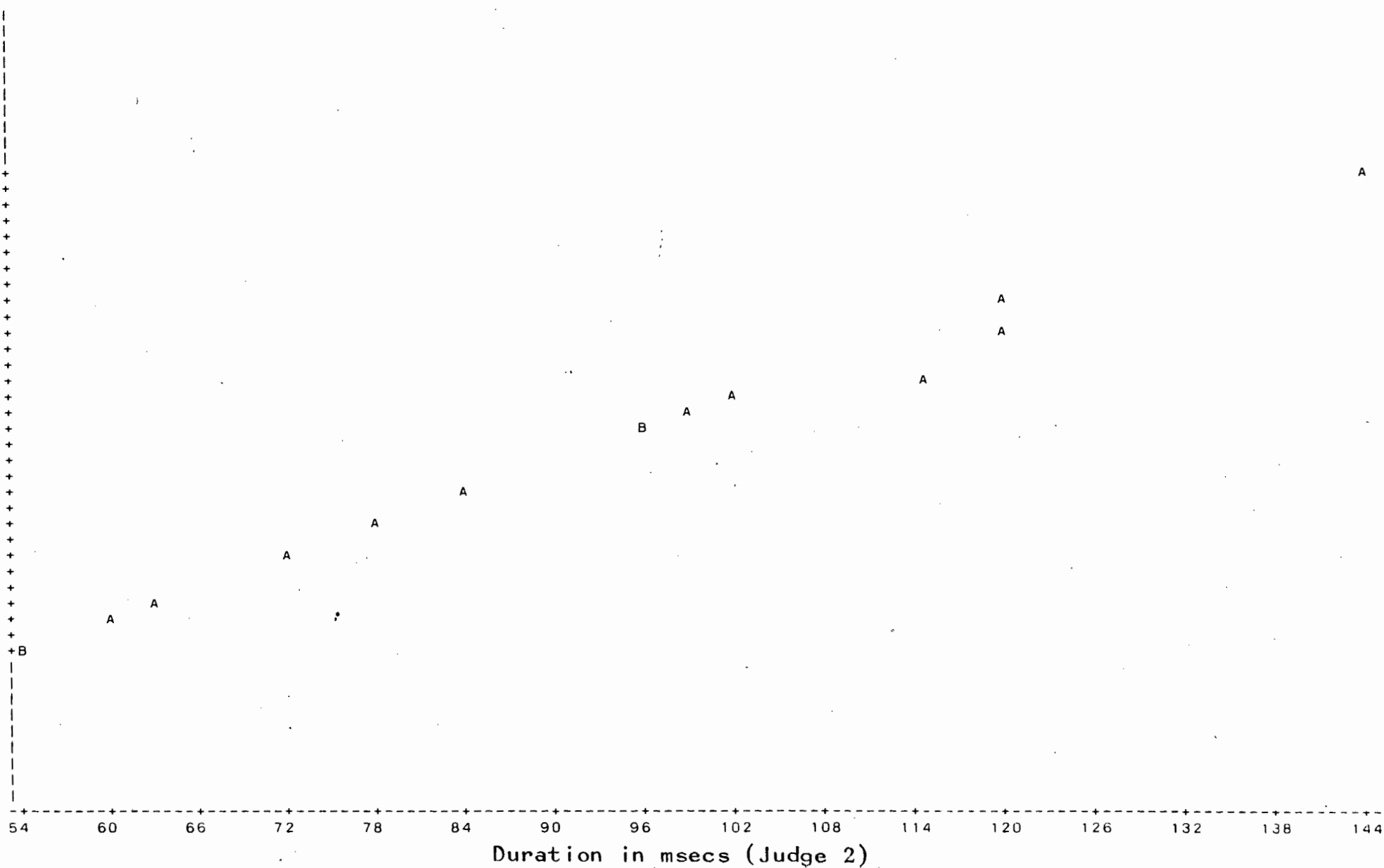


Fig. 20b(i) Plot illustrating interjudge agreement for stop closure duration of /ada/
Key: A = 1 observation, B = 2 observations, etc.

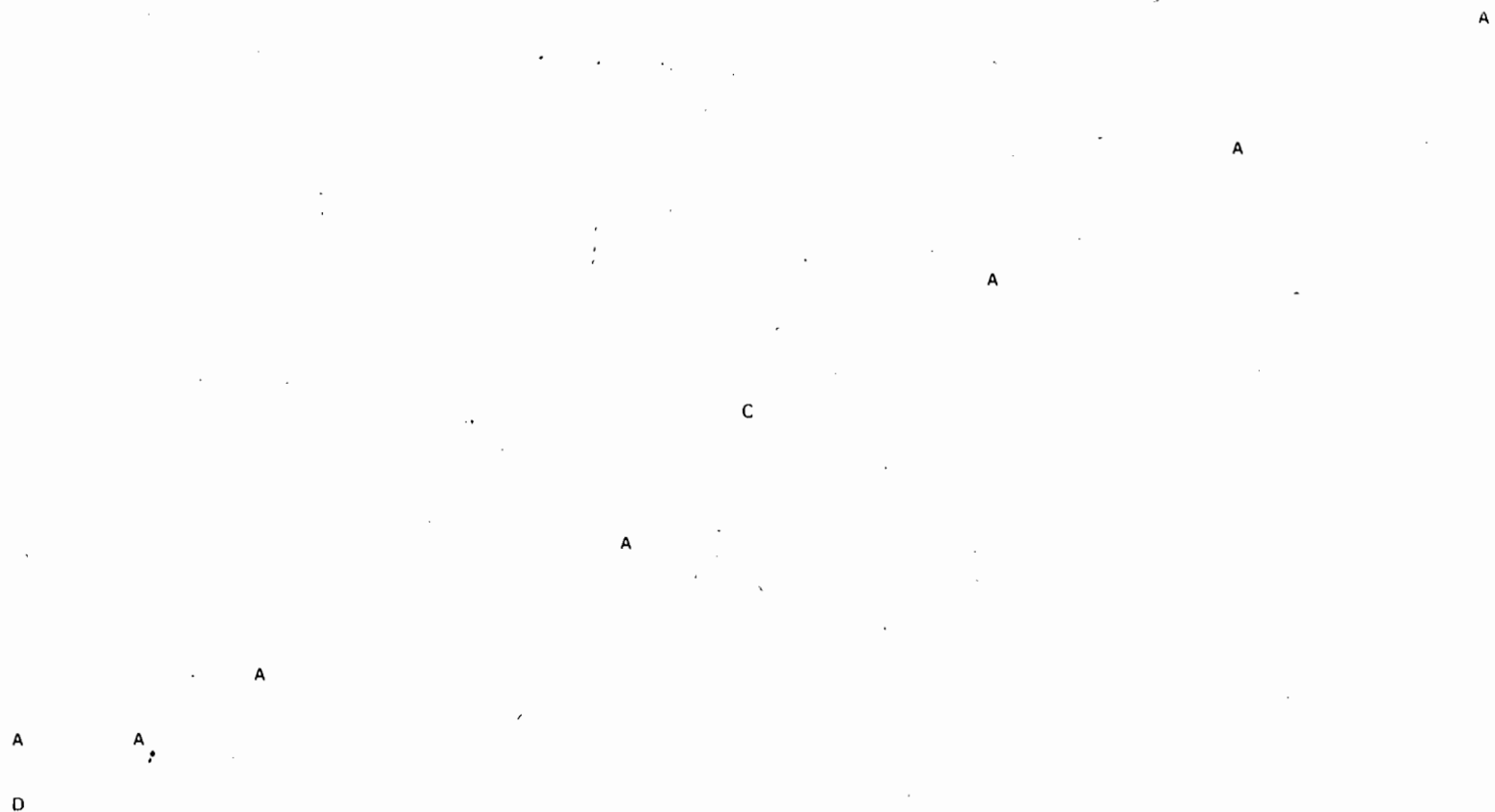
Duration
in msec
(Judge 1)

540
525
510
495
480
465
450
435
420
405
390
375
360
345
330

330 345 360 375 390 405 420 435 450 465 480 495 510 525 540

Duration in msec (Judge 2)

Fig. 20b(ii) Plot illustrating interjudge agreement for whole syllable duration in /ada/
Key: A = 1 observation, B = 2 observations, etc.



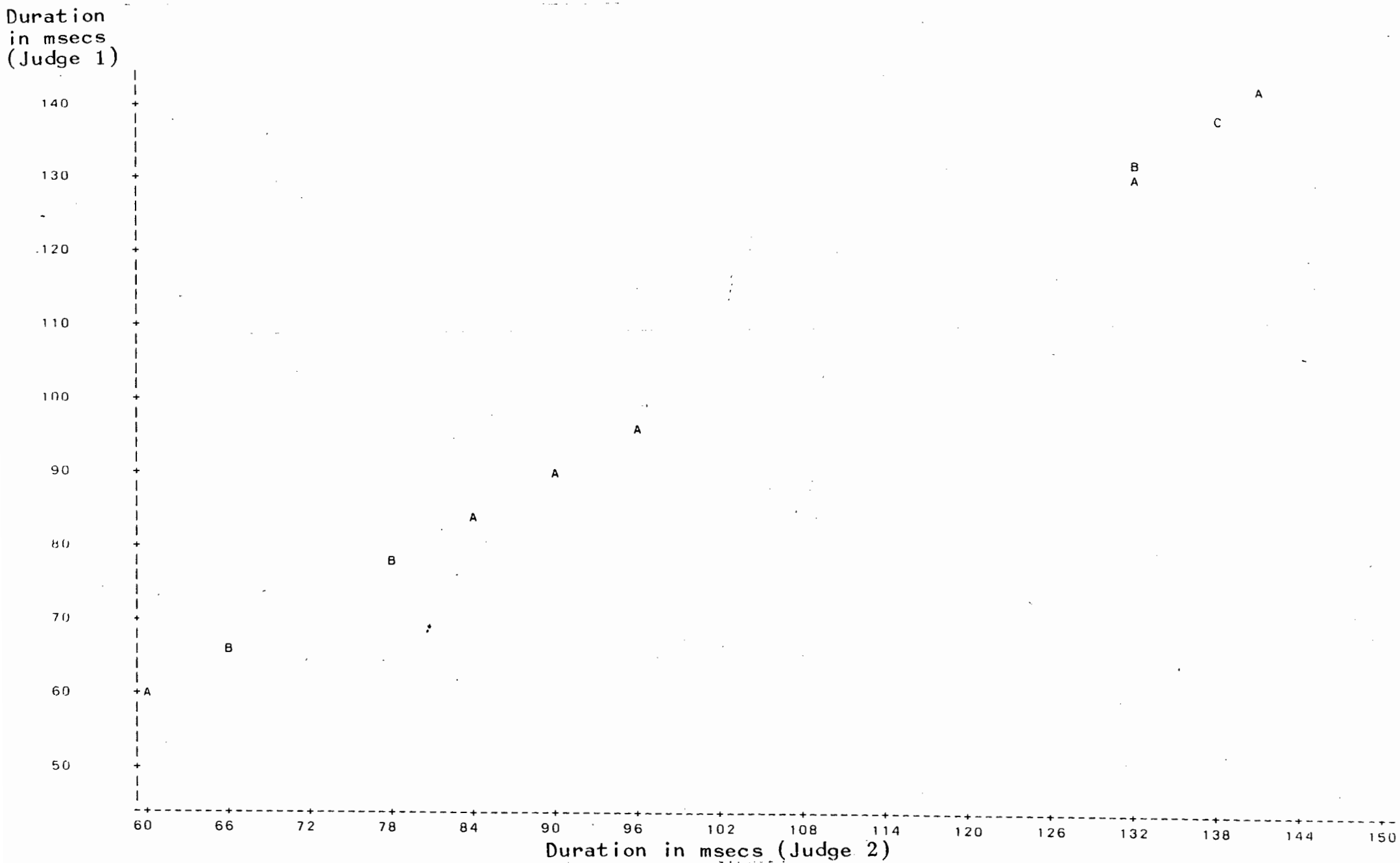


Fig. 20c(i) Plot illustrating interjudge agreement for stop closure duration of /ata/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

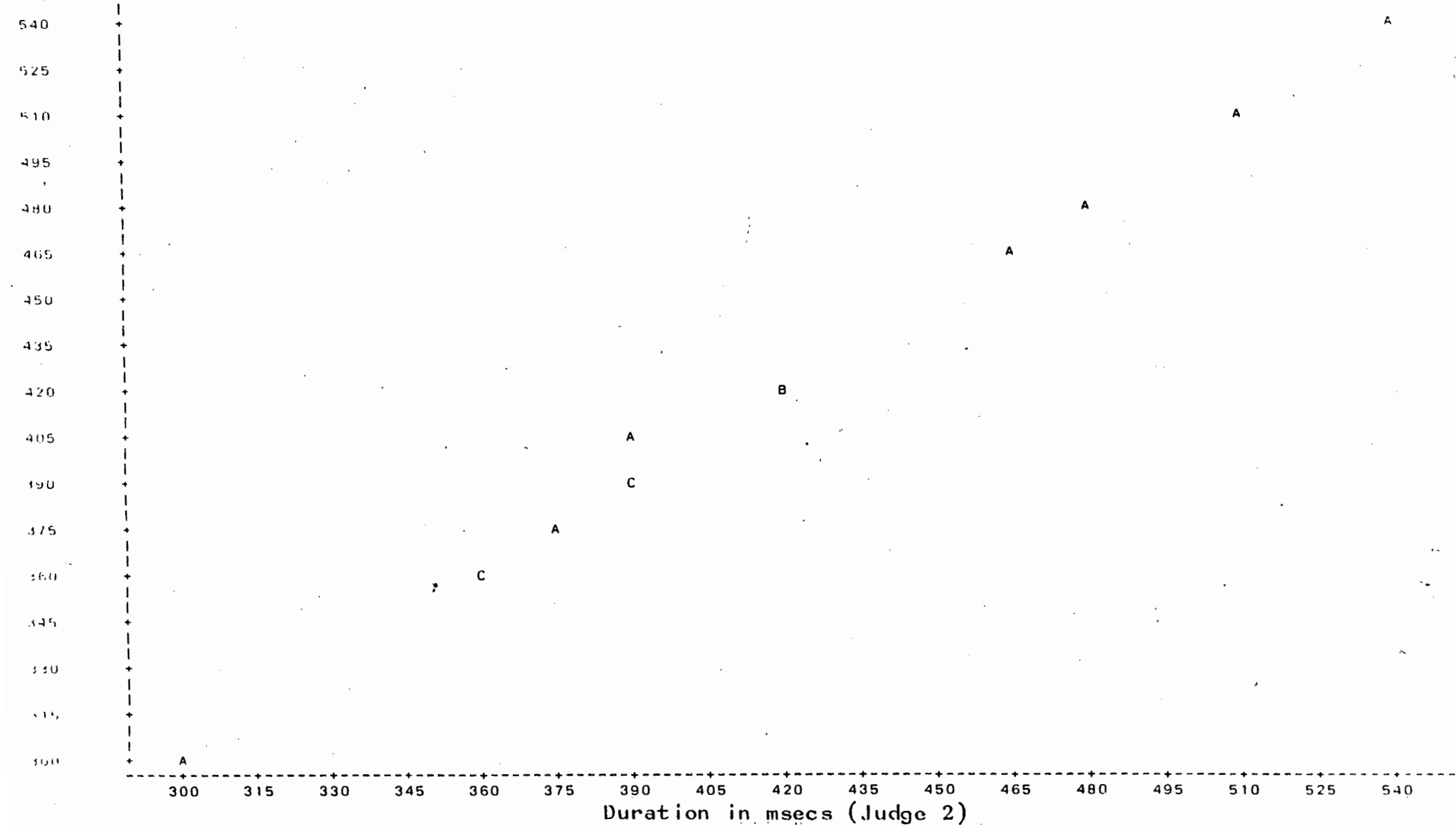


Fig. 20c(ii) Plot illustrating interjudge agreement for whole syllable duration of /ata/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

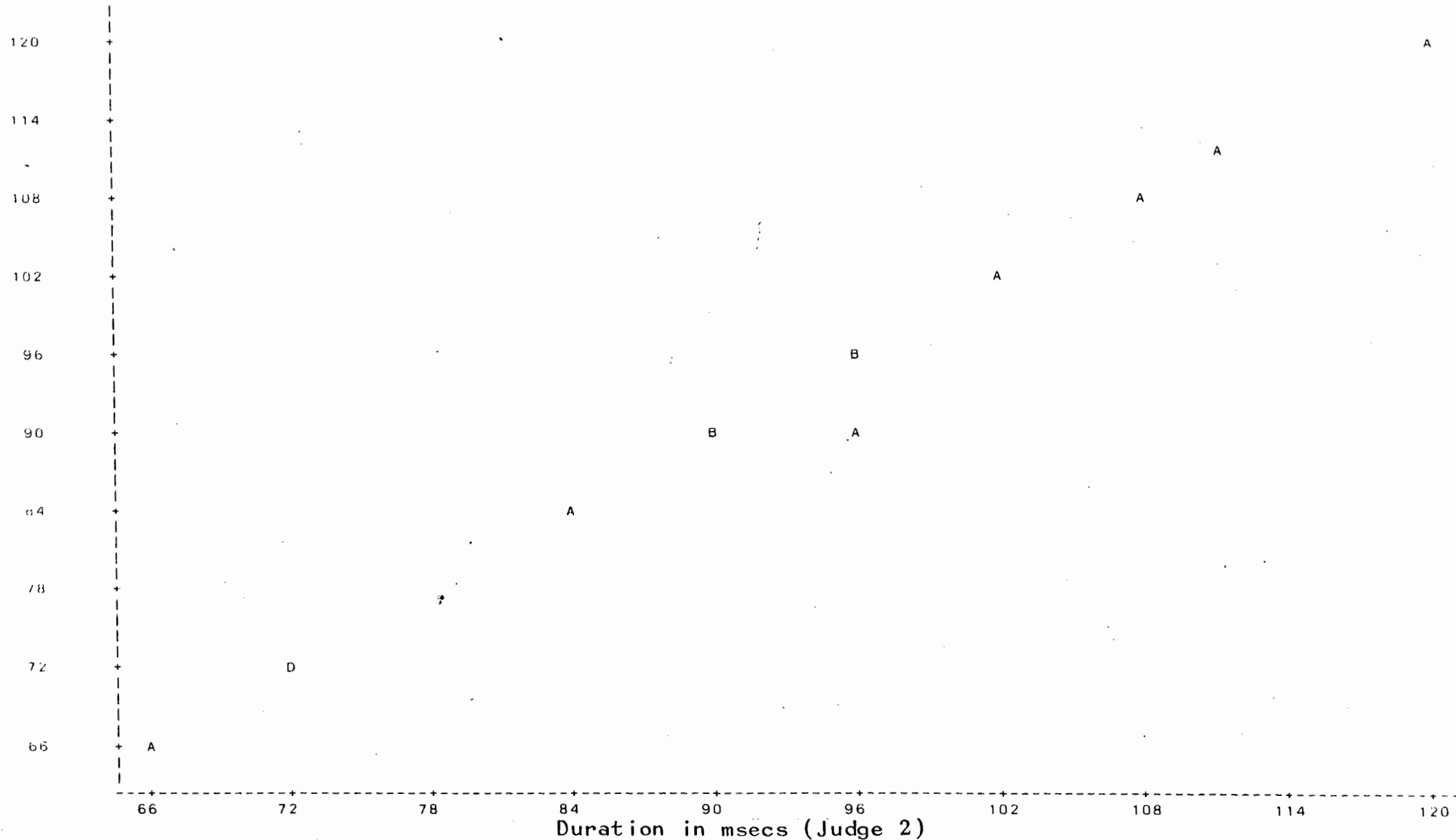


Fig. 20d(i) Plot illustrating interjudge agreement for stop closure duration of /idi/
Key: A = 1 observation, B = 2 observations, etc.

in msec
(Judge 1)

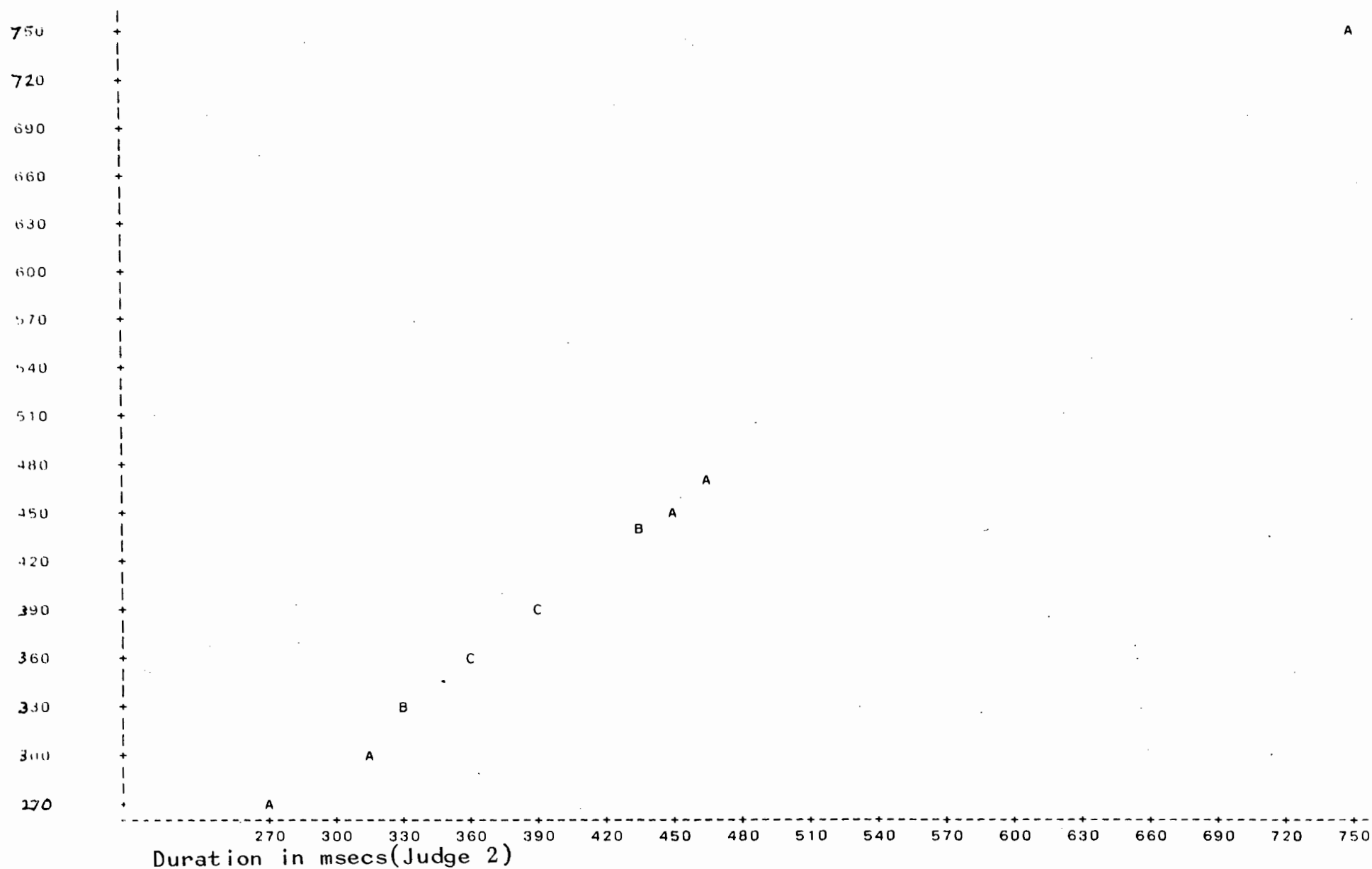


Fig. 20d(ii) Plot illustrating interjudge agreement for whole syllable duration of /idi/
Key: A = 1 observation, B = observations, etc.

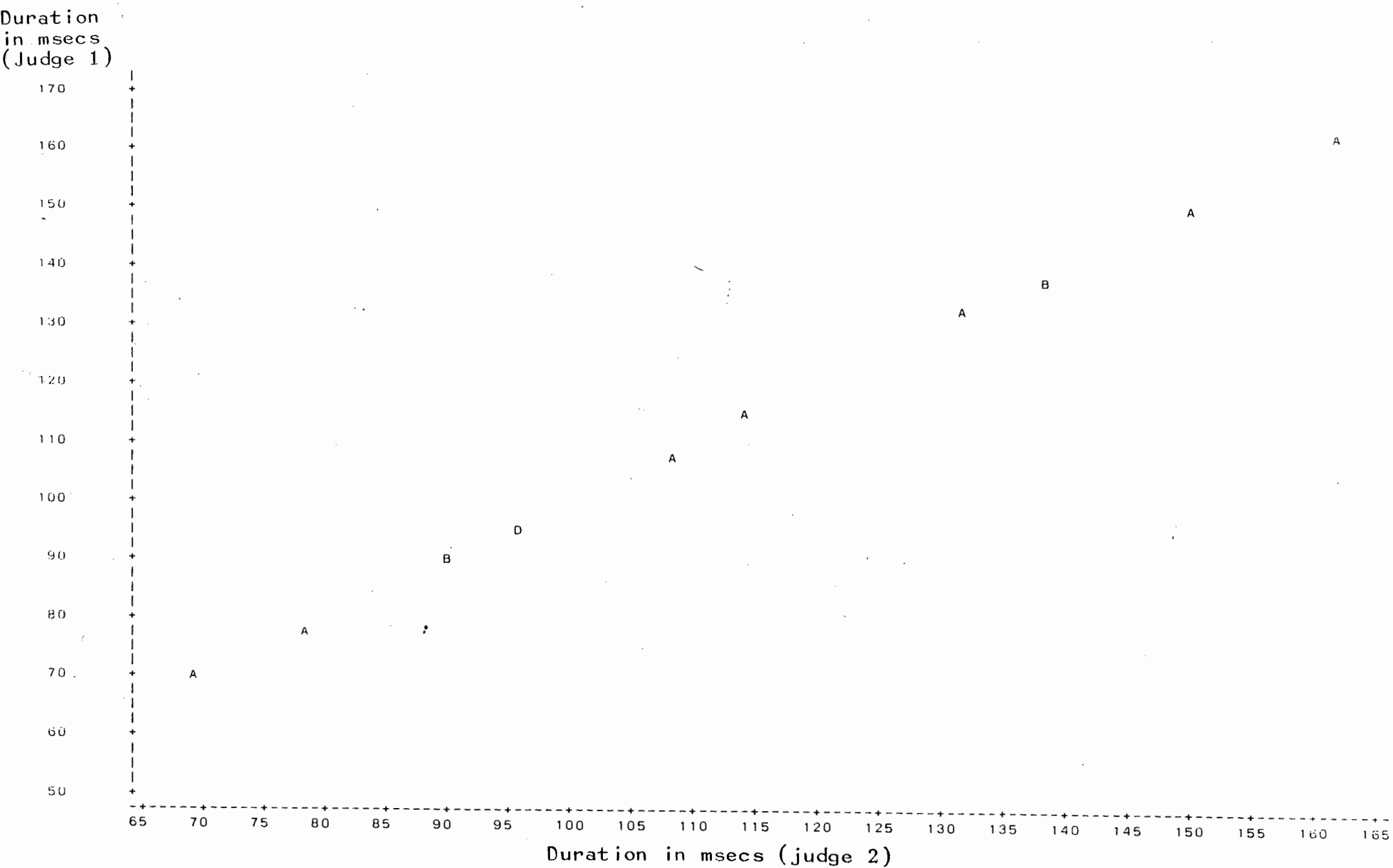


Fig. 20e(i) Plot illustrating interjudge agreement for stop closure duration of /ipi/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

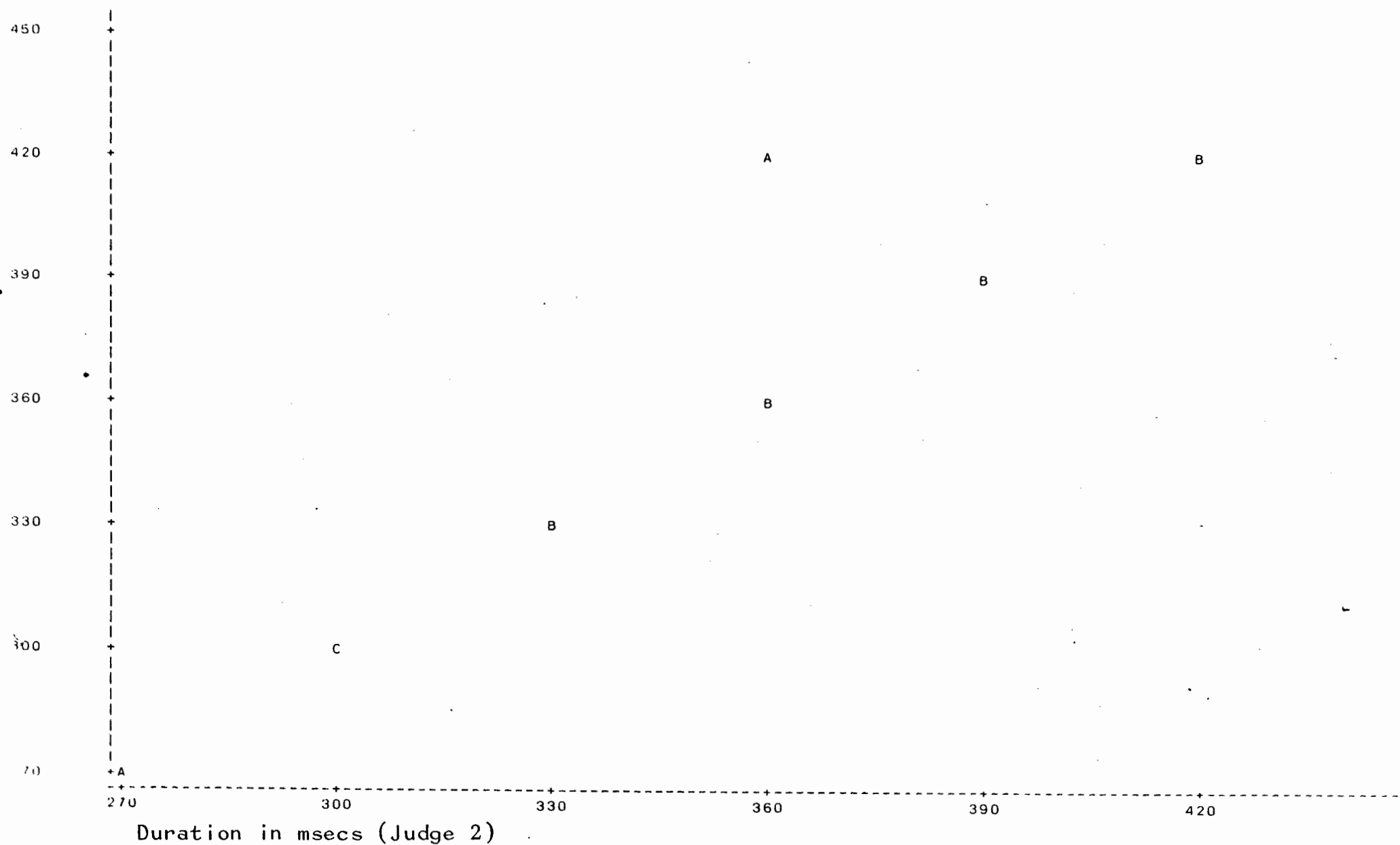


Fig. 20e(ii) Plot illustrating interjudge agreement for whole syllable duration of /ipi/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

228
222
216
210
204
198
192
186
180
174
168
162
156
150
144
138
132
126
120
114
108
102
96
90
84
78
72
66

66 78 90 102 114 126 138 150 162 174 186 198 210 222

Duration in msec (Judge 2)

Fig. 20f(i) Plot illustrating interjudge agreement for stop closure duration of /aba/
Key: A = 1 observation, B = 2 observations, etc.

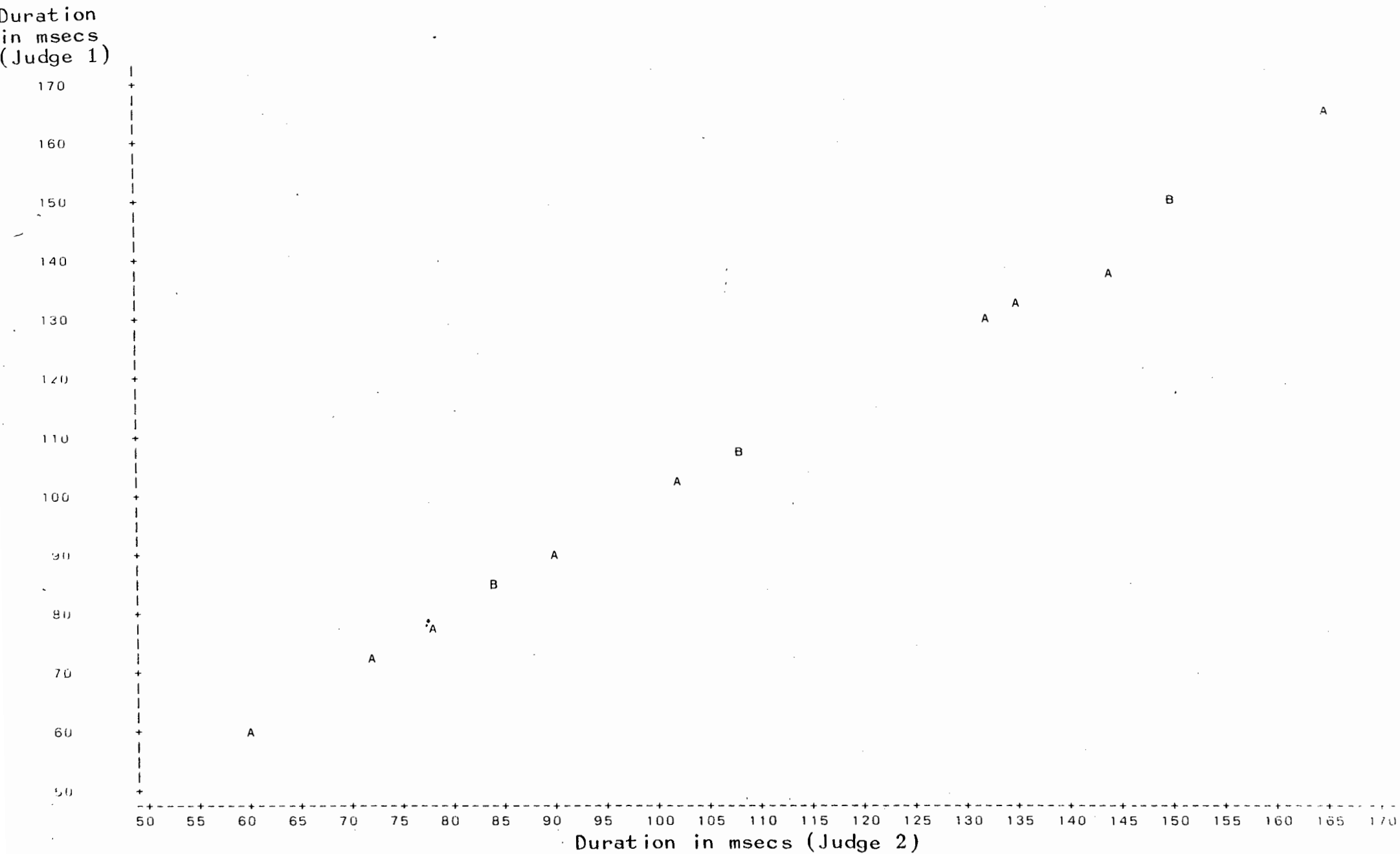


Fig. 20g(i) Plot illustrating interjudge agreement for stop closure duration of /iti/
Key: A = 1 observation, B = 2 observations, etc.

Duration
in msec
(Judge 1)

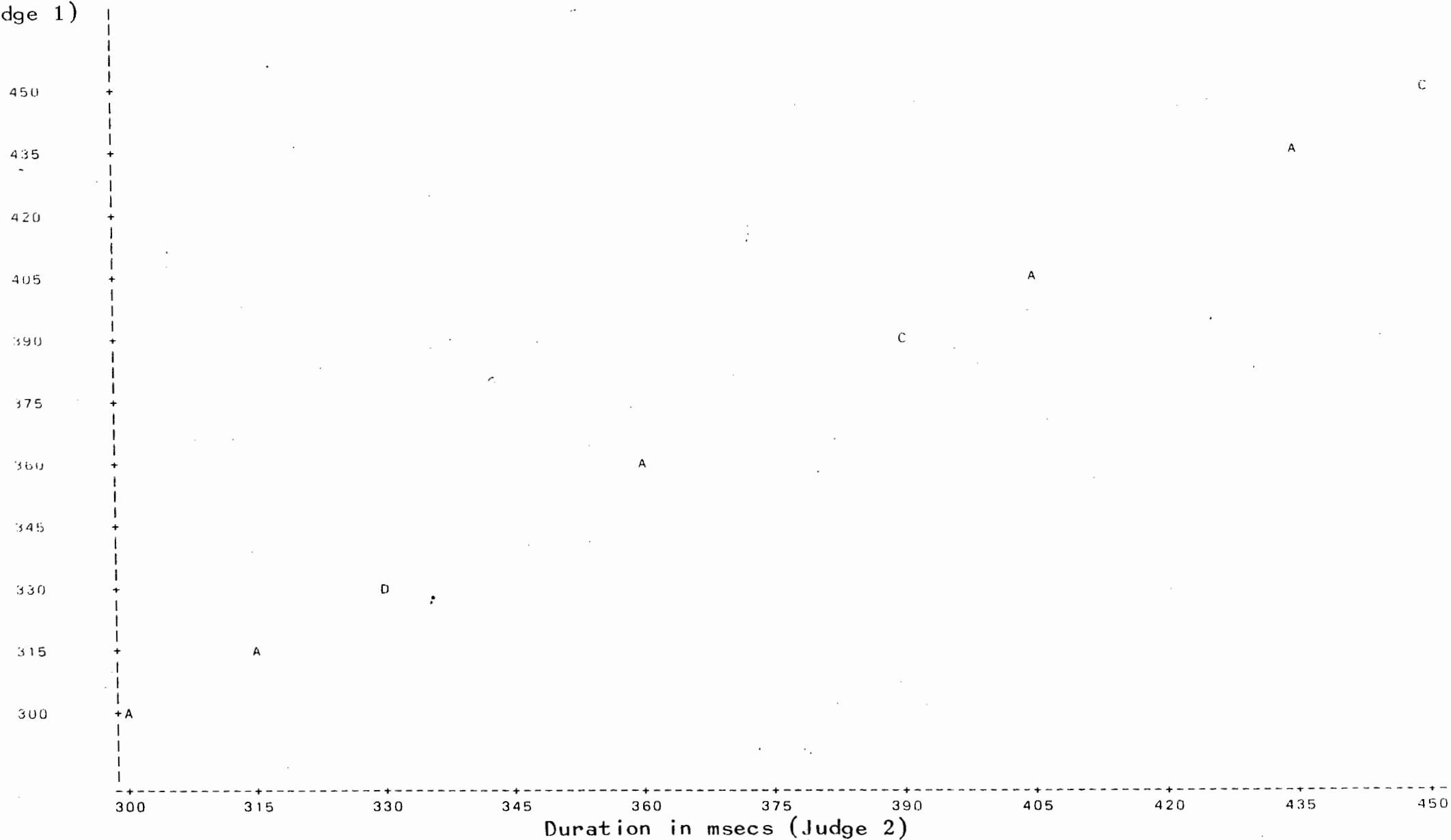


Fig. 20g(ii) Plot illustrating interjudge agreement for whole syllable duration of /iti/
Key: A = 1 observation, B = 2 observations, etc.

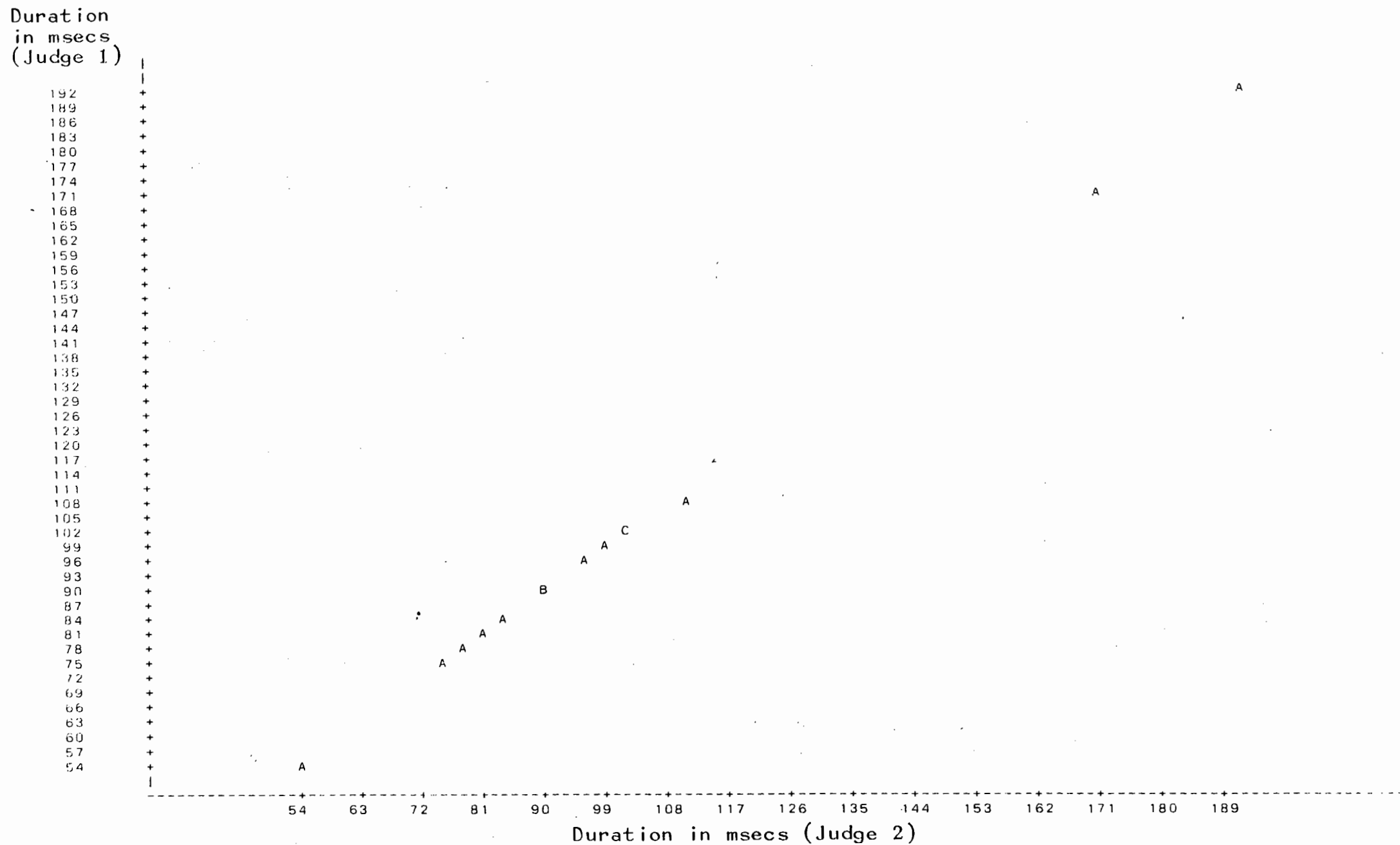


Fig. 20h(i) Plot illustrating interjudge agreement for stop closure duration of /ibi/
 Key: A = 1 observation, B = 2 observations, etc.

ration
msecs
udge 1)

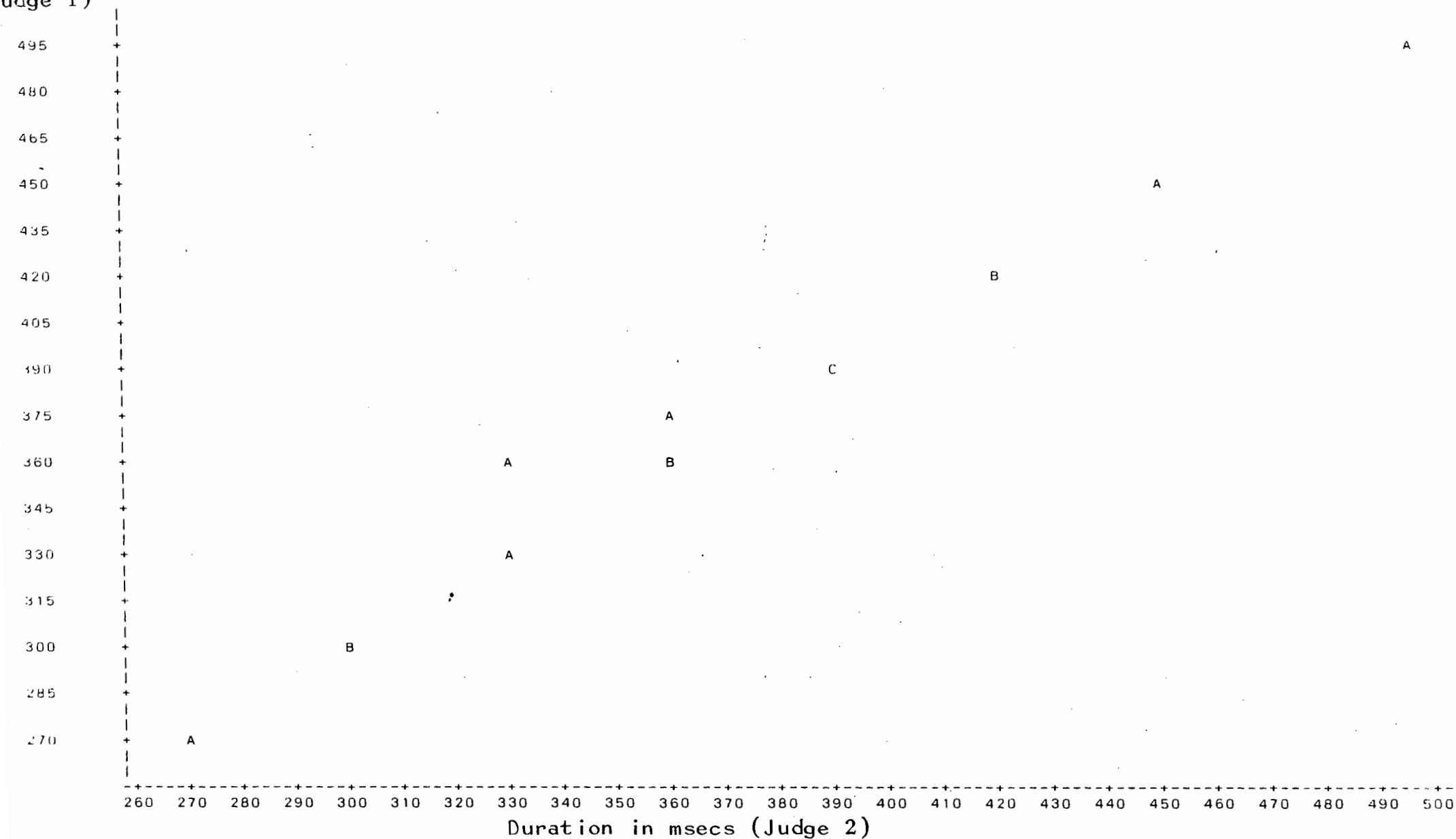


Fig. 20h(ii) Plot illustrating interjudge agreement for whole syllable duration of /ibi/
Key: A = 1 observation, B = 2 observations, etc.

Examination of the box plots yielded the following:

C Whole syllable duration measures

1 Cross-language comparisons

a) Central tendency of MM2

With the exception of /ata/ in the older groups, the following trend was consistently observed: English-speaking nonstutterers showed longer whole syllable durations than did Afrikaans speakers. This trend held across age groups, being somewhat more marked in the younger speakers. No consistent language-related trend was observed in the older stuttering groups. Younger stutterers showed a reverse trend to that of nonstutterers, viz. Afrikaans-speakers tended to use longer whole syllable durations than did English speakers.

b) Spread of MM2, central tendency of the range, spread of the range

No consistent language related trends were observed amongst the experimental groups on these measures.

2 Comparisons between younger and older speakers.

a) Central tendency of MM2

No discernible age-related trends were found amongst English-speaking nonstutterers. Small, but consistent trends differentiated the other groups. These trends were so slight that their significance is questionable. They are mentioned only for their consistency. Older Afrikaans nonstutterers had longer whole syllable durations than did younger ones. Older English stutterers had longer whole syllable durations compared with their younger counterparts. Younger Afrikaans stutterers, on the other hand, had slightly longer whole syllable durations than did older ones.

b) Spread of MM2

There were no consistent trends amongst the groups. However, in six out of the eight syllables, younger English stutterers had greater spread than did older ones.

c) Central tendency of the range

No consistent trends were apparent, but in six out of the eight syllables, younger Afrikaans nonstutterers tended to have higher median values than did older ones.

d) Spread of the range

No consistent trends were observed amongst the experimental groups.

3 Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

The following moderate trends were noted:

In the English-speaking groups, older and younger, nonstutterers used longer whole syllable durations compared with stutterers. The older Afrikaans-speaking groups failed to show any consistent trends differentiating stutterers from nonstutterers. The younger Afrikaans-speaking groups contrasted with the English groups in that stutterers had consistently longer whole syllable durations than did nonstutterers.

b) Spread of MM2

No clear trends were discernible.

c) Central tendency of the range

The only consistent trend was for young Afrikaans stutterers to have higher median values of the range than did their nonstuttering controls.

d) Spread of the range

No clear trends could be identified.

D Stop closure duration measures

1 Cross-language comparisons

a) Central tendency of MM2

The only clear trends were evident amongst the stuttering groups. Afrikaans-speaking stutterers showed greater median values, ie. longer stop closure durations, than did English-speaking stutterers. This trend was maintained across age groups. No discernible language-related trends could be identified in the nonstuttering groups.

b) Spread of MM2

The only consistent trend was a large one, viz. young English nonstutterers had much bigger spread of MM2 than did young Afrikaans nonstutterers.

c) Central tendency of the range

No discernible trends.

d) Spread of the range

In the case of nonstutterers, there was a clear trend toward greater spread of the range amongst Afrikaans-speakers of both age groups. No such language-related trends were observed in the stutterers.

2 Age-related comparisons

a) Central tendency of MM2

There was a slight tendency amongst Afrikaans nonstutterers and English stutterers for higher median values in the case of older compared with younger subjects.

b) Spread of MM2

There was a strong consistent trend for greater spread of MM2 in the case of young English nonstutterers compared with older ones.

c) Central tendency of the range

There was a trend in all groups (with the exception of some syllables in each group, however) for younger subjects to show greater central tendency of the range.

d) Spread of the range

No clear trends were discernible.

3 Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

With the exception of the older Afrikaans-speaking groups, there was a trend towards higher median values, ie. longer stop closure duration in the case of nonstutterers compared with stutterers. The older Afrikaans groups did not show discernible trends in this regard.

b) Spread of MM2

The only consistent trend was for young English nonstutterers to have greater spread for MM2 than did their stuttering controls.

c) Central tendency of the range

There were no clearcut trends but a suggestion of greater median values in older Afrikaans stutterers compared with nonstutterers.

d) Spread of the range

There was a consistent trend for older Afrikaans nonstutterers to exhibit greater spread compared with their stuttering controls.

E Percentage of the whole syllable occupied by stop closure

1 Cross-language comparisons

a) Central tendency of MM2

Amongst older speakers, stutterers as well as nonstutterers no

language-related trends could be discerned. With the exception of /apa/, there was a clear trend in the younger nonstuttering groups for Afrikaans-speakers to have greater median percentage duration values compared with English-speakers. The younger stuttering groups failed to demonstrate language-related trends.

b) Spread of MM2

No consistent trends were observed.

c) Central tendency of the range

There was a trend towards greater median values of the range in the case of older Afrikaans stutterers compared with English ones.

d) Spread of the range

Older Afrikaans nonstutterers tended to have greater spread of the range than did their English-speaking counterparts. The young nonstutterers showed a reverse trend. The stuttering groups showed no language-related trends.

2. Age-related comparisons

a) Central tendency of MM2

The Afrikaans nonstutterers and English stutterers both showed a trend toward higher median values in the case of younger speakers compared with older. The remaining groups failed to demonstrate discernible trends.

b) Spread of MM2

There was a trend, though not completely consistent, amongst the nonstutterers of both language groups for younger speakers to have a greater range of MM2 than did older speakers. There appeared to be a similar, but less marked trend amongst the stuttering groups.

c) Central tendency of the range

There was a trend toward higher median values of the range in younger speakers in the Afrikaans nonstuttering and English stuttering groups.

d) Spread of the range

No discernible trends.

3. Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

There was a small trend towards higher median values in the case of older English nonstutterers compared with their stuttering controls. No consistent trends were apparent in the remaining groups.

b) Spread of MM2

No discernible trends.

c) Central tendency of the range

No discernible trends.

d) Spread of the range

Stutterers tended to show greater spread of the range than nonstutterers in the older English-speaking groups. A reverse trend was discovered for the older and young Afrikaans-speaking groups. There were no discernible trends in the younger English groups.

F Comparison between voiced and voiceless stop closure durations1 Central tendency (median)

For stop plosives in /a/ environments in the VCV syllables employed in this study, there was a trend for longer closure durations in voiceless compared with voiced stops. This trend was maintained across languages and amongst all groups, with the exception of /apa/-/aba/ in the older and younger English stuttering groups. In these exceptional cases, stop closure duration did not differ between voiced and voiceless stops. In /i/ environments there were no consistent trends differentiating voiced from voiceless stops in terms of closure duration. On the whole, results for measures of stop closure duration per se agreed well with those for the percentage which stop closure duration was of the whole syllable duration in all groups.

a) Older English nonstutterers

Voiceless stop closure durations were longer than those of voiced stops at both bilabial and alveolar places-of-articulation as well as in both /i/ and /a/ environments. An exception was /ipi/-/ibi/ in which the voiced stop closure duration was a little longer than the voiceless one. Results for the measure of the percentage which stop closure duration was of the whole syllable duration agreed with those for stop closure duration per se, but the trends were smaller.

b) Older Afrikaans nonstutterers

On the whole, this group performed similarly to the English control group. Voiceless stop closure durations were consistently longer than those for voiced stops. This held true for both places-of-articulation and both vowel environments. On the whole, results for stop closure duration per se and the percentage which stop closure duration was of the whole syllable duration were comparable.

c) Older English stutterers

None, or only very slight, differences were found in stop closure duration between voiced and voiceless stops. The performance of this group thus differed considerably from that of the nonstuttering control group. Results

of the two duration measures were similar.

d) Older Afrikaans stutterers

Stop closure durations were consistently longer for voiceless compared with voiced stops at both places-of-articulation and in both vowel environments studied. Results of the two duration measures were comparable. The subjects in this group thus seemed to perform in a manner similar to that of their nonstuttering Afrikaans-speaking controls.

e) Young English nonstutterers

In the /a/ environment voiceless stop closure durations were consistently longer than those of voiced stops whether the measure examined was stop closure duration per se or the percentage which closure was of the whole syllable duration. This trend appeared to be emerging in the /i/ environment, but was not consistent, with some instances of a small reverse trend occurring.

f) Young Afrikaans nonstutterers

This group performed similarly to the older control group in that voiceless stop closure durations were longer than those for voiced stops. The trends were merely a little less marked in the younger group. The exception to the trend occurred on /ipi/-/ibi/ where no differences in closure duration between the voiced and voiceless stops could be detected.

g) Young English stutterers

Stop closure durational differences between voiced and voiceless stops appeared to be nonexistent or, where present, were smaller than those of the nonstuttering control group.

h) Young Afrikaans stutterers

Voiceless stop closure durations were longer than those of voiced stops in /a/ environments but these trends were not apparent in the /i/ environment where no differences or small reverse trends were observed. The normal timing trends which were emerging in the /a/ environments tended to be a little smaller than was the case in the nonstuttering control group.

2 Spread

In the case of stops in the low vowel /a/ environment voiceless stops were produced with a greater spread than were voiced stops by Afrikaans-speaking nonstutterers (old and young), younger Afrikaans stutterers and young English nonstutterers. Older English stutterers showed a reverse trend. No consistent trends were observed in the remaining groups. In the /i/ environment, most groups failed to show consistent trends. Voiced stops tended to carry bigger spread of durations than did voiceless stops in the older English nonstutterers, while older English stutterers showed a reverse trend. On the whole, then, no meaningful trends were found on this measure.

G Comparison between the influence of /i/ and /a/ environments on medial stop closure durations

Examination of the central tendency of the groups revealed the following:

1 Older English and Afrikaans nonstutterers

With only one exception in the English group, there was a consistent trend towards longer stop closure durations for both voiced and voiceless stops in the /i/ environment compared with the /a/ environment. Results for measures of stop closure per se and the percentage which stop closure was of the whole syllable duration were comparable. The exception in the English group was the voiceless bilabial on the stop closure per se measure.

2 Young English nonstutterers

This group showed the same trend as did the older controls, ie. longer stop closure durations in /i/ compared with /a/ environments. The degree of difference between the duration measures in the two vowel environments seemed to be similar to that observed in the older subjects. The only exception to the trend was the voiceless alveolar stop closure duration per se measure.

3 Young Afrikaans nonstutterers

With the exception of /ipi/-/apa/, stop closure durations were longer in /i/ than in /a/ environments. Thus, this group performed in a manner similar to that of the older speakers, however the degree of stop closure duration differences in the two vowel environments was smaller.

4 Older English stutterers

This group failed to show consistent trends differentiating medial stop closure durations in /i/ compared with /a/ environments.

5 Older Afrikaans stutterers

With the exception of /aba/-/ibi/, this group showed the normal trend towards longer stop closure durations in /i/ than in /a/ environments. However, with respect to the degree of closure duration differences between the two vowel contexts their performance resembled that of the younger Afrikaans nonstutterers.

6 Young English stutterers

When the measure examined was stop closure duration per se, little difference could be observed between stop closure durations in the respective vowel environments. When the percentage which stop closure duration was of the whole syllable duration was examined, the normal trend was apparent, but inconsistent.

7 Young Afrikaans stutterers

No consistent trends differentiated the vowel environment in terms of stop closure duration. As was the case with the young English stutterers, when percentage duration was examined, the normal trend was apparent but inconsistent.

IX DISCUSSION

A Whole syllable duration measures

The finding that English-speaking nonstutterers showed longer whole syllable duration measures than did Afrikaans nonstutterers, cannot simply be attributed to longer VOTs in the English group. VOT lengthens with age, yet the trend toward longer whole syllable durations was even more marked in younger than in older speakers. Since stop closure duration per se (which included transitions) did not differ between the language groups, it seems as if the English nonstutterers may have been using longer vowels than did the Afrikaans controls. The question arises as to whether or not these cross-language findings were influenced by the duration values in the speech of the two adult models. This notion may be negated by the findings in the stuttering groups, viz. that Afrikaans-speakers had longer whole syllable durations than did English-speakers. Furthermore in the next experiment (experiment four), no differences were found between the language groups in terms of duration of CVC syllables. It seems safe to assume, then, that the present results represent random variation.

The finding that English-speaking nonstutterers used longer whole syllable durations than did the stutterers, while results for the Afrikaans group were mixed, suggests that the stuttering subjects in this study were not using overall slower articulation rates than were the nonstutterers. This idea is supported by the finding that the two groups did not differ in terms of stop closure duration (which included transitions) and provides additional validation for the VOT findings in experiment one.

B Stop closure durations

Since there was good agreement between stop closure duration per se and percentage duration measures, only the former dimension will be discussed.

The bilabial stop closure durations for the older English nonstutterers are close to the lip closure duration measures obtained in an EMG study of one British English adult subject (Tatham and Morton 1969). Mean stop closure durations for phrases containing "a purr here" and "a burr here" in that study were 123.8 msec and 122.6 msec respectively. Mean /p/ and /b/ closure values in the present study were 106.25 and 101.13 msec. Adult South African English stop closure data is unavailable, but it is feasible that the older subjects had not yet reached adult values. The mean difference between /p/ and /b/ closure durations in this group was small (5.12 msec) compared with that of the English-speaking adult model (50.00 msec).

Afrikaans- and English-speaking subjects did not differ in terms of trends of actual closure duration, however Afrikaans-speakers showed greater variability, perhaps as a result of their increased speech rate.

Variability was greater amongst the younger speakers in all the groups compared with older ones, and probably reflects group heterogeneity of developmental levels as well as lack of established intrasubject timing. This confirms the reported trend (Tingley and Allen 1975; DiSimoni 1975; Smith 1978; Kent and Forner 1980; Eguchi and Hirsh 1969) for immature speakers to show increased variability of speech timing.

One implication of the finding that, on the whole, nonstutterers tended to have longer stop closure durations for both voiced and voiceless stops than did stutterers is that it is unlikely that the latter group were stuttering on the medial stops in the VCV syllables. It is also apparent that the stutterers were not having voice initiation difficulties following voiceless medial stop closure since VOT was included in the duration measure. The slower VOTs demonstrated in this group in experiment one seems to be confined to word-initial or utterance-initial stops.

It is possible to speculate that the stuttering children might have had a less complete devoicing gesture on medial voiceless stops than did nonstutterers. If they were economising on glottal abduction in compensation for a relatively inert mechanism, or in order to avoid any possible difficulties with initiating adduction from a widely abducted position, this might account for the shorter closure durations in this group. However, such an explanation implies a high degree of neuromuscular sophistication in subjects as young as three years. Furthermore, since the trend toward shorter stop closure durations in the stutterers did not extend to older Afrikaans speakers, perhaps one should be cautious of over-interpretation of the results.

Metz et al (1983) found that a decrease in stuttering frequency following therapy with adults was accompanied, inter alia, by a decrease in the silent periods of voiced and voiceless medial stops. They interpreted their results as implying that silence in the intervocalic interval may reflect "...the operational status of some underlying mechanism responsible for disfluent speech" (p 535) and propose that therapy serves to normalize the underlying articulatory timing relationships. In the light of the present findings of shorter closure durations in many stutterers compared with nonstutterers it is possible that the long silent intervals in Metz et al's subjects prior to therapy might have reflected secondary development of stuttering. If this is so, it calls into question their use of correlational data to support suppositions regarding underlying causal mechanisms in the speech of stutterers.

The task involved in the present experiment was a relatively easy one for the stutterers, in that it involved a repetition task consisting of fairly rhythmically-presented short VCV words with minimal semantic, syntactic or communicative loading. This was deliberately done in order to enhance the chances of obtaining the subjects' fluent productions. The demands of such a task are far removed from those of naturally-encoded speech. However, at least at this fairly basic level of speech, the stuttering children of both languages did not differ from nonstuttering controls in terms of whole-syllable or stop closure durations in VCV nonsense words.

These findings may be contrasted with those of Starkweather and Myers (1979) who studied the timing of one intervocalic interval (IVI), /əsa/, produced by fourteen adult American English stutterers and their nonstuttering controls. The total IVI was longer in the case of the stutterers, the increased duration mainly being the result of longer transitions. Steady state subsegments in which neither the frequency nor intensity of the signal changed were similar for the two groups. The authors suggested that the stutterers may have had slower movements of speech and voice mechanisms but

that coarticulatory aspects of timing were unaffected. The results of the present study, on the other hand, which failed to differentiate stuttering from nonstuttering children in terms of IVIs (which included VOT transitions) did not support the idea that the stutterers were moving their vocal tracts more slowly. Perhaps Starkweather and Myers' findings on adult stutterers reflected a secondary development of stuttering, viz. the adoption of a slower speech rate as a means of enhancing fluency. If that were so, one might have expected steady state segments also to have been lengthened, although it is interesting to speculate that stutterers may become so adept at counteracting stuttering that they selectively slow down transitions. Certainly the discrepancy between the two studies emphasises the importance of studying child stutterers, even though the effects of secondary development cannot be eliminated in this group. Finally, as Starkweather (1983) points out, he and Myers studied only one IVI, so it is not known to what extent their findings may be generalized.

The observation of the present study that nonstutterers used longer stop closure durations than did stutterers contrasts with findings for other speech-disordered populations. Catts and Jensen (1983) found that phonologically-disordered 3.10-5.7-year-olds had longer mean closure durations for final stops than did normal controls, although the two groups did not differ in terms of their ability to differentiate between voiced and voiceless stops by means of closure duration. In the present study there was no indication that stutterers were more variable in their production of stop closure duration than were nonstutterers and this provides a further point of contrast with findings in articulation-disordered populations such as functionally articulation-disordered children (Weismer and Elbert 1982) and phonologically-disordered children (Catts and Jensen 1983).

No consistent age-related trends were observed for either whole syllable duration or stop closure duration. This is in agreement with Kubaska and Keating (1981) who observed that, when the position of words in utterances were controlled, and once children had reached the two-word utterance stage of development, word durations did not change significantly over time in three American English children. This finding conflicted with previous research (Kent and Forner 1980; Smith 1978) which showed that mean durations decreased with age. Apart from the need to control for position-in-utterance, this discrepancy can possibly be attributed to the fact that the Kubaska and Keating study was a longitudinal one whereas the others tested samples of children at different ages. It is not possible to directly compare actual syllable durations in the present study with those of Kubaska and Keating since their speech sample did not include VCV syllables. In general, the age-related findings discussed thus far in the present experiment failed to identify large consistent trends which might have been interpreted as a developmental pattern, other than that of decreasing variability of production with age. Similarly, Hawkins (1973) failed to find convincing age-related trends pertaining to the timing relationships of segments within consonant clusters in her 4-7 year old population. It must be noted, though, that her sample consisted of only seven children.

In contrast, DiSimoni (1974a; 1974b) found clear developmental patterns between 3 and 9 years of age, viz. that the durations of /s/ in VCV nonsense syllables shortened as a function of age and approximated adult values by 9 years. Unfortunately, he did not report on the stress patterns adopted by

his subjects and whether or not they remained constant. Kent and Forner (1980) and Smith (1978) also reported a decrease in mean segmental durations with age; however, as was demonstrated in experiment one and widely reported elsewhere in the literature, VOT lengthens with age in languages using long-lag voiceless stops. Hawkins explained the lack of positive developmental findings in her own and certain other studies by postulating that, once the child has achieved acceptable, albeit immature, productions, he may not change them for some years. In addition to Hawkins' postulate, and in view of the clear age-related VOT data, it seems likely that certain elements of speech are singled out for development in this age group, possibly on the basis of their phonemic significance.

C Comparisons between voiced and voiceless stops

1 Cross-language comparisons

Voiceless stops were accompanied by longer closure duration periods than were voiced stops in the /a/ environment. This trend was maintained for both places-of-articulation, across languages and amongst all groups with isolated exceptions in the stuttering groups. Both older nonstuttering groups showed the voicing differentiation by means of stop closure duration in the /i/ environment as well. This finding of longer closure durations for voiceless stops is in agreement with established trends for adult American English speakers (Lisker 1957; Malecot 1968; Prosek and House 1975; Smith 1978), for two adult Dutch speakers (Slis and Cohen 1969), Canadian English adults (Suen and Beddoes 1974) and normal 2-, 4- and 6-year-old American English children (Catts and Jensen 1983; Smith 1978). Since these studies all used small numbers of subjects and a variety of speech stimuli and segmentation criteria, actual closure durations cited vary, as they might in any case be expected to do with different languages, dialects and ages.

The differences between voiced and voiceless stops in terms of closure duration values are thought to be more marked in children than in adults. This is indirectly supported by the present data in both the English- and Afrikaans-speaking nonstutterers (See Table XVI), which show greater differences for younger than for older speakers at both places-of-articulation.

A comparison between labial and alveolar places-of-articulation in terms of the difference in mean stop closure duration between voiced and voiceless stops indicates that the nonstutterers showed greater values for /t/-/d/ than for /p/-/b/. These findings contrast with those of Suen and Beddoes for Canadian English adults, who showed the shortest silent intervals for alveolar sounds, this being attributed to the relatively greater mobility of the tongue-tip. No consistent place-of-articulation patterns were found in the stutterers in the present study. Nonstutterers had a mean closure duration difference between voiced and voiceless stops of 9.3 msec. This is lower than the reported adult American range of 15-65 msec (Catts and Jensen 1983). The younger South African English nonstutterers had a mean closure duration difference of 16.7 msec, which is far below the values reported by Smith (1978) for American English children of comparable ages. These discrepancies probably largely reflect dialectal differences, although the influence of methodological differences cannot be discounted. The older Afrikaans nonstutterers had a mean voiced/voiceless stop closure duration

difference of 16.7 msec., which is shorter than that reported for two adult Dutch speakers by Slis and Cohen (1969).

2 Age-related trends

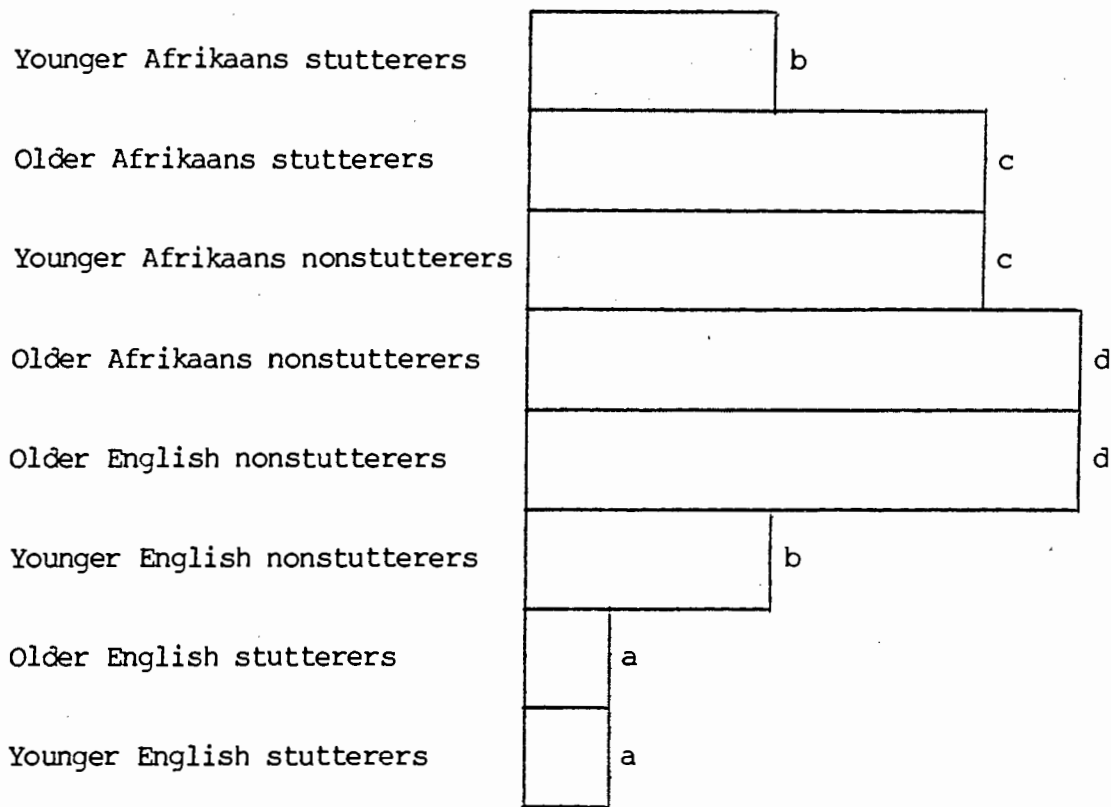
Younger Afrikaans nonstutterers performed similarly to older ones showing the stop closure duration voicing distinction in both /a/ and /i/ environments. However, the trend was less marked than in the older group and a little less consistent. The voicing differentiation was present in young English nonstutterers in the /a/ environment. Apparently, there is a developmental trend toward lengthening of voiceless stop closure duration with age so as to provide the perceptual voicing cue for medial stop cognates. The relatively late development of longer durations for voiceless stops probably reflects the increased muscular effort required to produce them (Suen and Beddoes 1974).

The age-related differences were found to be less clearcut in the stuttering groups.

3 Comparisons between stutterers and nonstutterers

Older English stutterers differed markedly from their nonstuttering controls in that they failed to show convincing voicing distinctions by means of medial stop closure durations. Older Afrikaans stutterers performed in a similar manner to younger Afrikaans nonstutterers. Younger Afrikaans stutterers were producing the voicing distinction in the /a/ environment, ie. they performed like the young English nonstutterers. Young English stutterers gave indications of inconsistent voicing distinctions but had not established it in either vowel environment.

The progress of the eight experimental groups in acquiring the voicing distinction by means of differential medial stop closure duration is schematically compared in Fig.21.



Key:

(a) Little convincing voicing distinction.	(b) Voicing distinction present in /a/ environment but to a lesser degree than is the case with (d). Just emerging in the /i/ environment.	(c) Voicing distinction present in /a/ and /i/ environments, but to a lesser degree than (d).	(d) Clear voicing distinction in /a/ and /i/ environments.

Fig.21 Schematic representation of relative progress of the experimental groups in acquisition of the voicing distinction of medial stops as expressed in the stop closure duration.

If Fig.21 is interpreted as indicating developmental trends it can be seen that Afrikaans nonstutterers appear to develop the voicing distinction with the most ease. Younger English nonstutterers and Afrikaans stutterers seem to perform similarly to one another. English stutterers appear to have the most difficulty in acquiring the contrast. In short, the voicing contrast for medial stops as expressed in the stop closure duration is slower to develop in English- compared with Afrikaans-speaking children and in stutterers relative to nonstutterers. English stutterers consequently perform poorest in this regard. The comparative difficulty apparently experienced by stutterers in acquiring the longer voiceless stop closure durations may be related to the greater degree of muscular effort required to produce them (Suen and Beddoes 1974). However the possibility also exists that these effects reflect neural preprogramming and that a more cognitive functional level may be involved (see General Discussion). There does not appear to be a ready explanation for the cross-language differences.

D The influence of /a/ and /i/ vowel environments on medial stop closure duration

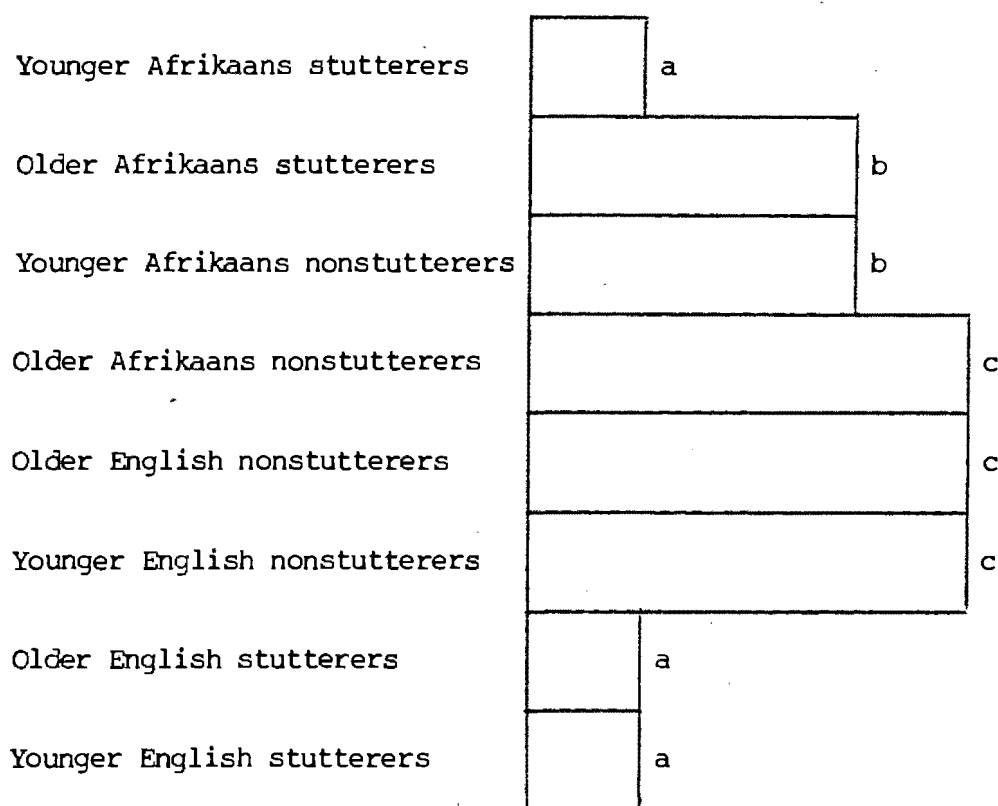
The finding that closure durations of both voiced and voiceless medial stops were greater in /i/ compared with /a/ environments is in agreement with the results of acoustic studies by Schwartz (1969) and DiSimoni (1974), and a study of linguo-palatal contact by Butcher and Weiher (1976) which compared the influence of /a/ and /u/. Schwartz measured the duration of medial /s/ and /ʃ/ in VCV nonsense words spoken by adult American English speakers, while DiSimoni studied medial /s/ duration in VCV nonsense words spoken by 3-6- and 9-year-old American English children. Similarly, Suen and Beddoes (1974) found that short vowels produced the longest silent interval in all stops in a sample of adult Canadian English speech.

In further agreement with DiSimoni, age-related differences were observed in the present study. The influence of vowel environment on medial stop closure duration was greater in the older than in the younger nonstuttering subjects. The younger English and Afrikaans stuttering groups failed to demonstrate differential stop closure durations relative to the vowel environment. Neither did older English stutterers show consistent trends in this regard, while the older Afrikaans stutterers performed in a manner similar to the younger Afrikaans nonstutterers ie. the normal trend was apparent, but to a lesser degree than was the case with the older nonstutterers.

These results, together with those of DiSimoni, lead one to conclude that there may be a developmental trend in the direction of lengthening of medial stop closure durations in the high vowel environment. In the present study, this had already emerged in the young English nonstutterers who performed similarly to the older ones. Older Afrikaans nonstutterers performed similarly to English controls. The trend was present, but to a lesser degree, in young Afrikaans nonstutterers, who did not perform quite as well as their English controls. Cross-language differences were thus only noticeable in the younger groups, Afrikaans speakers being slower to demonstrate the trend than English speakers.

The stutterers performed differently to the nonstutterers. The normal trend showed signs of beginning to emerge in the younger stutterers but was much less consistent than was the case with the nonstuttering controls. Older

Afrikaans stutterers performed in a manner similar to younger Afrikaans nonstutterers. Older English stutterers differed markedly from their nonstuttering peers in that they showed very little voicing distinction. These age-related trends are schematically portrayed in Fig.22.



Key:

(a) Little stop closure differentiation in /i/ and /a/ environments.	(b) Closure durational differences between /i/ and /a/ environments are present, but to a lesser degree, or less consistently than (c).	(c) Clear stop closure durational differences between /i/ and /a/ environments.

Fig.22 Schematic representation of the relative stages of acquisition of medial stop closure durational differences in /i/ and /a/ vowel environments of the experimental groups.

Schwartz (1974) has speculated that the shorter stop closure duration prior to /a/ might simply be the result of anticipatory coarticulation - earlier consonant release allowing for the greater distance to be covered to reach the low vowel compared with a high one. If one accepts this explanation, then the relative slowness on the part of the stutterers in the present study to develop stop closure durational differences relative to high or low vowel environments may be, at least in part, influenced by the way in which vowels are formed by stutterers. Klich and May (1982) found that vowels in the

fluent speech of adult American English stutterers were restricted spatially (more centralized formants) as well as temporally (little variation in mean formant transition rates) compared with normative data in the literature. However, until this is demonstrated in stuttering children, it is not known whether Klich and May's results reflect secondary development of stuttering or an articulatory difficulty more closely linked to the core of stuttering. Neither is it known whether the vowel environmental influence on medial stop closure duration is simply a mechanical coarticulatory phenomenon, as Schwartz suggests, or whether it is linked to phonological timing rules. If it merely reflects a coarticulatory phenomenon, it is difficult to explain why Afrikaans-speakers are relatively slow to demonstrate this distinction. Until clarity is obtained on the nature of this temporal feature, it is difficult to interpret the cross-language results and the findings on stutterers in the present study.

With respect of the acquisition of differential medial stop closure duration relative to the voicing feature as well as to vowel environment, the relatively poor performance of the stutterers of both language groups in the present study is further evidence of the breakdown, or poor development, of speech timing control in this group. The level of the disturbance, ie. whether phonological or more neuromuscular/aerodynamic, is unknown.

X CONCLUSIONS

A Cross-language findings

Hypothesis 1(a) predicted that English and Afrikaans speakers would not exhibit the same closure duration values but their voiceless stop closures would be longer in the English-speaking group. In fact, it was found that the two groups did not differ in terms of closure duration, although that of Afrikaans-speakers was more variable. Consequently, this portion of the hypothesis was rejected in favour of the null hypothesis.

Hypothesis 1(b) was substantiated, ie. both English- and Afrikaans-speaking groups demonstrated longer stop closure durations in voiceless compared with voiced stops and in /i/ compared with /a/ vowel environments.

B Age-related findings

The expectations of hypothesis 2 were partly fulfilled. There appeared to be a developmental trend in the direction of lengthening of medial stop closure duration of voiceless stops. This voicing distinction appeared to be acquired earlier in both vowel environments in Afrikaans-speakers compared with English-speakers. A second age-related trend, which was also interpreted as reflecting a developmental pattern was toward lengthening of medial stop closure duration in the /i/ vowel environment relative to /a/. English-speaking stutterers did not show these age-related trends and the question remains whether it could be demonstrated in a group of similar subjects older than 6 and 7 years.

That portion of hypothesis 2 which predicted that whole syllable duration and medial stop closure duration would shorten with time, ie. be shorter in the older speakers, was rejected. Whole syllable duration was not found to differ

between younger and older groups, while stop closure duration increased slightly. However, variability of closure duration production was less in older speakers than younger and hypothesis 2(c) was supported.

C Comparisons between stutterers and nonstutterers

Since stutterers did not show longer whole syllable or medial stop closure durations than did nonstutterers, sections 3(a) and (b) of the hypothesis were rejected. In fact there was a trend, albeit not completely consistent, toward shorter closure durations on the part of stutterers. Considering the VOT transition was included in the closure duration measure, it seemed unlikely that the stutterers were simply moving their speech mechanisms more slowly than were nonstutterers. Hypothesis 3(c) was sustained. The stuttering subjects appeared to be acquiring the normal developmental trend toward lengthening of medial stop closure duration in voiceless stops compared with voiced ones, and in the /i/ vowel environment relative to /a/, however, their performance in this regard was inferior to that of nonstutterers and gave the impression of delayed acquisition. Afrikaans stutterers lagged behind their nonstuttering controls, while English stutterers, at least in the age groups studied, failed to show differential stop closure durations. These results were taken as evidence of a developmental difficulty with the acquisition of speech timing probably involving the phonological level of planning. However, the influence of possible aerodynamic/neuromuscular factors is unknown and depends on clarification of the normal processes underlying these temporal features of speech.

AN INVESTIGATION INTO THE DURATION OF MEDIAL VOWELS IN VOICED AND VOICELESS
SIBILANT AND STOP PLOSIVE ENVIRONMENTS IN CVC NONSENSE SYLLABLES

- I Aims of the experiment
- II Outline of the experimental design
- III Hypotheses
- IV Material
- V Procedures
- VI Data analysis
- VII Statistical treatment
- VIII Results
- IX Discussion
- X Conclusions
- XI Summary of results and conclusions

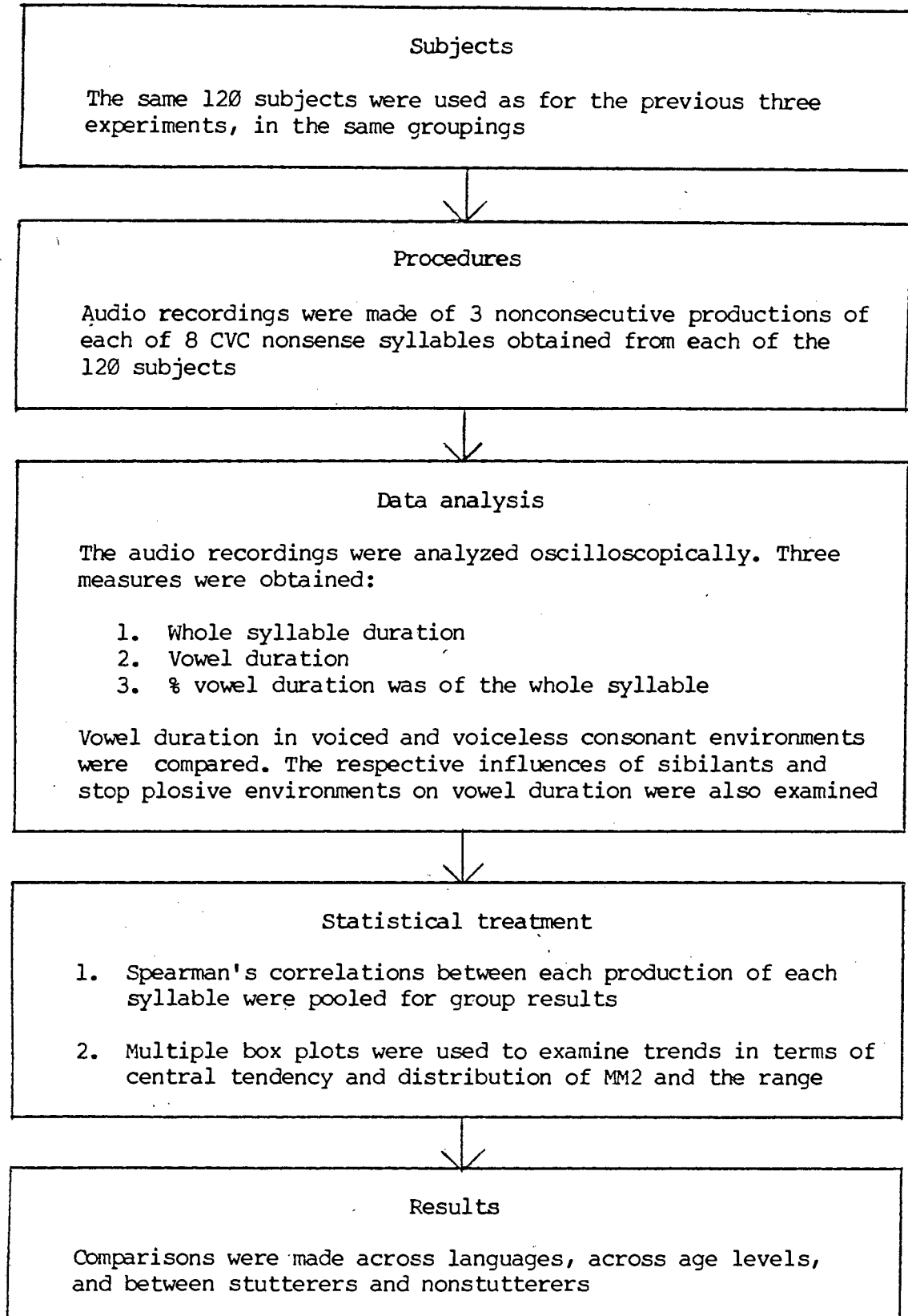
I AIMS OF THE EXPERIMENT

This experiment was aimed at determining whether any trends characterized the eight experimental groups in terms of medial vowel duration relative to the consonant environment. The influence on vowel duration of the voicing feature of the consonant environment, as well as the influence of sibilant versus stop plosive consonants were to be determined. Vectors of interest included comparisons between English- and Afrikaans-speakers, younger and older speakers and stutterers and nonstutterers.

II OUTLINE OF THE EXPERIMENTAL DESIGN

A summary of the design for this experiment appears in Table XVII:

TABLE XVII Outline of research design for experiment four



III HYPOTHESES

1. Cross-language comparisons

- a) It was predicted that whole syllable and vowel durations would be comparable for English- and Afrikaans-speakers at both age levels. This lack of cross-language differentiation was expected to apply to stutterers as well as to nonstutterers.
- b) It was hypothesized that speakers from the two language groups would not differ in terms of the influence of voicing or manner-of-articulation features of the consonant environment on vowel duration. Speakers from both language groups were expected to perform in a similar way by lengthening vowel duration in voiced and sibilant environments and shortening it in voiceless and plosive environments.

2. Age-related comparisons

- a) It was anticipated that vowel duration as well as whole syllable durations would be shorter in all the older groups compared with the younger ones, since segment duration is reported to decrease with age (Kent 1976).
- b) Older speakers were expected to show greater vowel length in voiced and sibilant and consonant environments than were younger speakers.

3. Comparisons between stutterers and nonstutterers

- a) It was postulated that whole syllable durations would be greater in stutterers than in nonstutterers, since there are indications in the literature of slower vocal tract movements in stutterers (Starkweather 1983).
- b) It was predicted that vowel duration would be similar for stutterers and nonstutterers, in view of Starkweather and Myer's (1979) suggestion that the two groups may not differ in terms of steady state segment durations.
- c) The stuttering subjects were expected to show the normal trends in terms of the influence of voicing and manner-of-articulation of the consonant environment, but to a lesser degree than the nonstutterers, reflecting a possible developmental lag in the acquisition of speech timing rules.
- d) Finally, the stutterers were expected to perform in a more variable fashion in all measures compared with nonstutterers.

IV MATERIAL

Three randomized word lists, each containing the same eight CVC nonsense syllables were used (see Table XVIII of the Appendix). The lists yielded three nonconsecutive productions of each of the following syllables by each subject:

/pip/	/pap/	/sis/	/sas/
/bib/	/bab/	/ziz/	/zaz/

The high and low vowels each occurred in voiced and voiceless stop plosive and sibilant consonant environments. The nonsense syllables were the same as those used by DiSimoni (1974) in his study of six adult American English stutterers.

V PROCEDURES

These were the same as for experiment three, the practice items being modified so as to fit the CVC format.

VI DATA ANALYSIS

As was the case with experiments one and three, interjudge agreement (Figs.23a to 23l) was sufficiently high to justify completion of the measurements by one judge. However, it should be noted that agreement was slightly less close for the CVC syllables than for VOT or VCV syllables.

Of the 2,880 tokens recorded, 143 (ie. 4.97%) were discarded as they were whispered, masked, contained clear phonemic substitutions, etc. This left 2,737 tokens available for analysis. Tape editing, instrumentation and procedures for oscilloscopic analysis were the same as for experiment three.

Segmentation criteria were as follows:

Vowel duration in voiceless plosive environments was judged to begin following the voice onset transition with the beginning of quasiperiodic activity. The end of the vowel duration was signalled by the onset of a quiescent wave (see Fig.24 line b). In the case of voiced consonant environments, vowel duration was regarded as starting after the beginning of quasiperiodic activity (Fig.25 line a). It ended with a sudden diminishing of the energy of the quasirandom waveform (line b).

In the voiceless sibilant environment, quasirandom activity of the initial consonant gave way to quasiperiodic activity of the vowel (Fig.26 line a). The end of vowel duration was indicated by a change back to quasirandom waveforms. Line b is placed at the midpoint of a boundary area between the vowel and final consonant.

In the case of the voiced sibilant environment, quasirandom or combined waveforms signalling the consonant gave way to quasiperiodic activity at vowel onset (Fig.27 line a). At vowel offset, quasirandom or combined waves signalled the beginning of the final consonant.

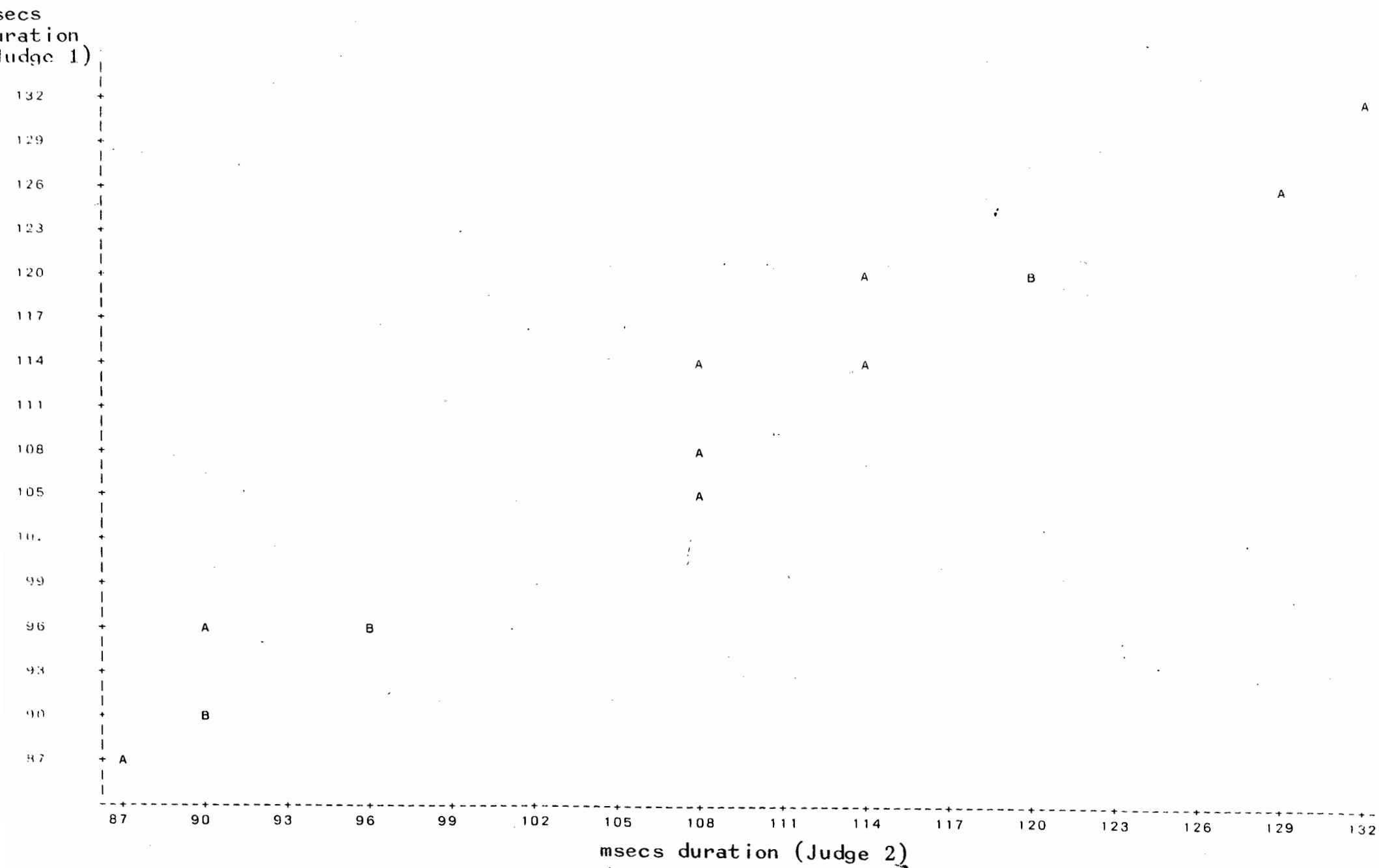


Fig. 23a Plot showing interjudge agreement for vowel duration of /pip/
Key: A = 1 observation, B = 2 observations. etc.

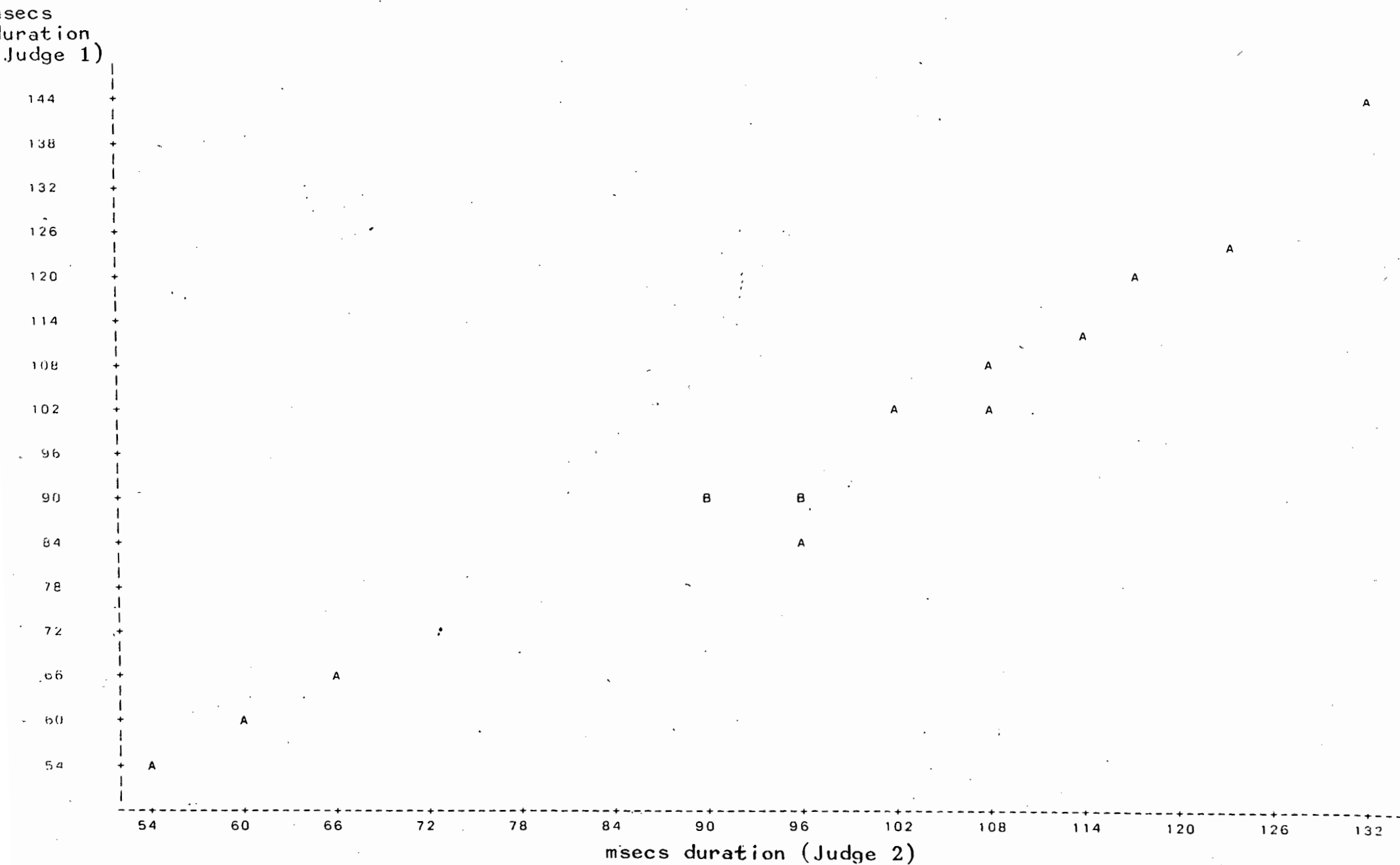


Fig. 23b Plot showing interjudge agreement for vowel duration of /sis/
Key: A = 1 observation, B = 2 observations, etc.

secs
duration
(Judge 1)

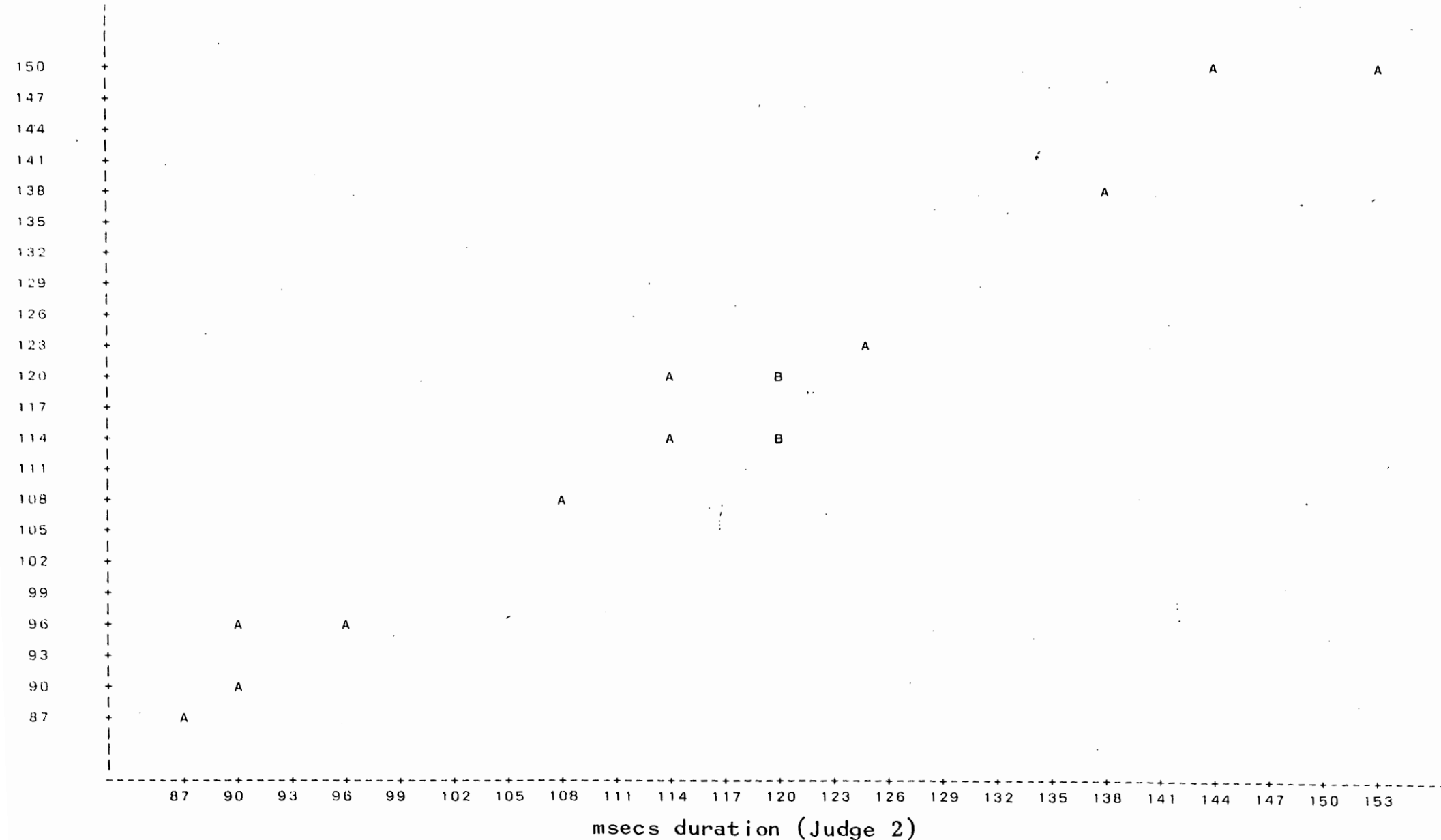


Fig. 23c Plot showing interjudge agreement for vowel duration of /bib/
Key: A = 1 observation, B = 2 observations, etc.

msecs
duration
(Judge 1)

252
246
240
234
228
222
216
210
204
198
192
186
180
174
168
162
156
150
144
138
132
126
120
114
108
102
96
90
84

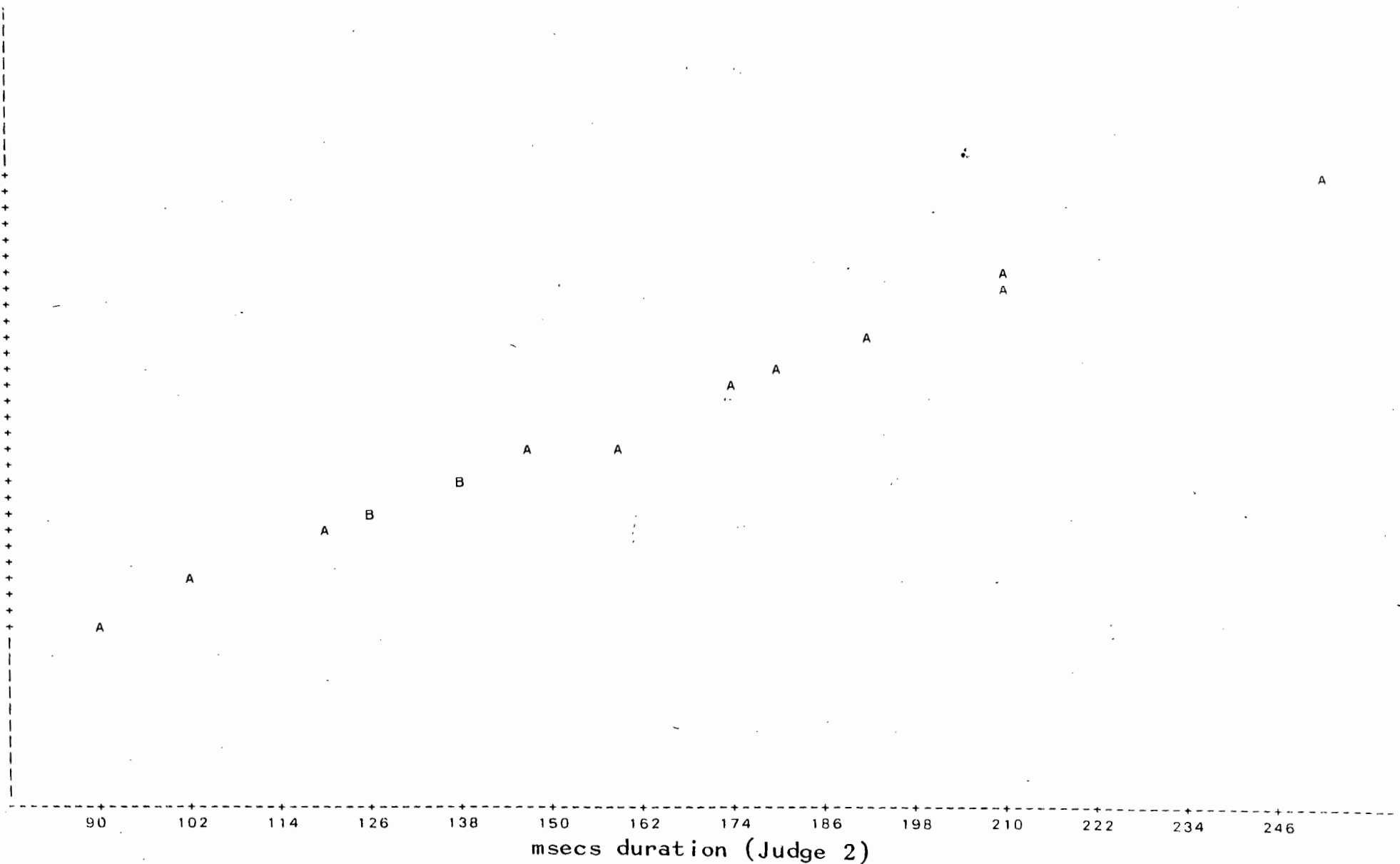


Fig. 23d Plot showing interjudge agreement for vowel duration of /ziz/
Key: A = 1 observation, B = 2 observations, etc.

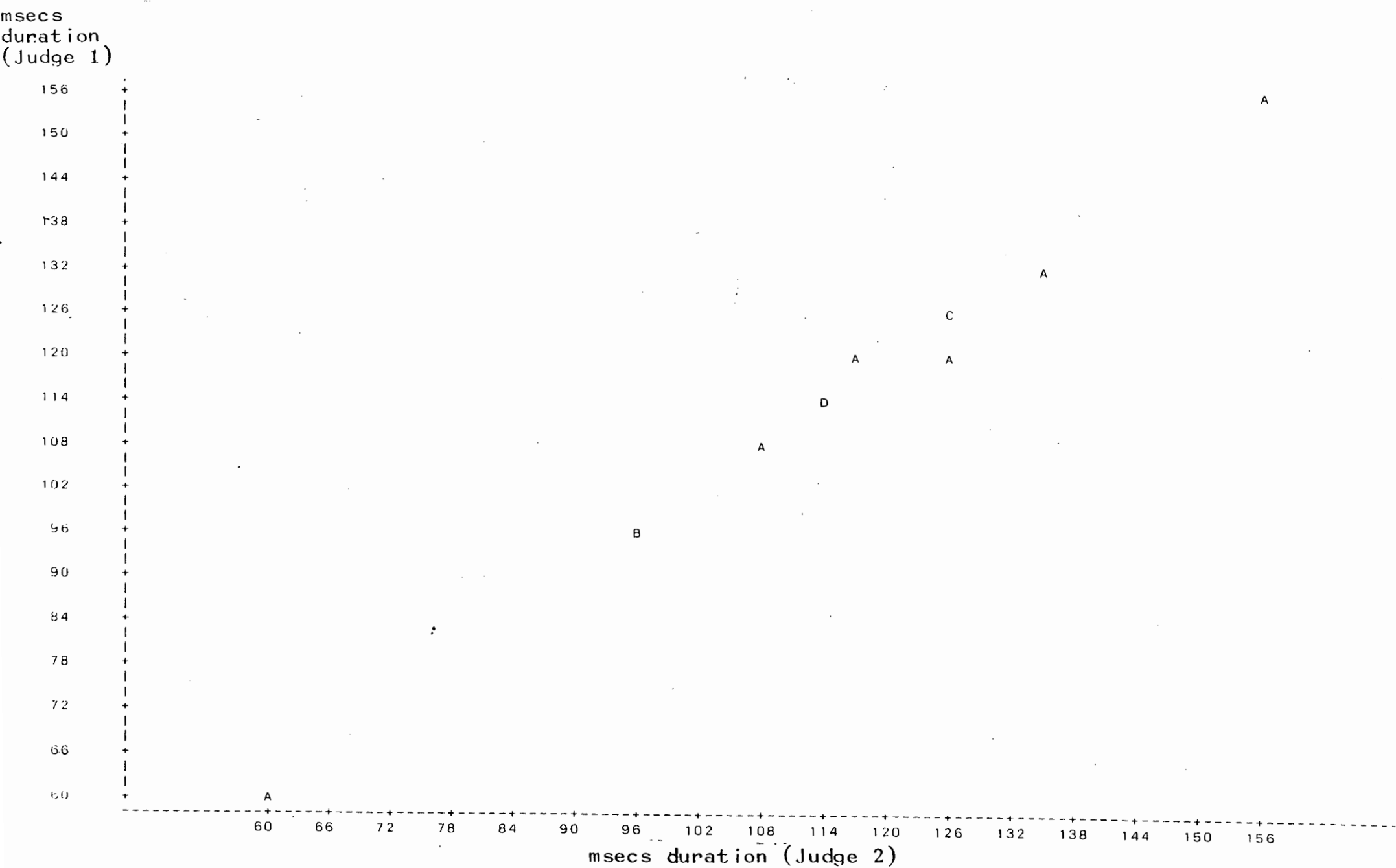


Fig. 23e Plot showing interjudge agreement for vowel duration of /pap/
 Key: A = 1 observation, B = 2 observations, etc.

msecs
duration
(Judge 1)

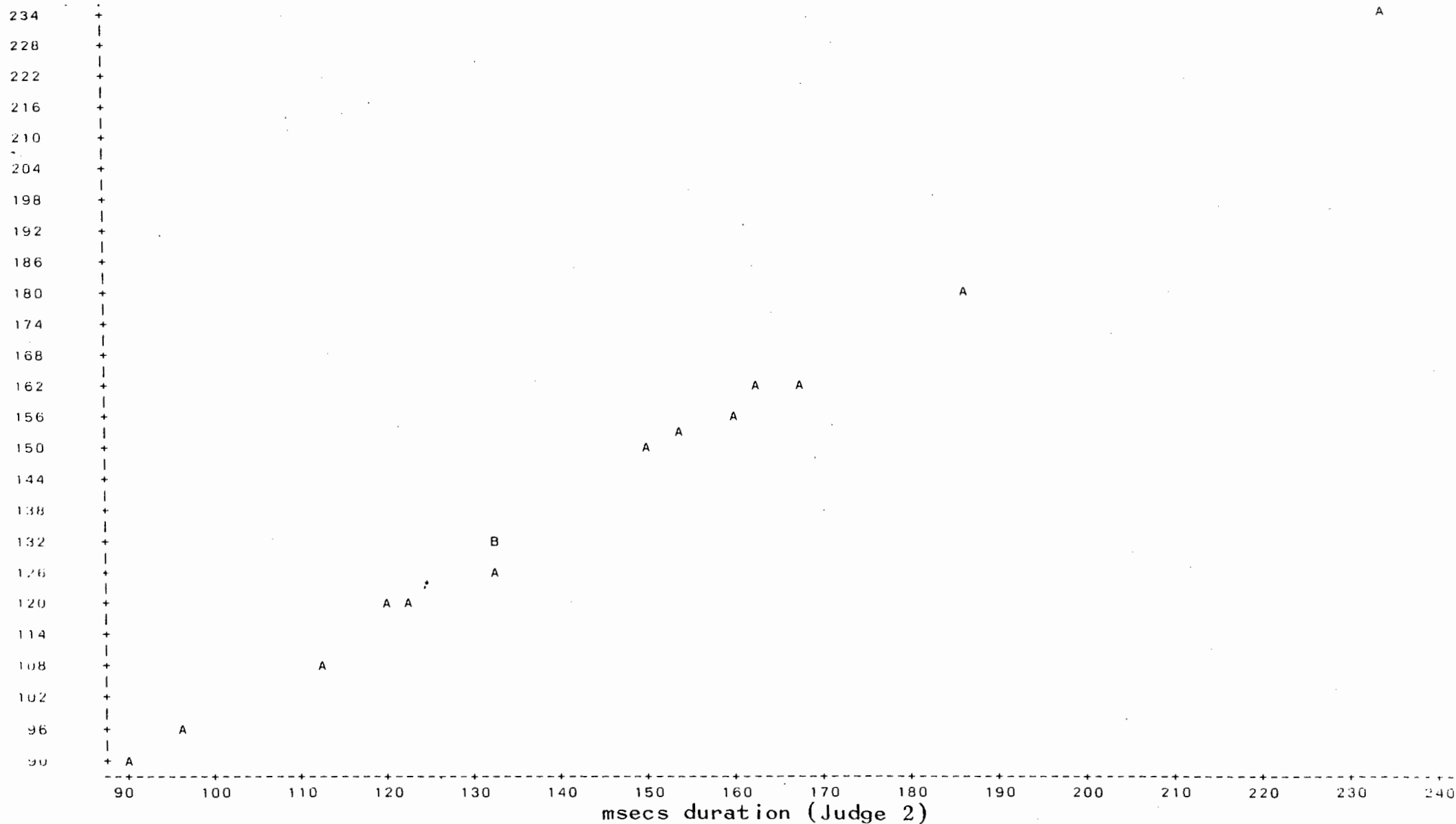


Fig. 23f Plot showing interjudge agreement for vowel duration of /bab/
Key: A = 1 observation, B = 2 observations, etc.

msecs
duration
(Judge 1)

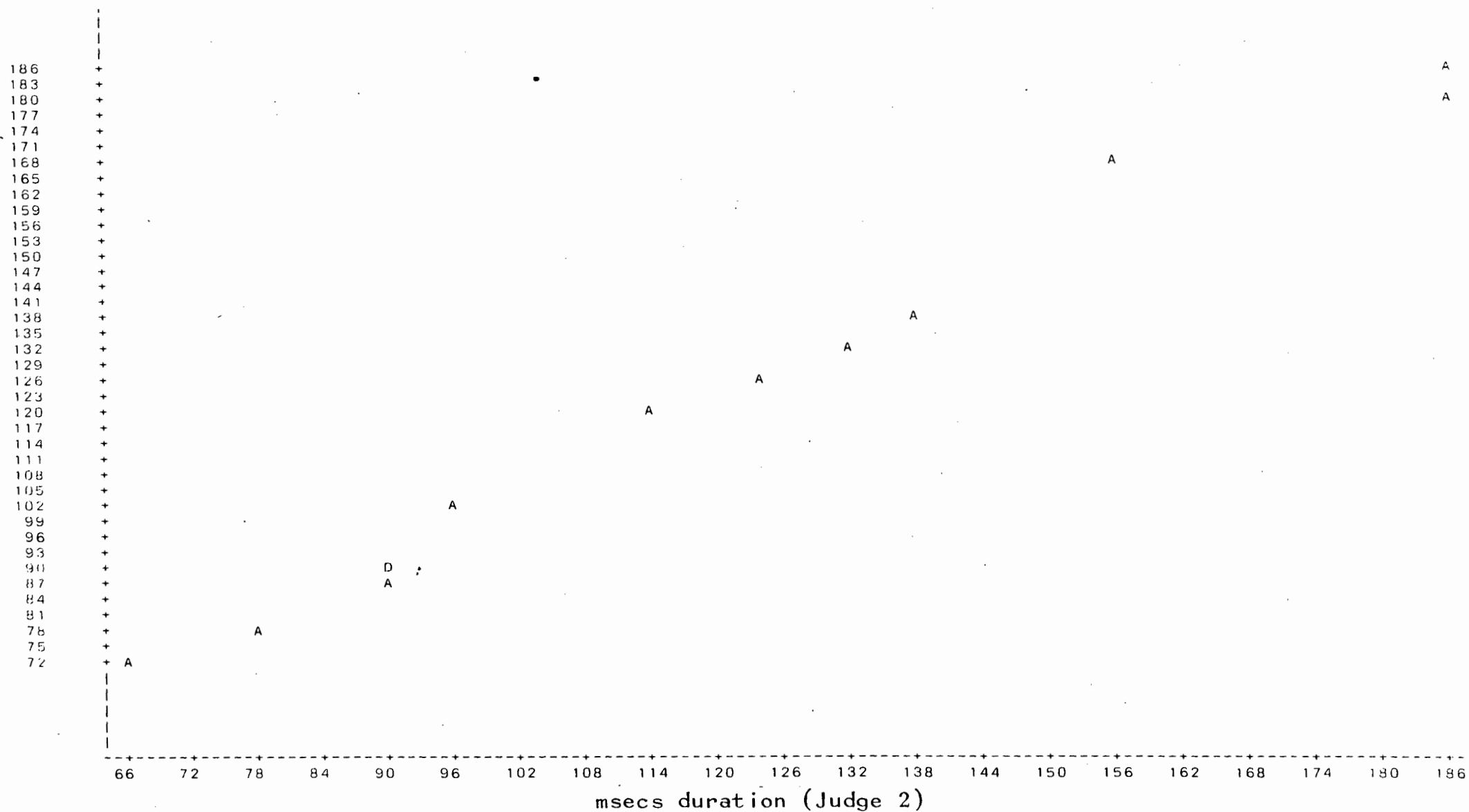


Fig. 23g Plot showing interjudge agreement for vowel duration of /sas/
Key : A = 1 observation, B = 2 observations, etc.

msecs
duration
(Judge 1)

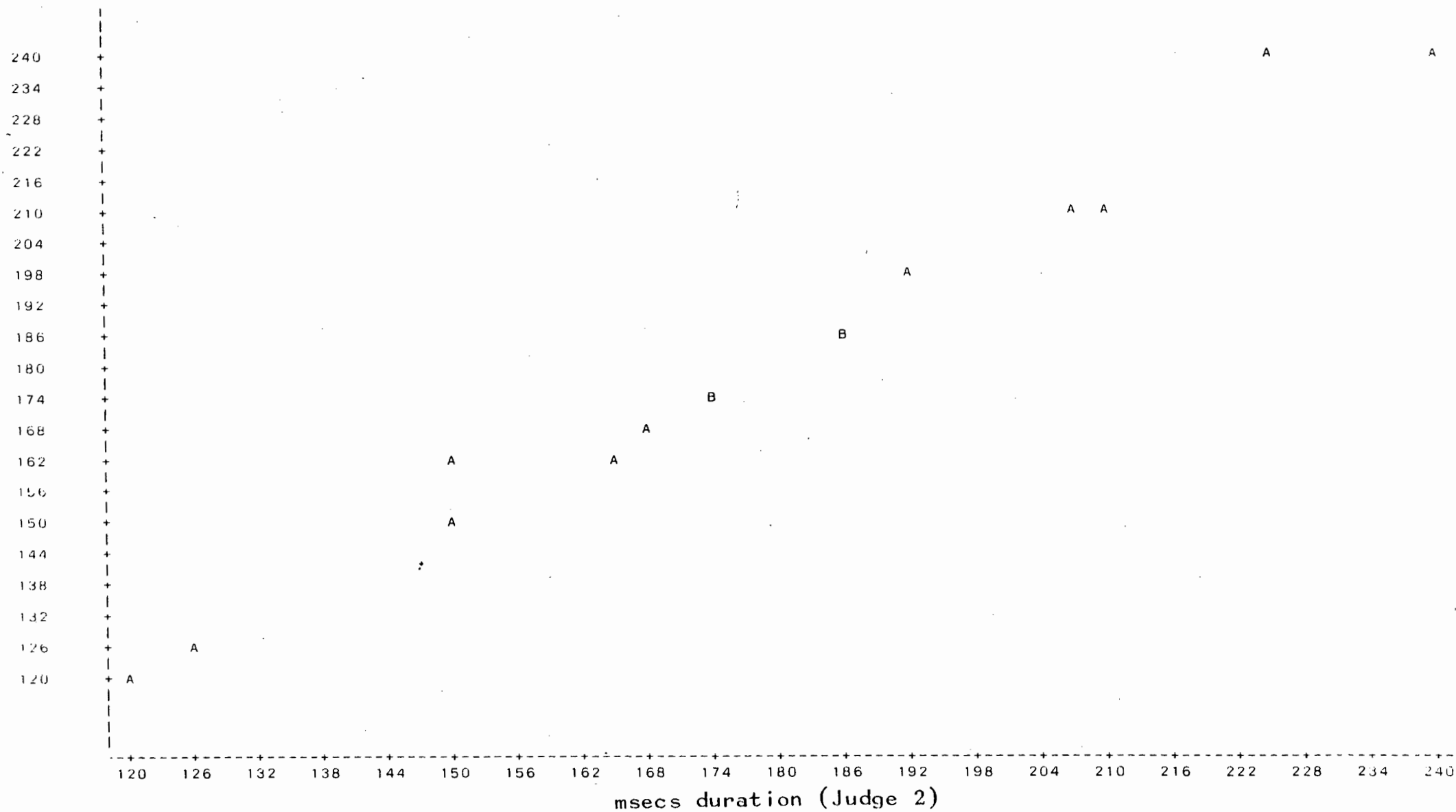


Fig. 23h Plot showing interjudge agreement for vowel duration of /zaz/
Key: A = 1 observation, B = 2 observations, etc.

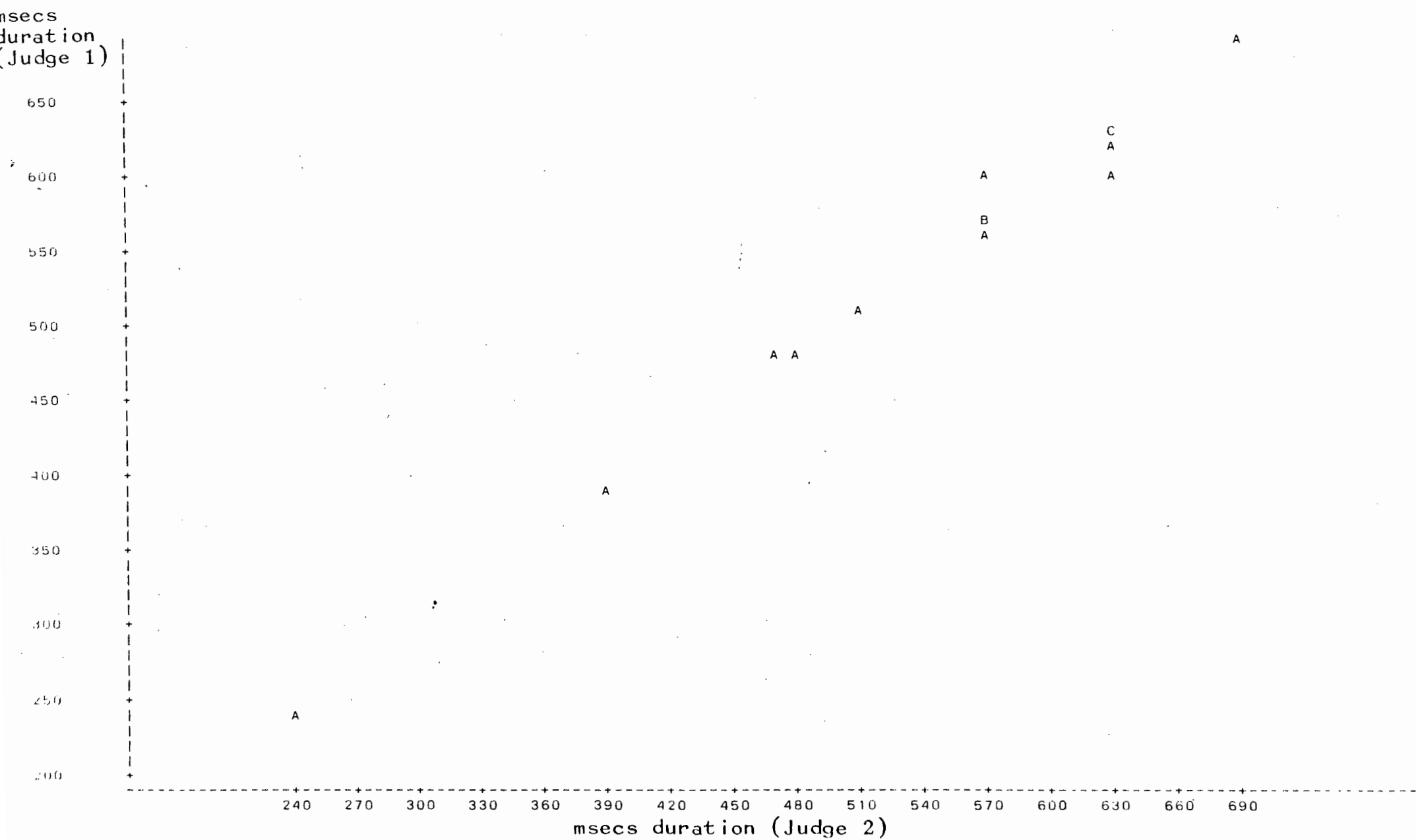


Fig. 23i Plot showing interjudge agreement for syllable duration of /sas/
Key: A = 1 observation, B = 2 observations, etc.

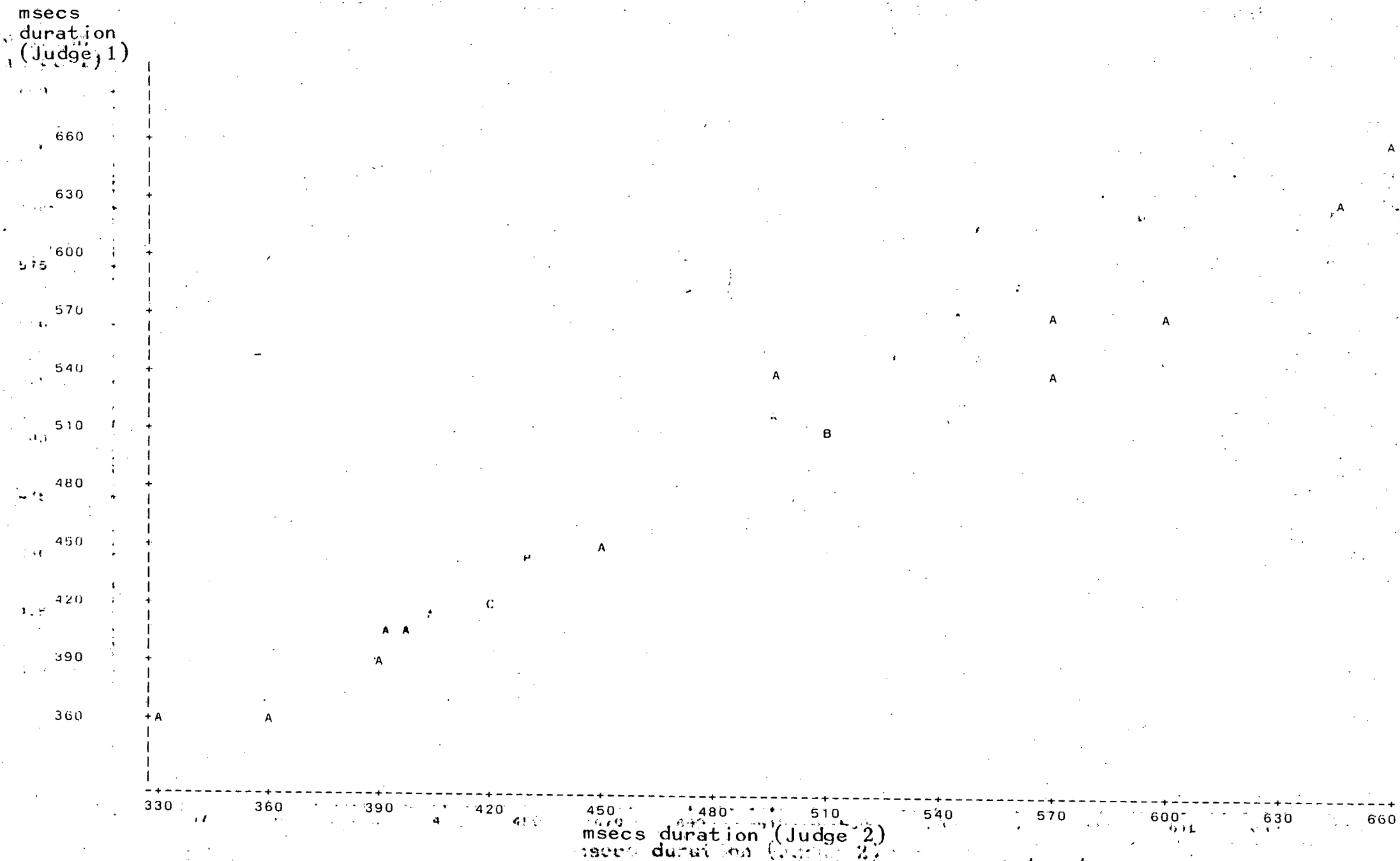


Fig. 23j. Plot showing interjudge agreement for syllable duration of /zaz/.

Key: cA = 1 observation, cB = 2 observations, etc.

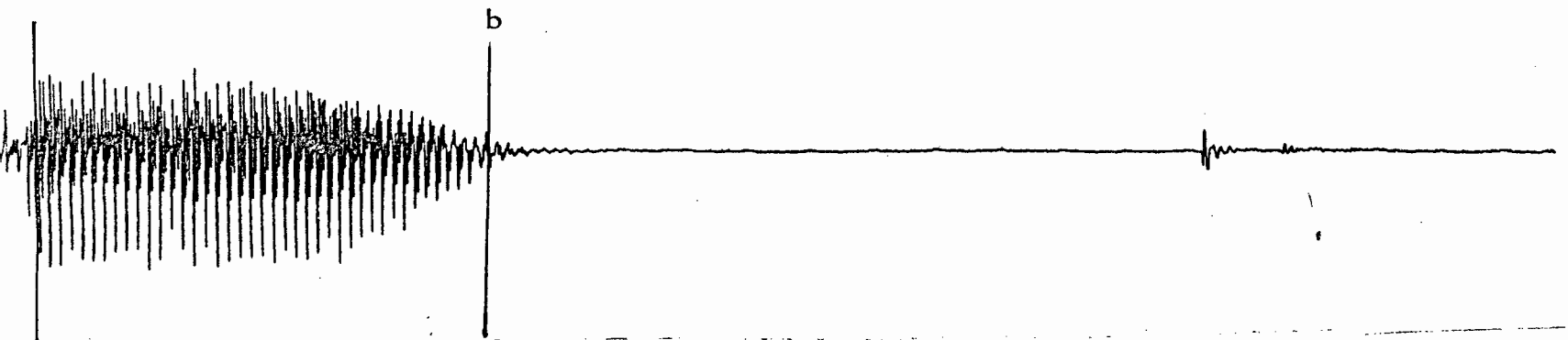


Fig. 24 Production of /pap/ by Subject 37 (vowel duration 150 msec). Vowel onset occurs with quasiperiodic activity following the voice onset transition (line a). It ends with the onset of the quiescent wave (line b) signalling closure of the final stop. Low amplitude, random pulses are included in the final stop closure.

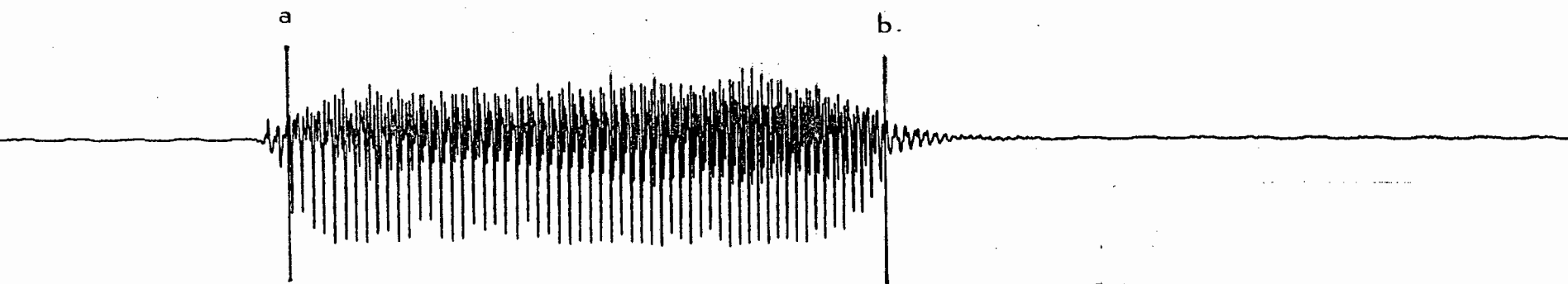


Fig. 25 Production of /bab/ by Subject 37 (Medial vowel duration 192 msec). The interval between lines a and b signals vowel duration.

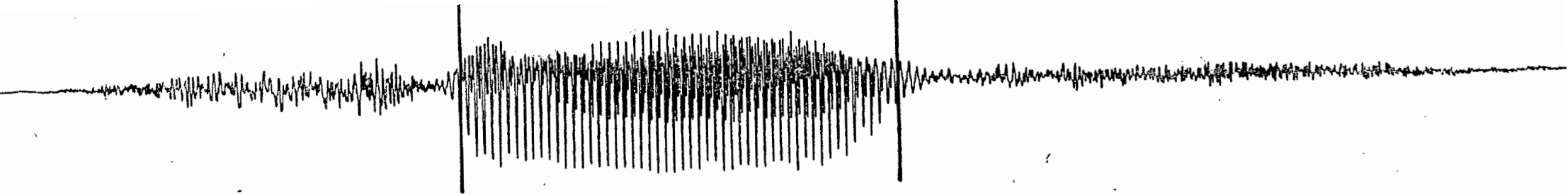


fig. 26 Production of /sas/ by Subject 37 (vowel duration 180 msec). Lines a and b indicate vowel boundaries.

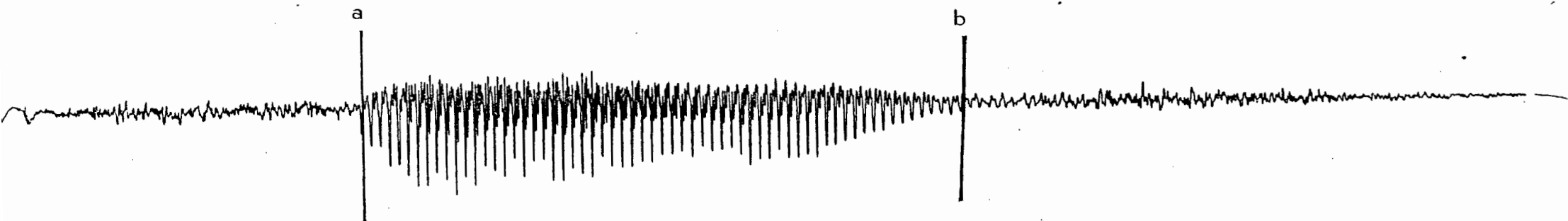


fig. 27 Production of /zaz/ by Subject 37. The interval a to b indicates vowel duration (240 msec).

VII STATISTICAL TREATMENT

This followed the same format as for experiment three.

1. Multiple box plots were devised illustrating:
 - a) central tendency (median) and range for MM2.
 - b) central tendency and spread of the range. These dimensions were plotted separately for each syllable and allow for comparison between the eight experimental groups in terms of vowel duration per se, whole syllable duration, and the percentage which the vowel duration occupied of the whole syllable. Note that whole syllable and percentage duration measures apply to sibilant-vowel-sibilant syllables only, since it was not possible to establish exact syllable boundaries for those beginning and ending with stops. The multiple box plots are illustrated in Figs.28 to 33.
2. Further multiple box plots were obtained illustrating the central tendency and distribution of MM2 and the range for vowel duration in voiced/voiceless and sibilant/stop plosive consonant environments. These plots were separately devised for the eight groups and are illustrated in Figs.34a to 34h.

In examining and comparing the multiple box plots, the reader's attention is drawn to the fact that the millisecond scales on the Y axes differ from one set of plots to the next.
3. The results of the Spearman's correlations performed on each production of each syllable by the respective groups are illustrated in Figs.35a to 35h in the Appendix. These did not fall into any patterns which could be said to characterize any of the groups.
4. Table XIX summarizes mean vowel durations and ranges for each consonant environment for the eight groups respectively. In these instances the range was simply obtained by subtracting group minimum from maximum scores.
5. Table XX summarizes mean vowel durations for voiced and voiceless as well as sibilant and stop plosive consonant environments for the eight groups.

TABLE XIX Mean vowel durations and ranges for each syllable in the eight experimental groups

	pip	bib	pap	bab	sis	ziz	sas	zaz
Group 1. Older English nonstutterers	<u>$\bar{x}$ duration.</u> 66.13 <u>Range.</u> 30-108	126.04 60-195	96.6 66-138	129.66 84-156	72.71 30-120	178.00 90-270	82.97 30-156	185.13 102-243
Group 2. Older Afrikaans nonstutterers	<u>$\bar{x}$ duration.</u> 94.7 <u>Range.</u> 63-210	116.56 81-162	118.82 75-156	145.89 93-234	108.12 60-210	176.26 84-330	147.66 102-186	212.68 120-390
Group 3. Older English stutterers	<u>$\bar{x}$ duration.</u> 89.5 <u>Range.</u> 45-300	131.38 78-210	102.2 60-186	151.06 87-222	90.66 54-168	185.82 77-276	108.8 60-180	238.98 96-1180
Group 4. Older Afrikaans stutterers	<u>$\bar{x}$ duration.</u> 92.8 <u>Range.</u> 60-129	113.06 60-162	113.59 42-150	137.50 60-204	101.83 36-150	172.36 102-360	129.95 60-180	190.34 90-270
Group 5. Younger English nonstutterers	<u>$\bar{x}$ duration.</u> 86.66 <u>Range.</u> 50-120	131.84 84-192	100.20 57-156	145.45 29-270	77.30 54-156	193.08 99-306	92.70 56-156	197.74 114-264
Group 6. Younger Afrikaans nonstutterers	<u>$\bar{x}$ duration.</u> 88.44 <u>Range.</u> 48-138	99.79 24-156	98.27 60-150	122.85 48-240	105.26 18-570	145.95 72-270	103.79 54-150	152.40 72-300
Group 7. Younger English stutterers	<u>$\bar{x}$ duration.</u> 79.33 <u>Range.</u> 42-138	118.98 54-180	129.90 60-150	147.43 90-243	90.80 54-270	155.87 84-222	89.80 54-276	180.74 90-324
Group 8. Younger Afrikaans stutterers	<u>$\bar{x}$ duration.</u> 94.73 <u>Range.</u> 54-171	147.11 57-270	154.60 57-204	171.12 81-300	121.48 42-216	208.78 75-375	139.26 66-204	128.00 114-360

Note: All figures are expressed in msec.

TABLE XX Mean vowel durations in voiced/voiceless and sibilant/plosive consonant environments

	Voiced consonant environ- ment	Voiceless consonant environ- ment	Sibilant environ- ment	Stop plosive environ- ment	Voiced- voiceless environ- ment difference	Stop- sibilant environ- ment difference
Group 1. Older English nonstutterers	154.71	79.60	129.70	104.70	75.11	25.00
Group 2. Older Afrikaans nonstutterers	162.85	117.33	178.35	89.29	45.52	89.06
Group 3. Older English stutterers	176.81	97.79	178.73	118.54	79.02	60.19
Group 4. Older Afrikaans stutterers	153.32	132.74	148.62	114.24	20.58	34.38
Group 5. Younger English nonstutterers	167.03	89.22	140.21	93.54	77.81	46.67
Group 6. Younger Afrikaans nonstutterers	130.25	98.94	126.85	102.34	31.31	24.51
Group 7. Younger English stutterers	150.76	97.46	129.30	118.91	53.30	10.39
Group 8. Younger Afrikaans stutterers	163.75	127.52	149.38	105.11	36.23	44.27

Note: All figures are expressed in msec.

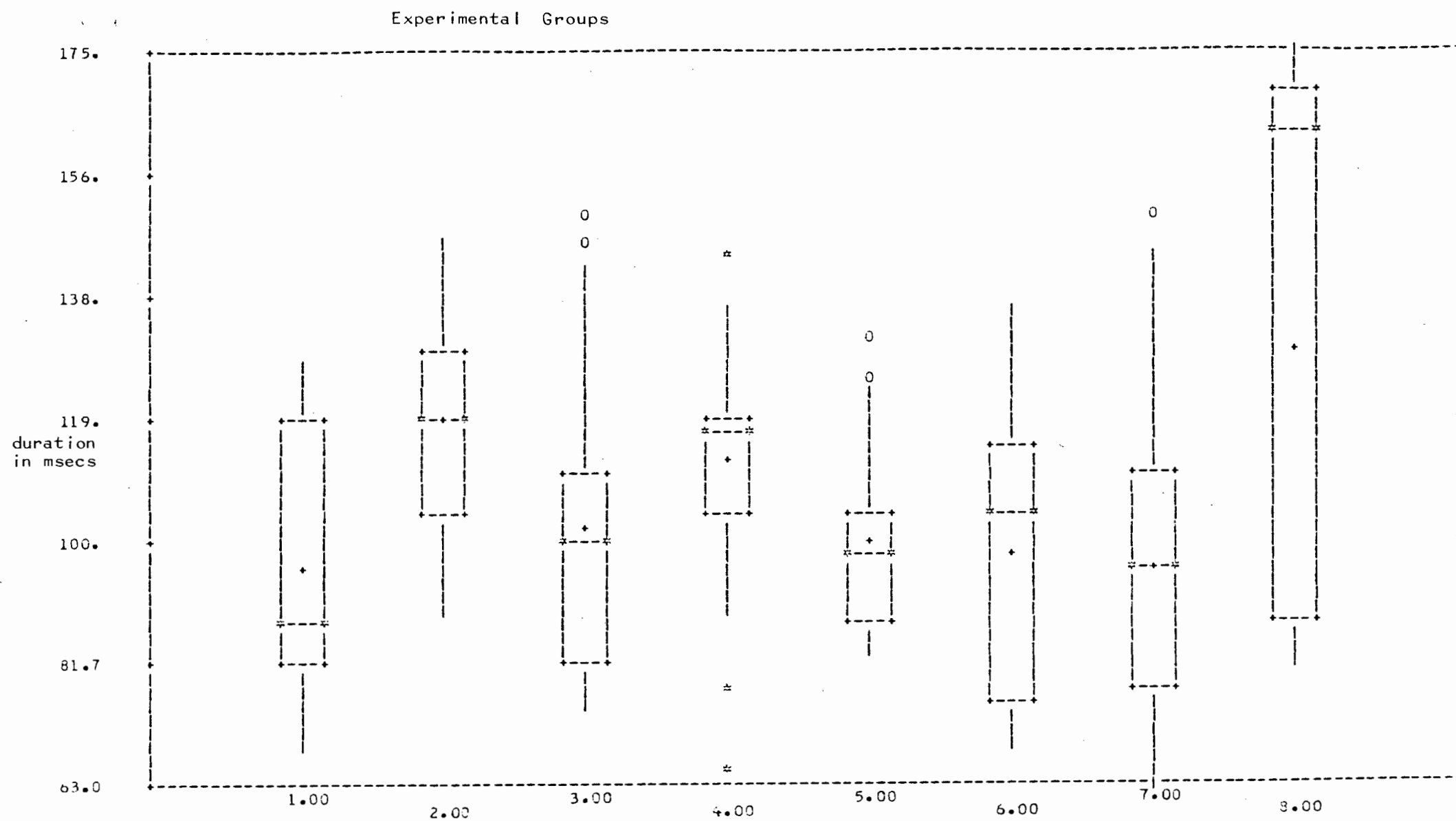


Fig. 28a Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /pap/

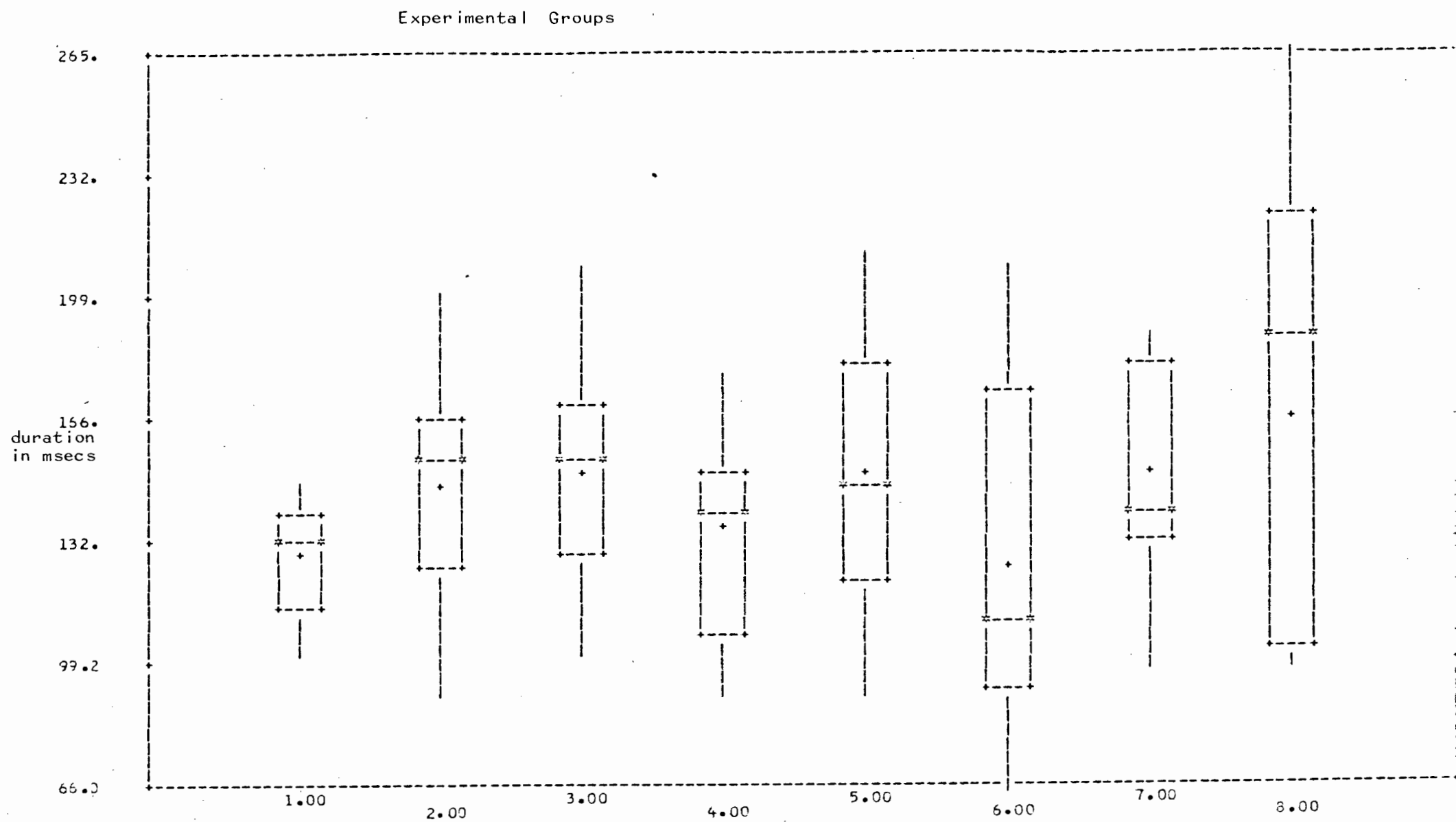


Fig. 28 b Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /bab/

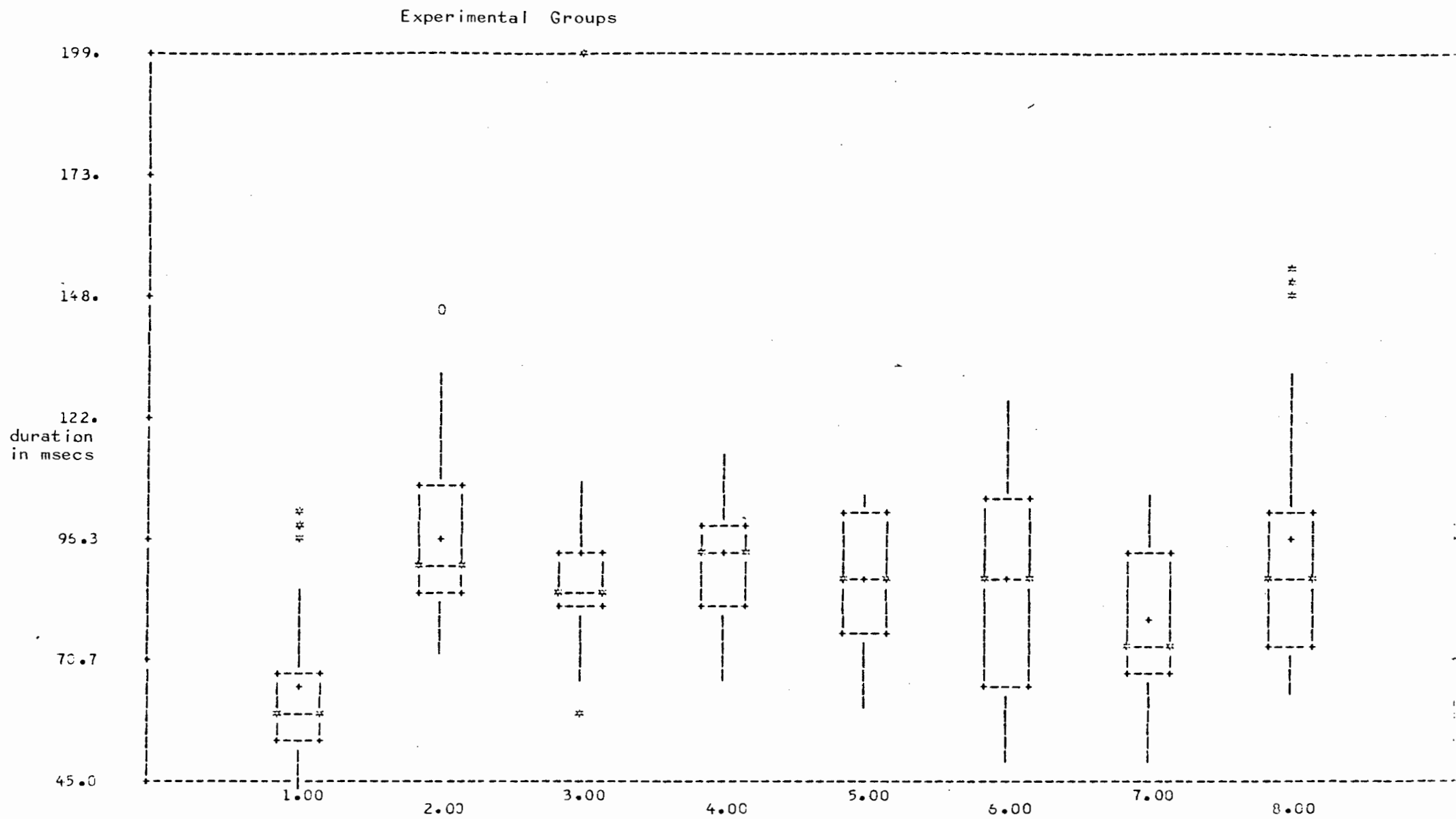


Fig. 28c Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /pip/

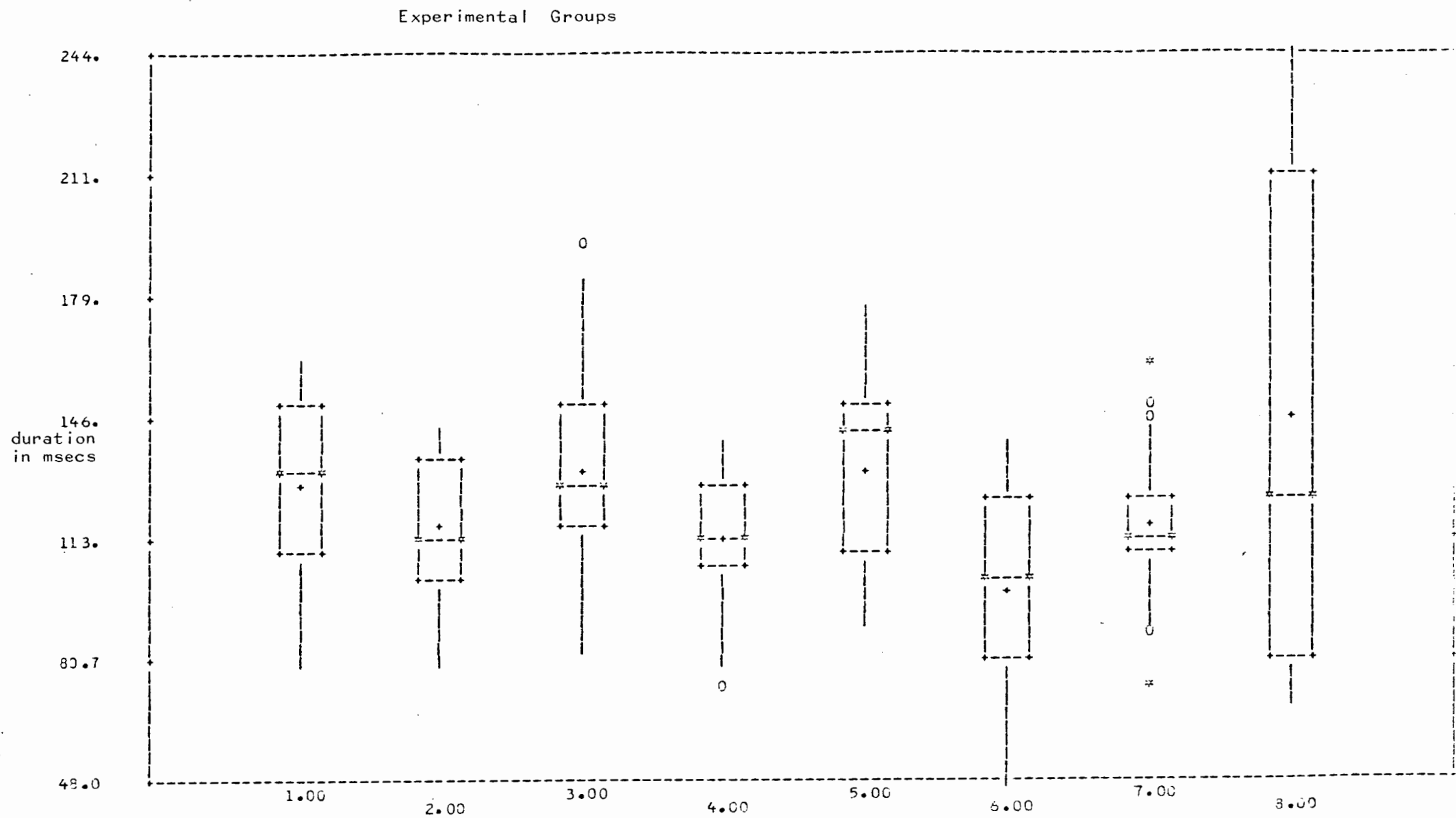


Fig. 28d Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /bib/

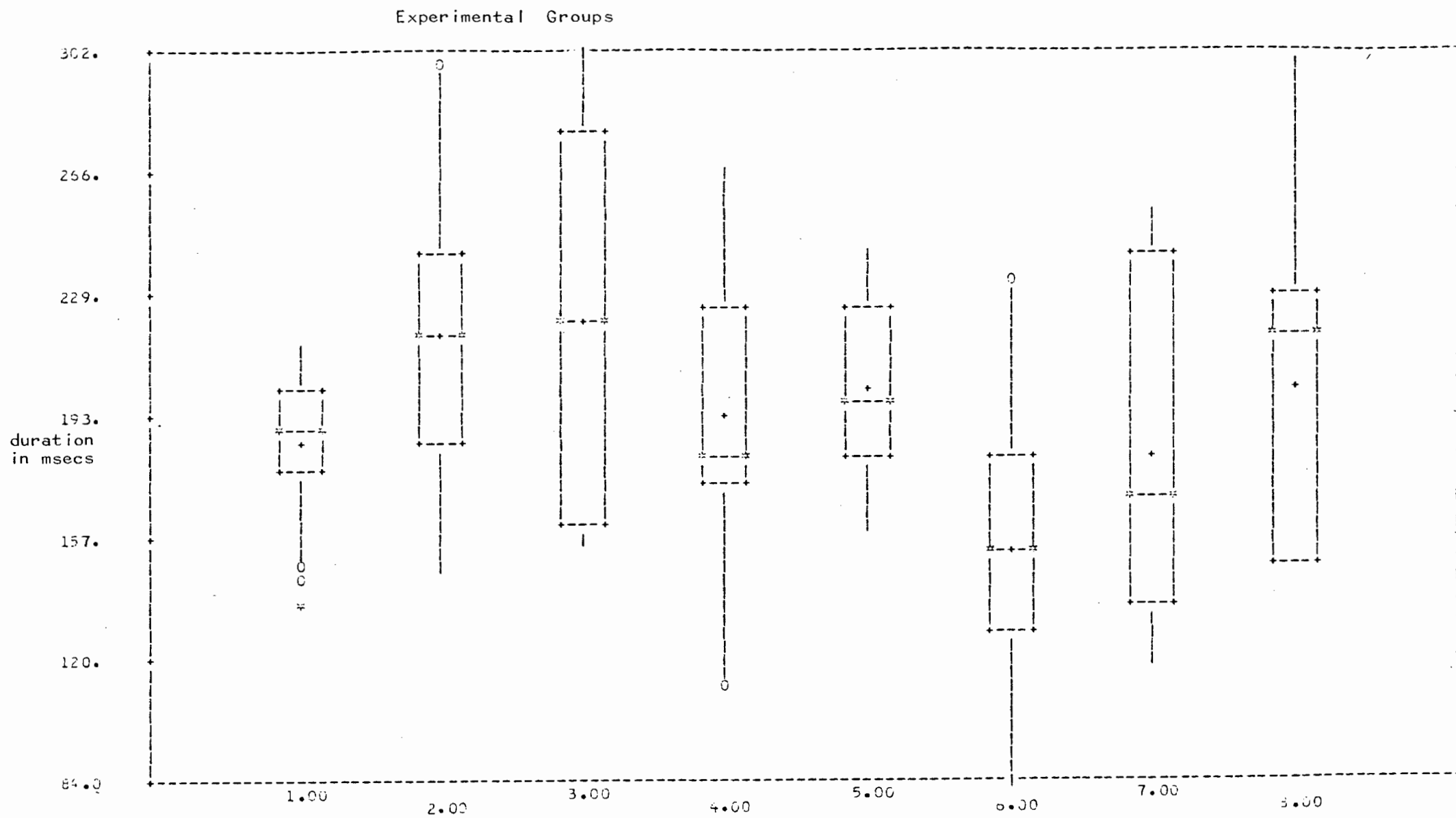


Fig. 28e Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /zaz/

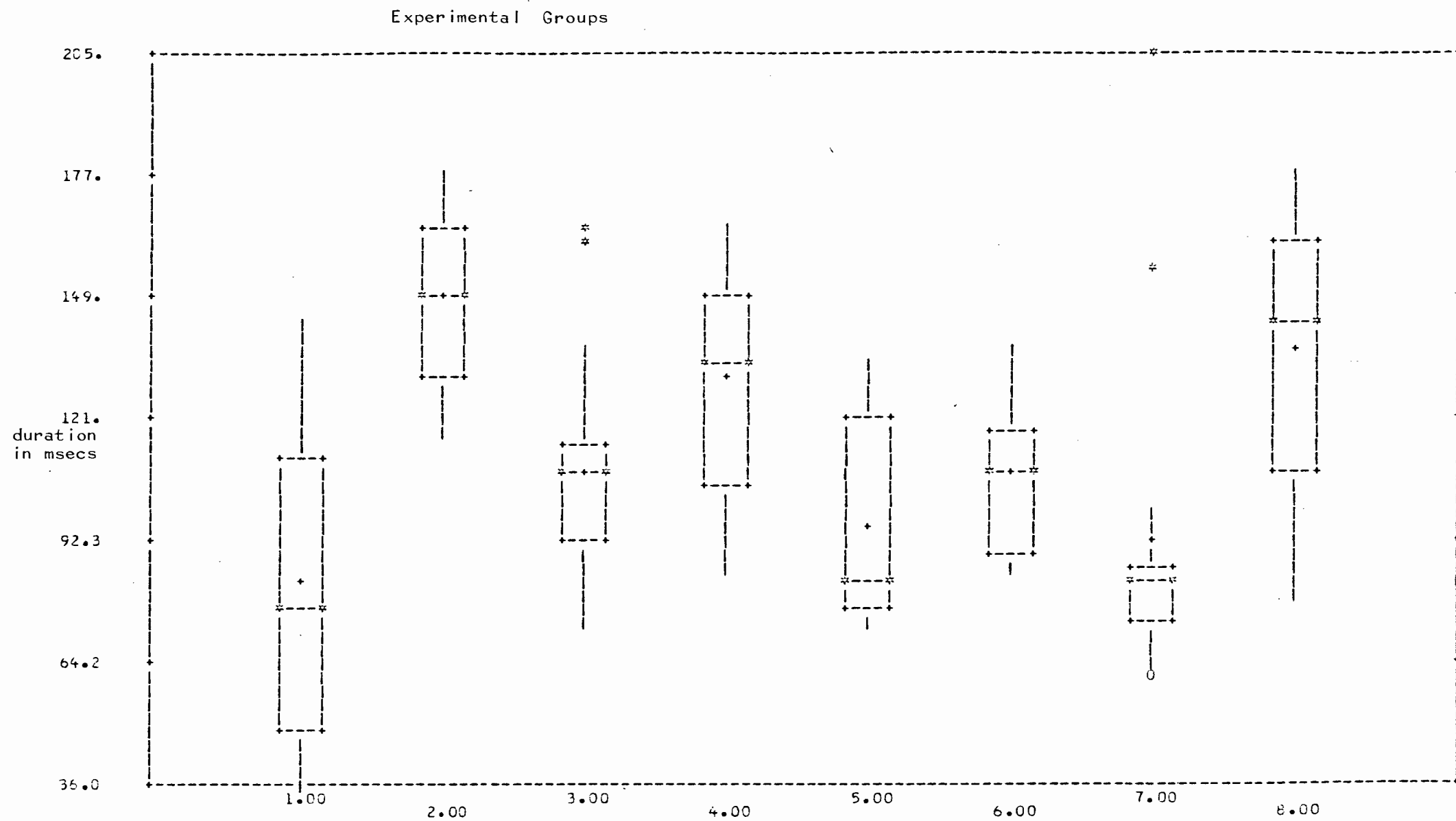


Fig. 28 f Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /sas/

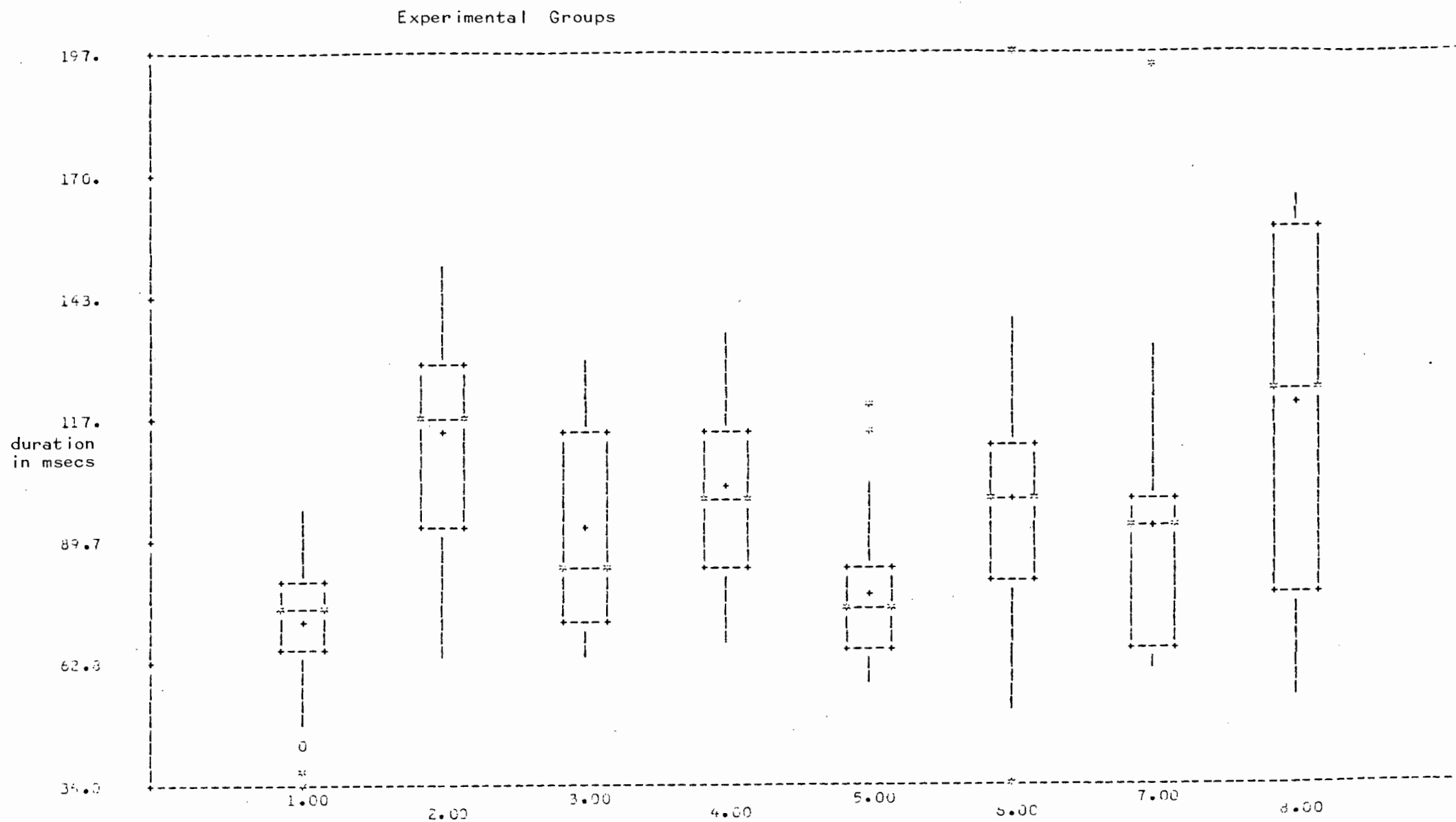


Fig. 28g Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /sis/

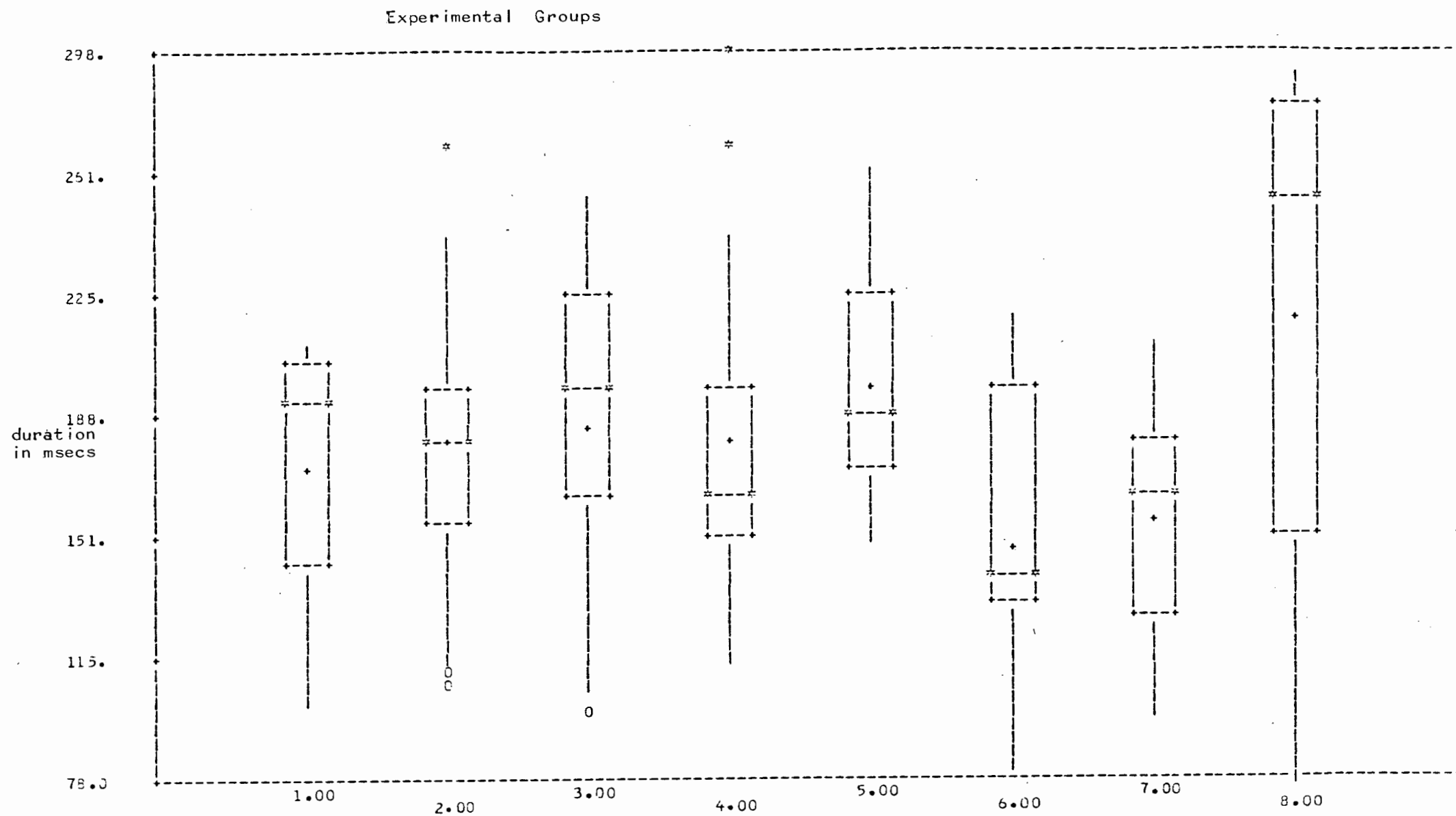


Fig. 28h Multiple box plots showing central tendency and distribution of MM2 for vowel duration of /ziz/

Experimental Groups

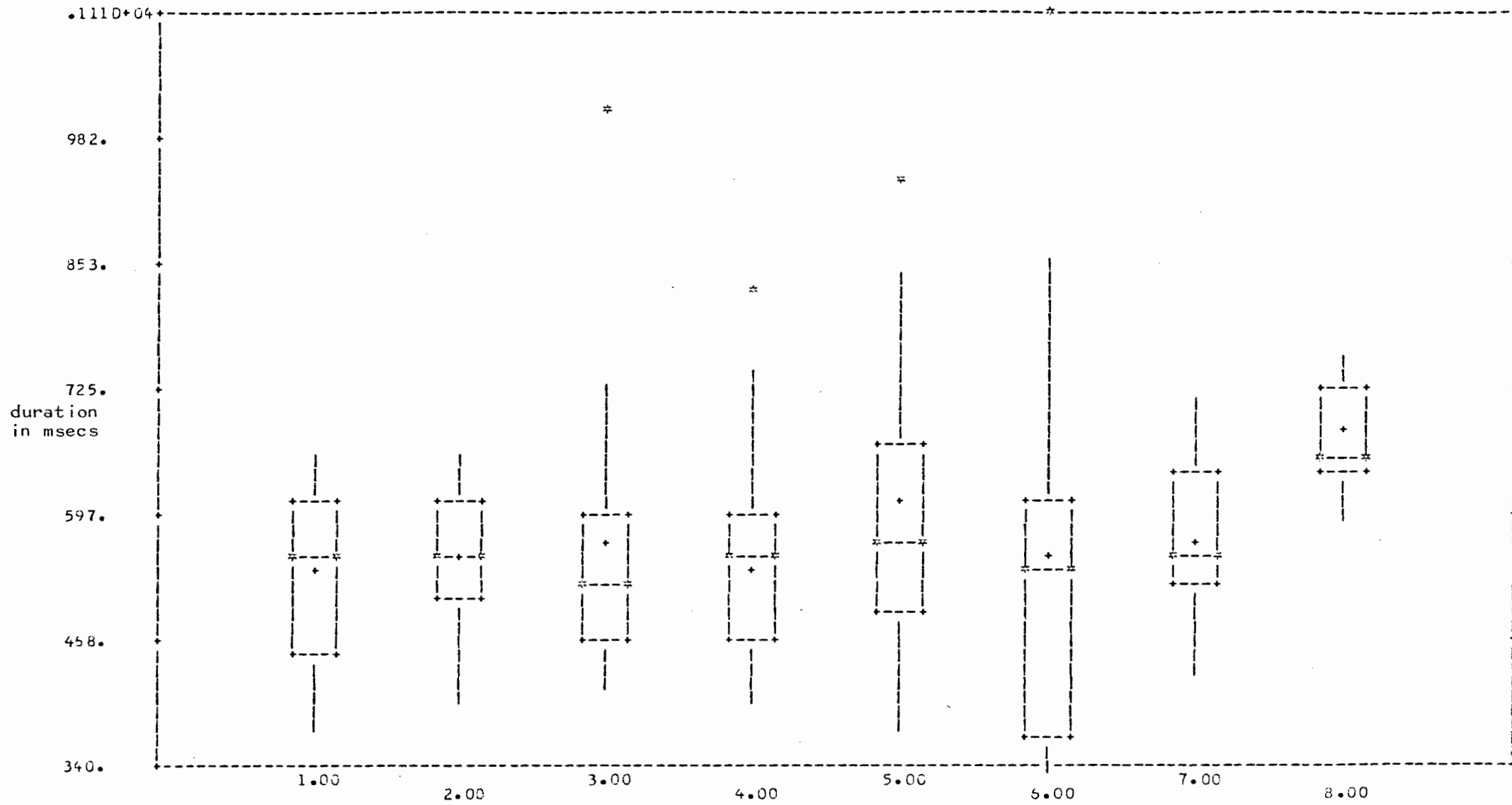


Fig. 29b Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /zaz/

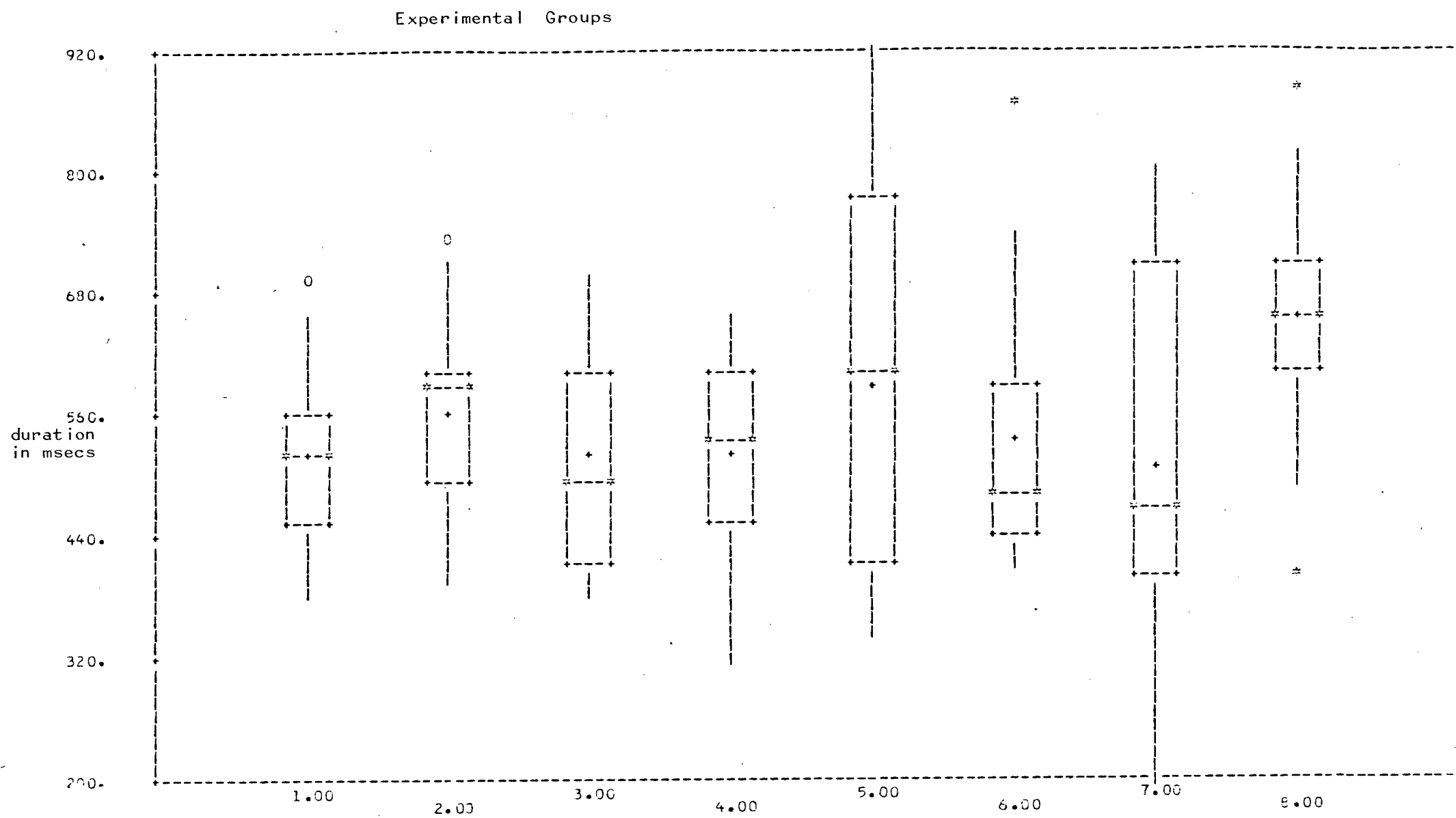


Fig. 29c Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /sis/

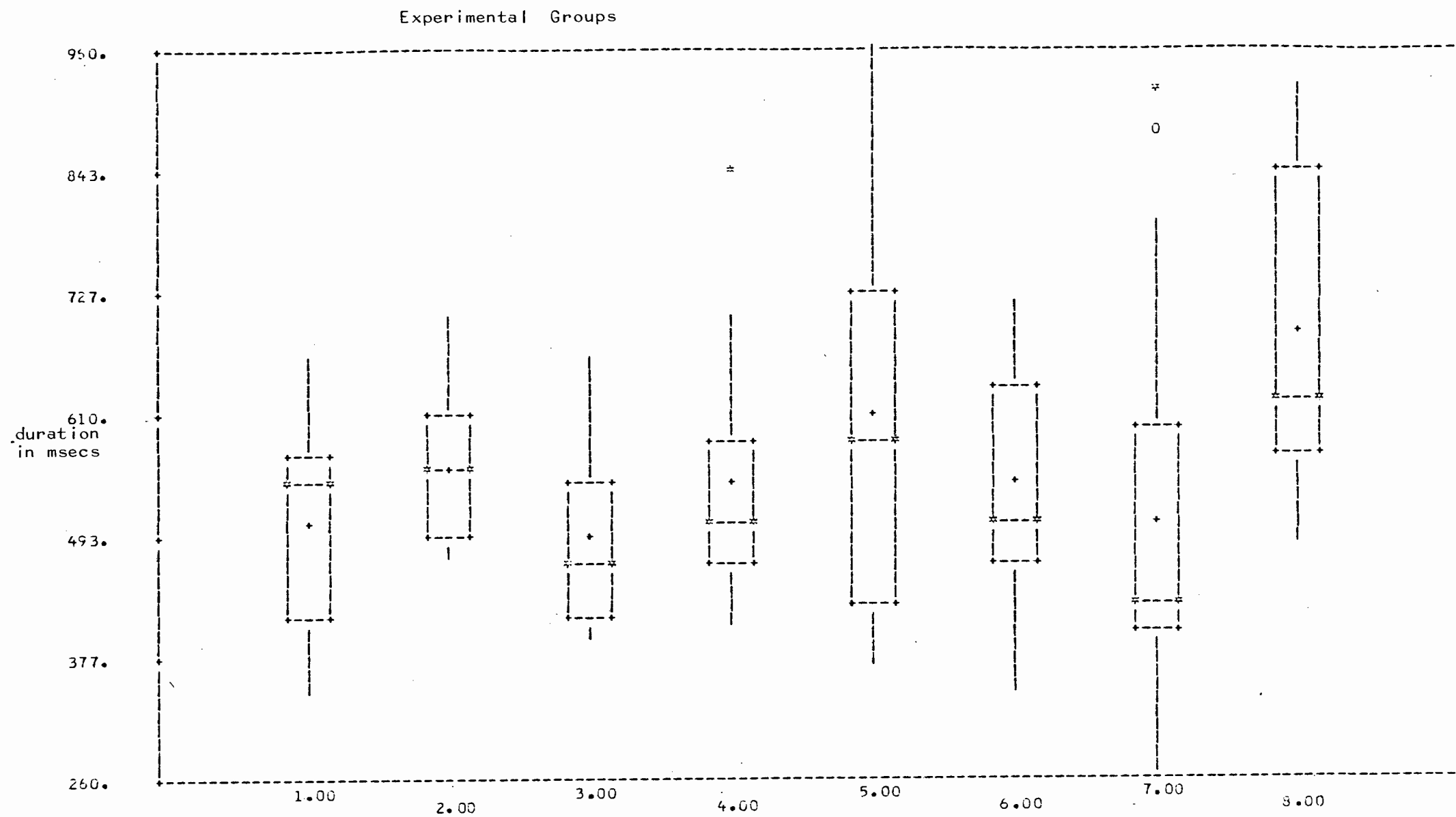


Fig. 29d Multiple box plots showing central tendency and distribution of MM2 for whole syllable duration of /ziz/

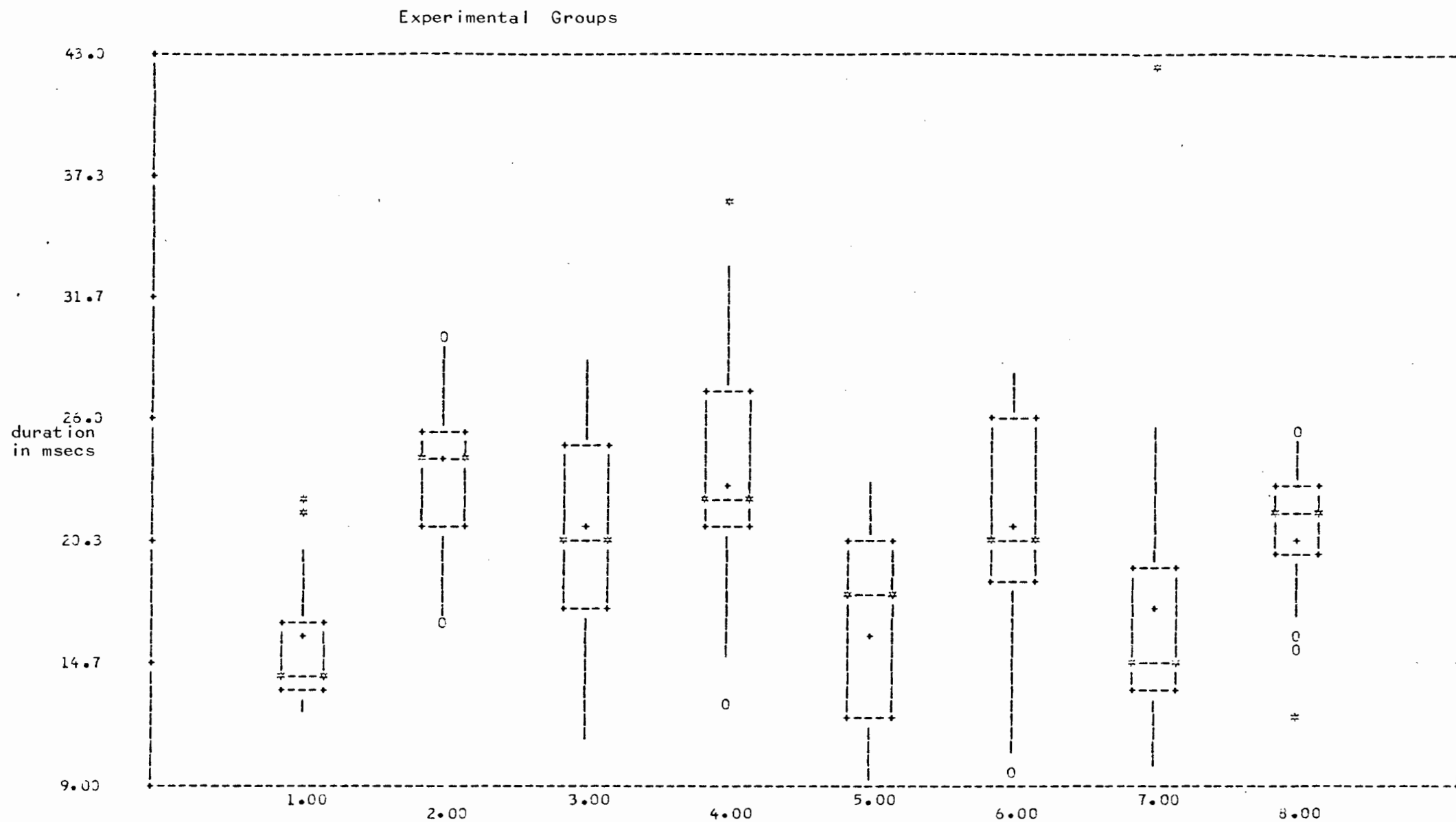


Fig. 30a Multiple box plots illustrating central tendency and distribution of MM2 for % vowel duration of /sas/

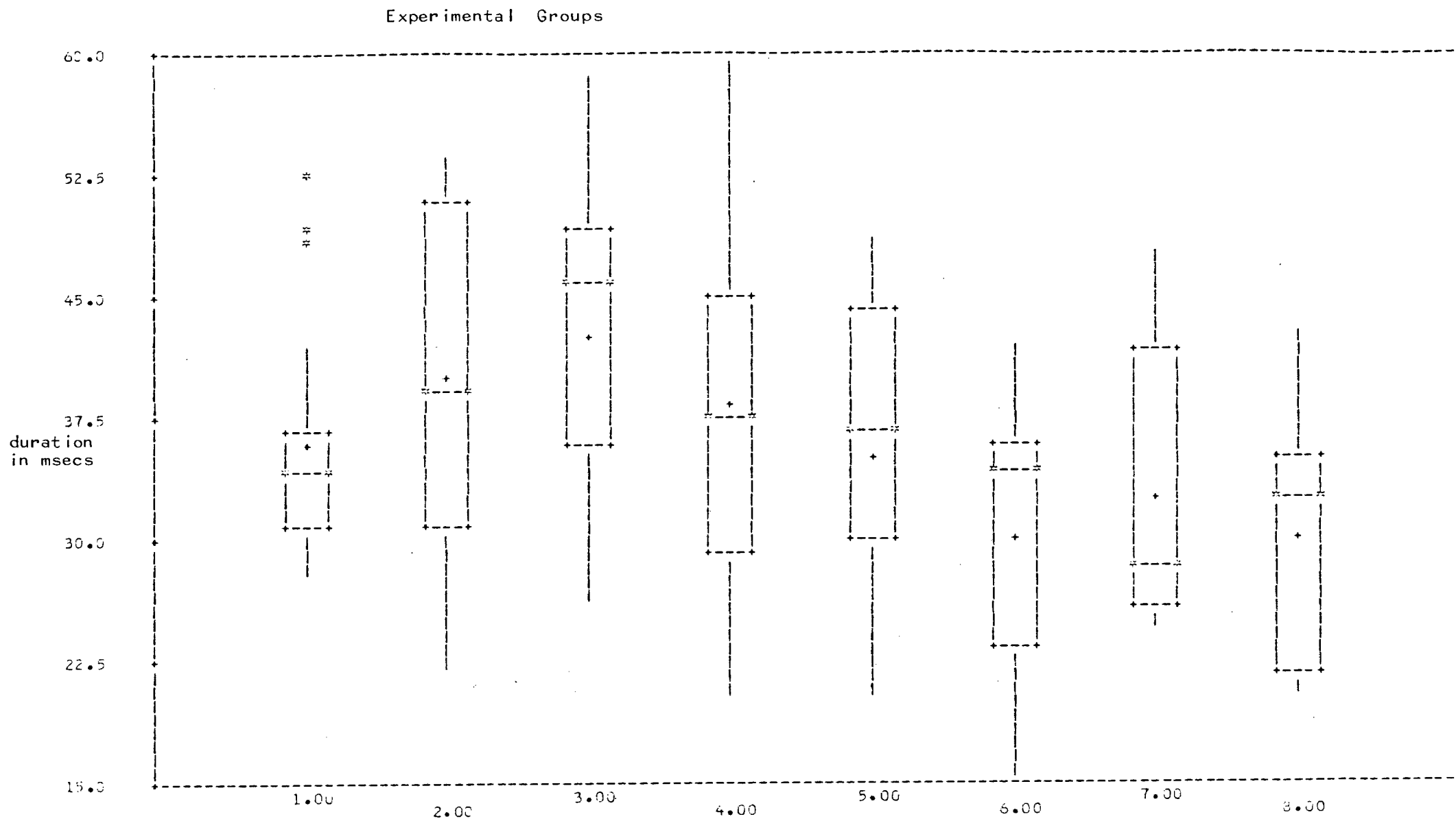


Fig. 30b Multiple box plots illustrating central tendency and distribution of MM2 for % vowel duration of /az/

Experimental Groups

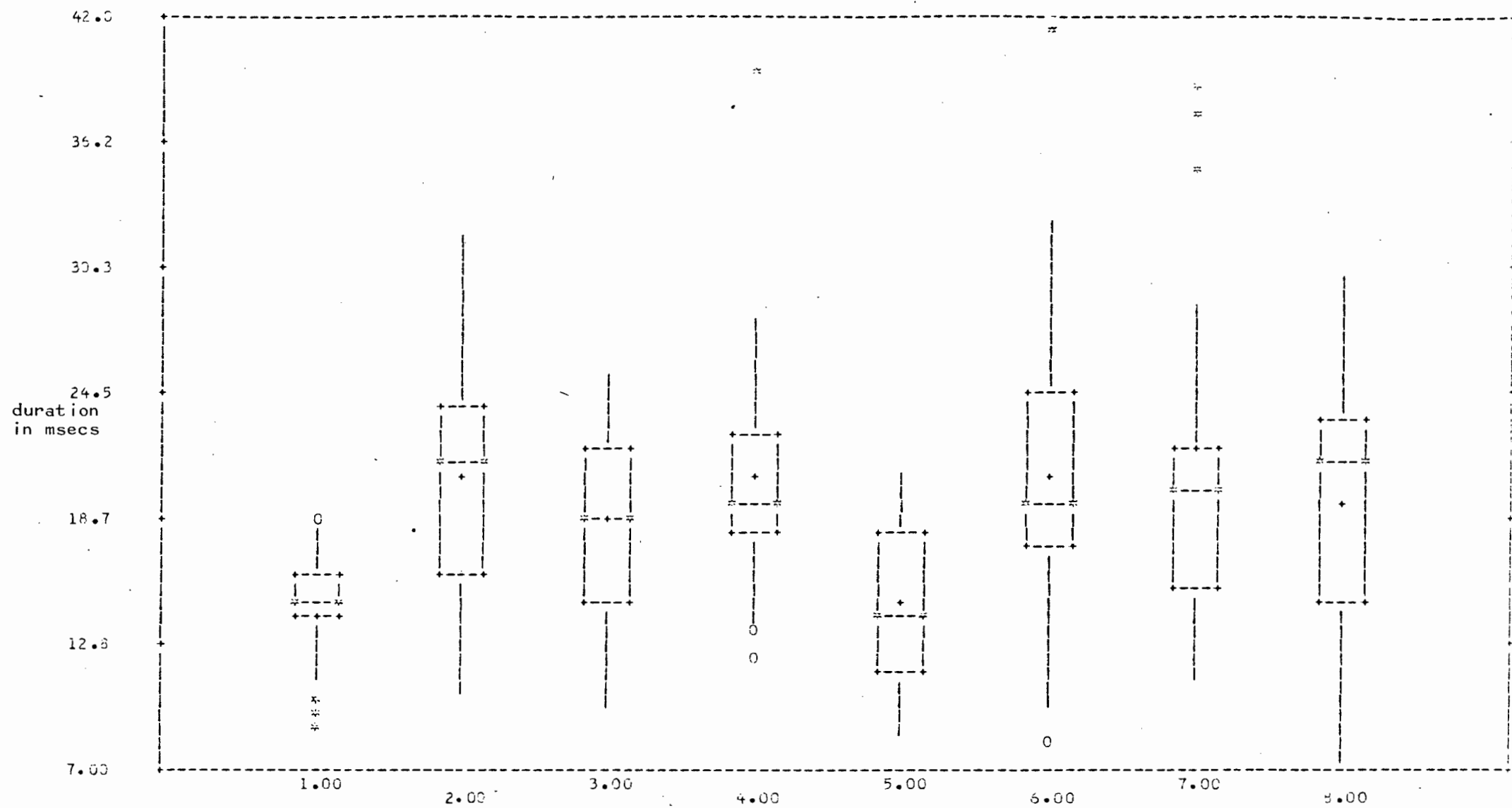


Fig. 30c Multiple box plots illustrating central tendency and distribution of MM2 for % vowel duration of /sis/

Experimental Groups

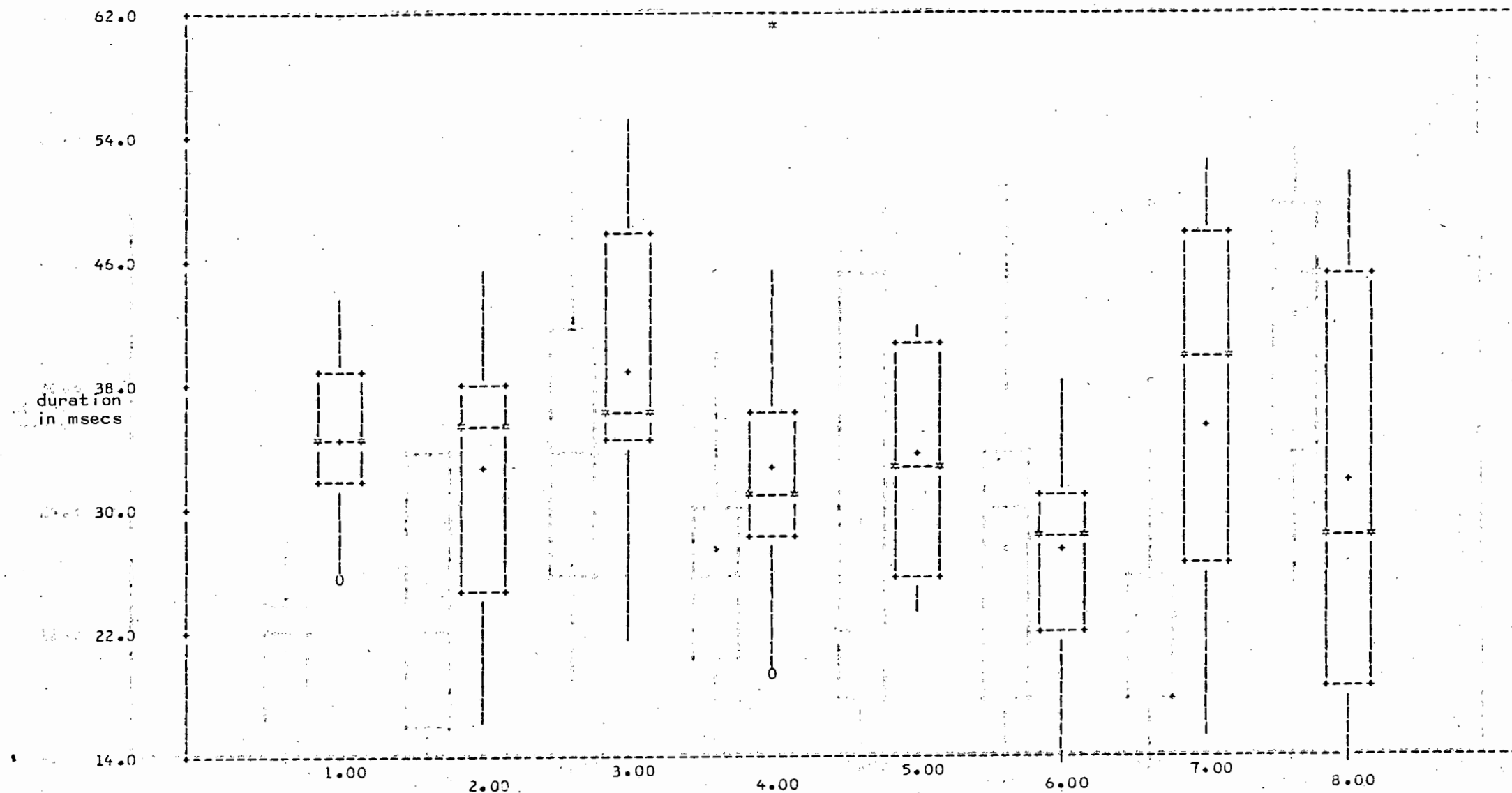


Fig. 30d: Multiple box plots illustrating central tendency and distribution of MM2 for % vowel duration of /iz/

Experimental Groups

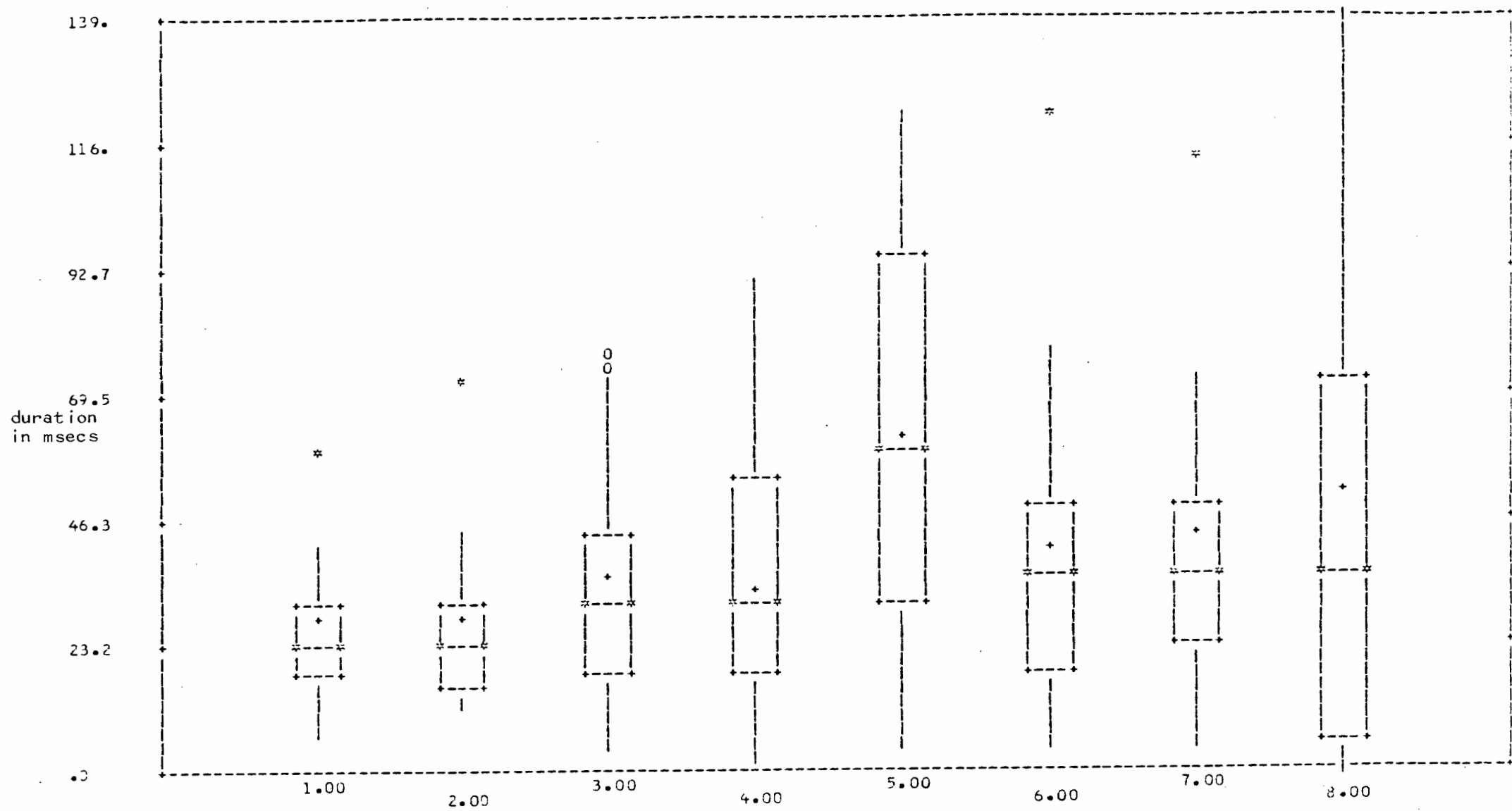


Fig. 31b Multiple box plots showing central tendency and distribution of the range for vowel duration of /bab/

Experimental Groups

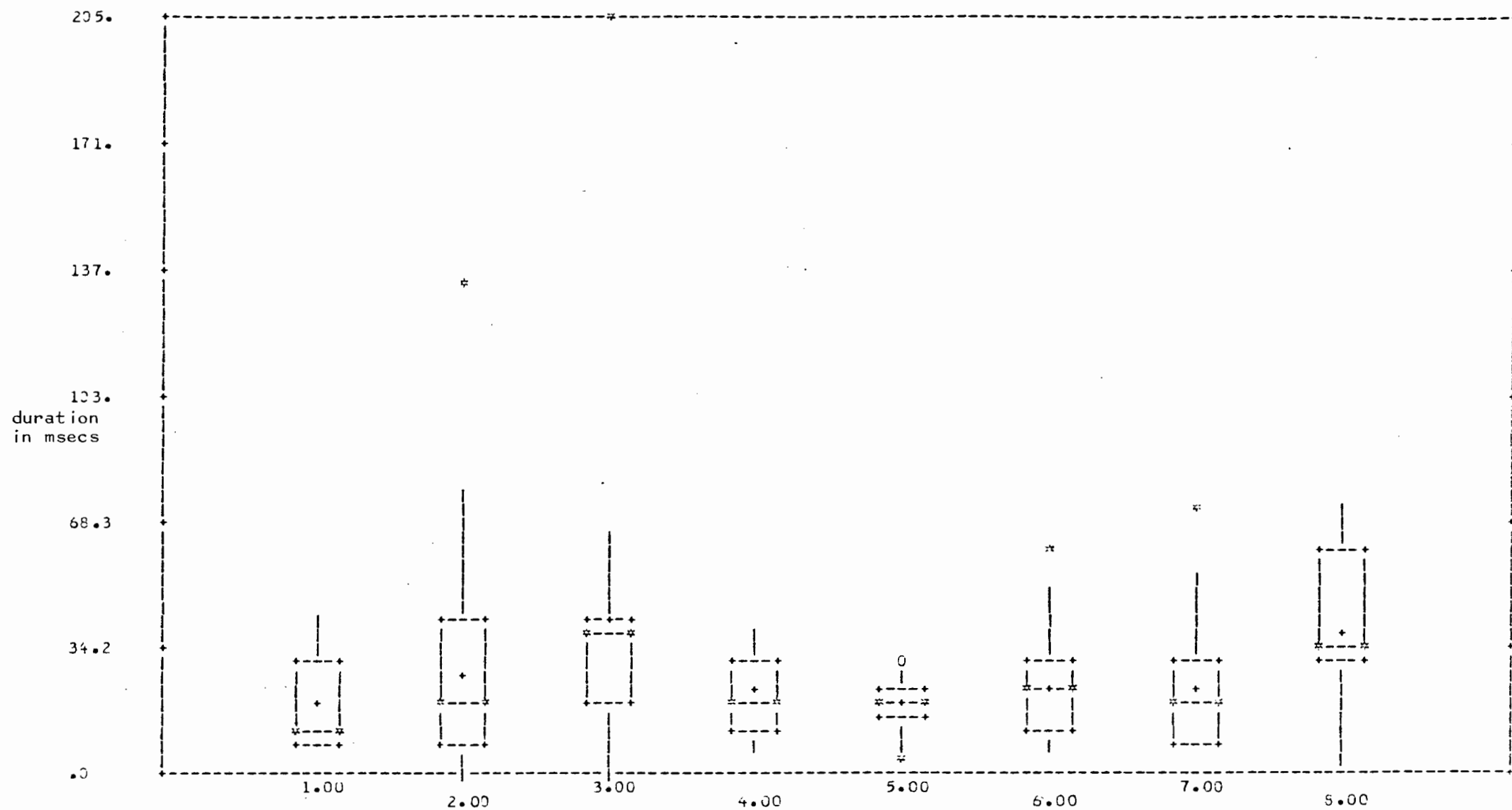


Fig. 31c Multiple box plots showing central tendency and distribution of the range for vowel duration of /pip/

Experimental Groups

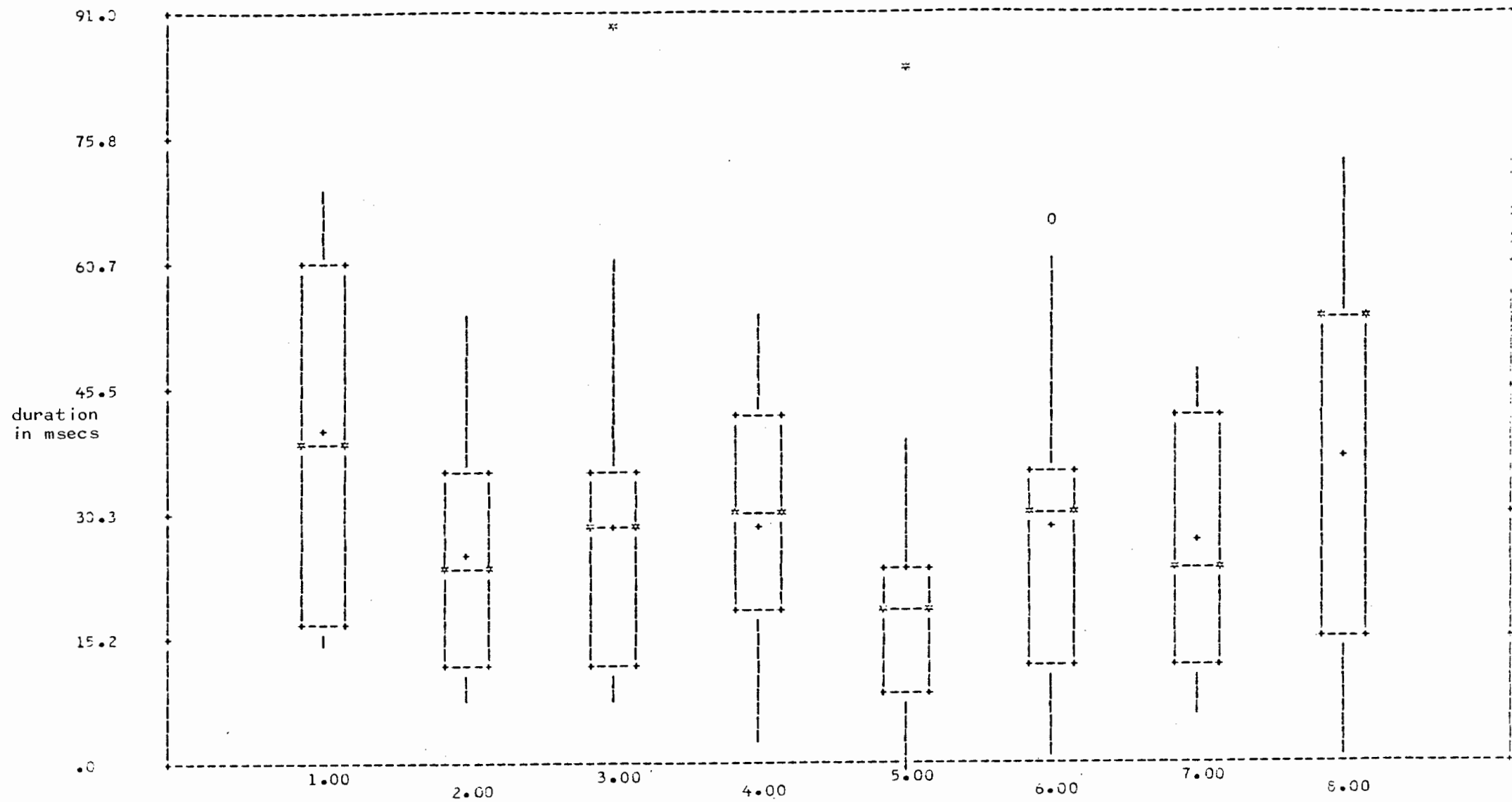


Fig. 31d Multiple box plots showing central tendency and distribution of the range for vowel duration of /bib/

Experimental Groups

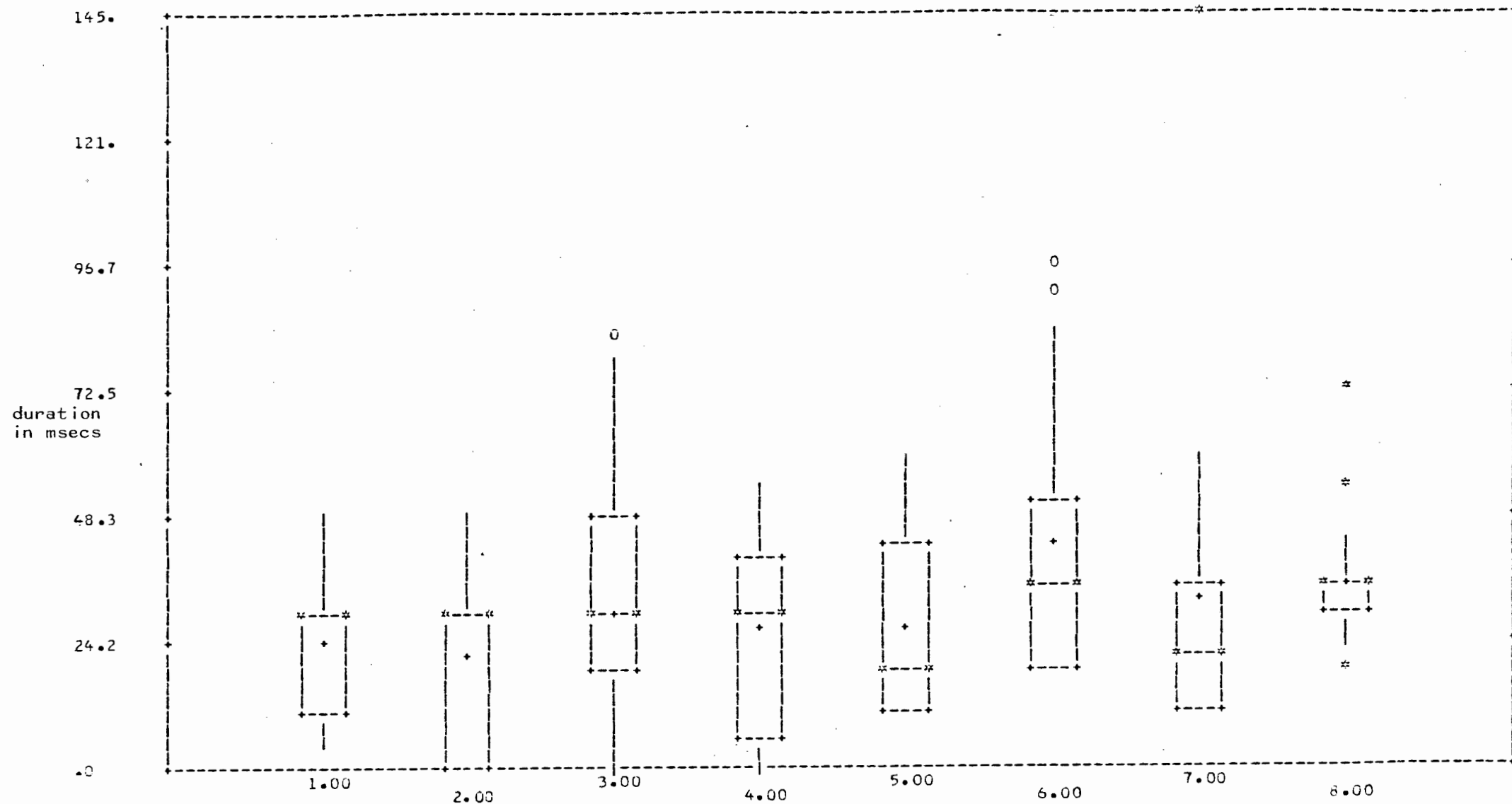


Fig. 31e Multiple box plots showing central tendency and distribution of the range for vowel duration of /sas/

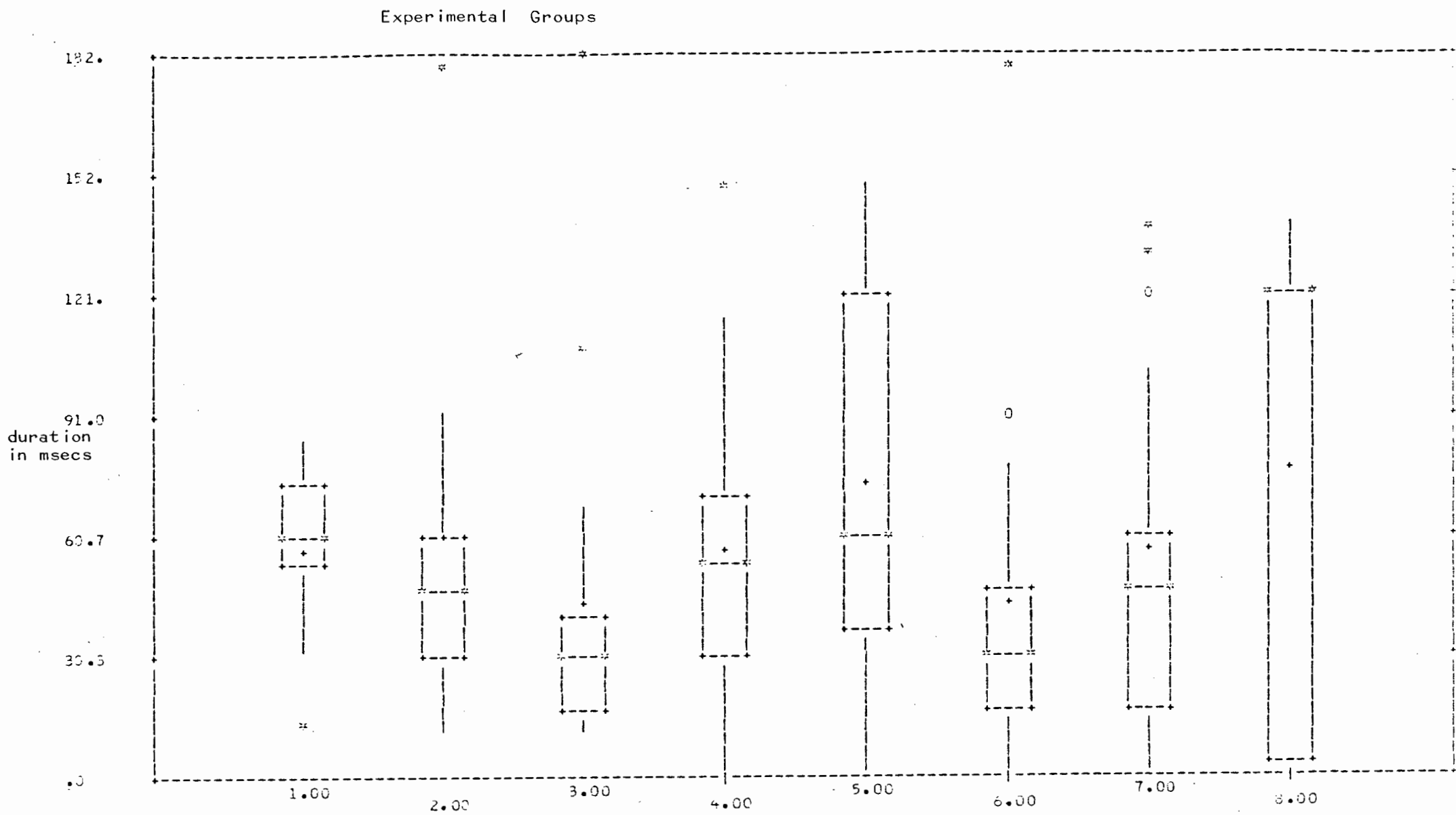


Fig 31f Multiple box plots showing central tendency and distribution of the range for vowel duration of /zaz/

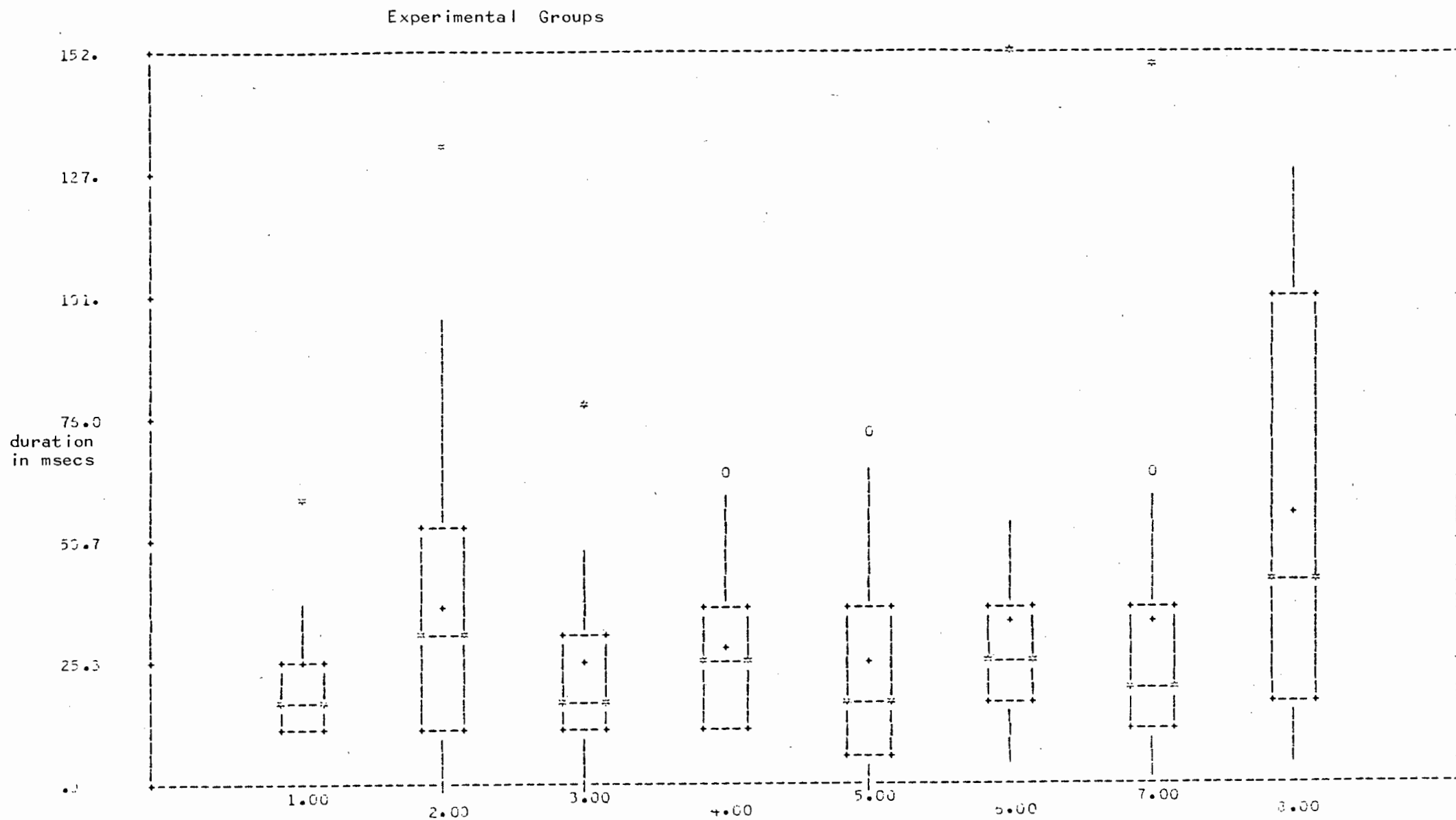


Fig. 31g Multiple box plots showing central tendency and distribution of the range for vowel duration of /sis/

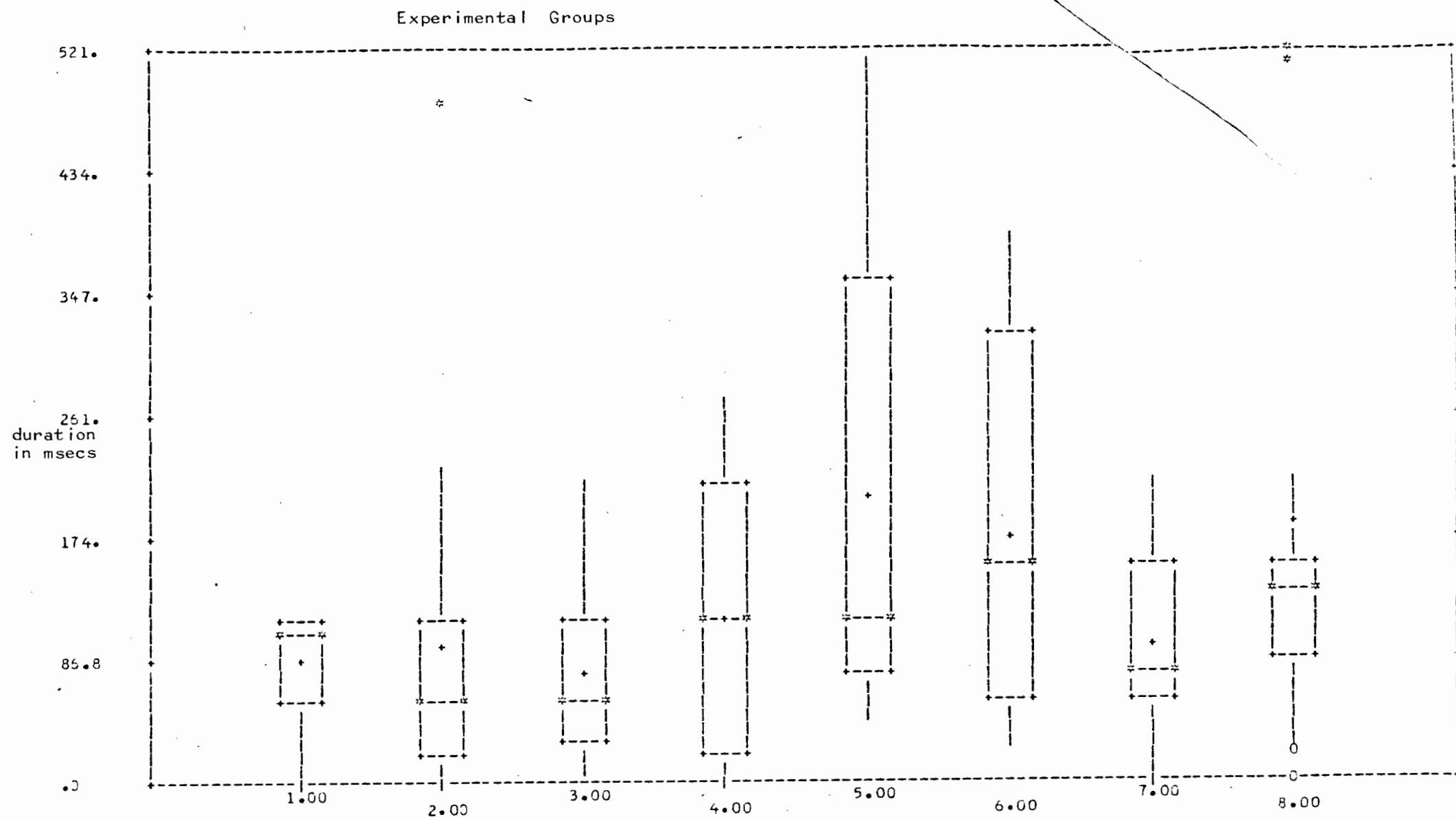


Fig. 32a Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /sas/

Experimental Groups

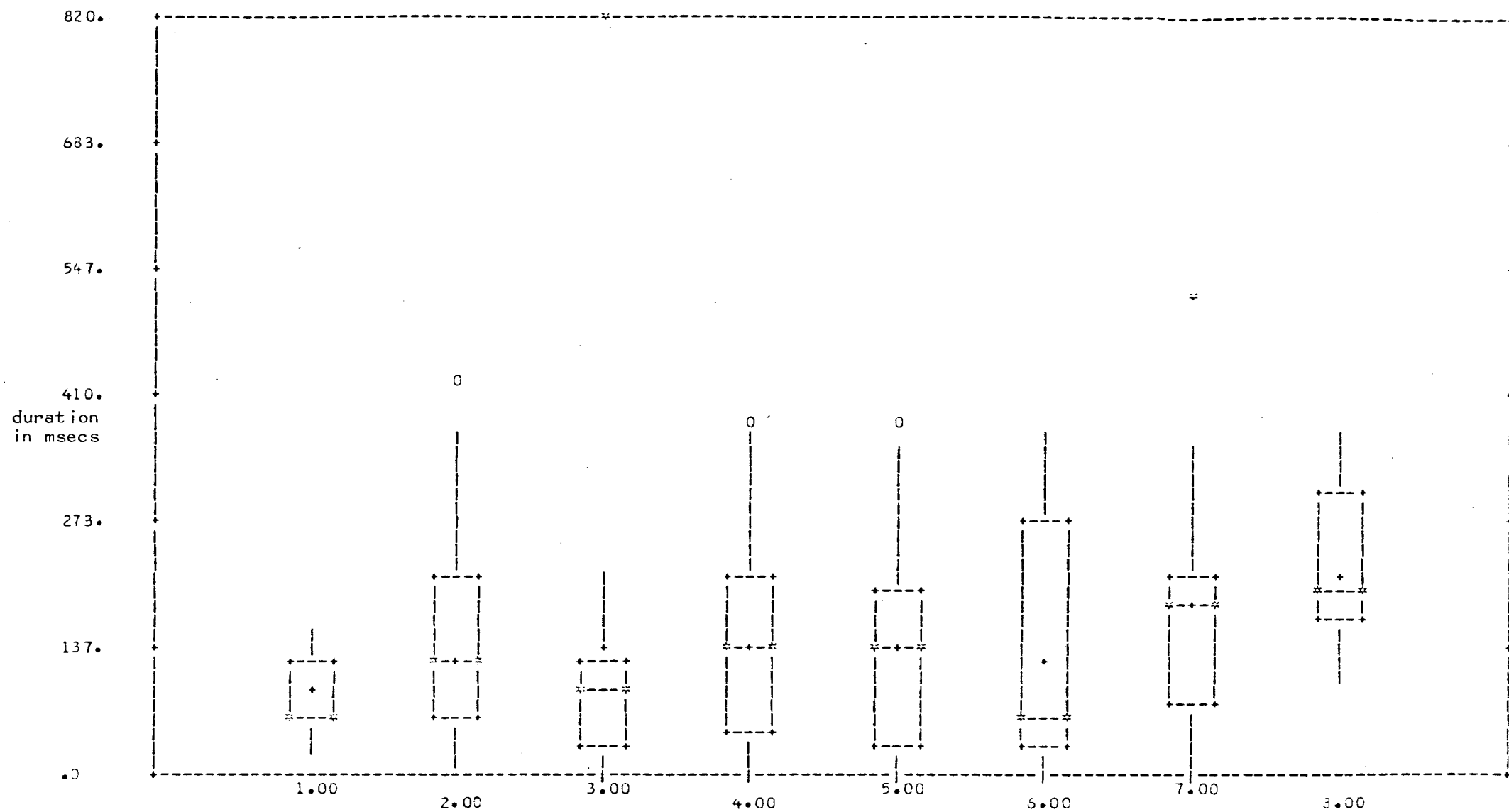


Fig. 32b Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /zaz/

Experimental Groups

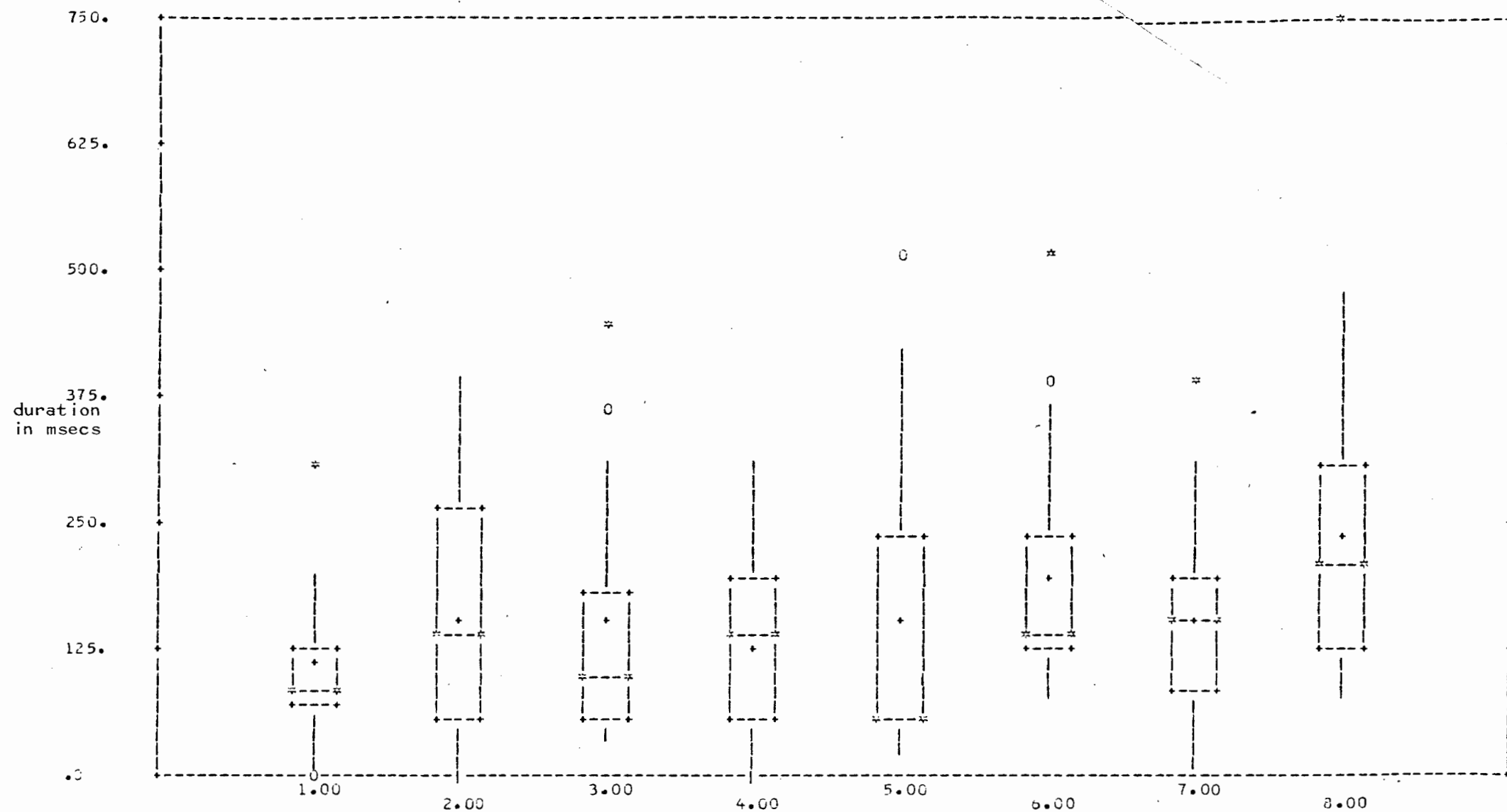


Fig. 32c Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /sis/

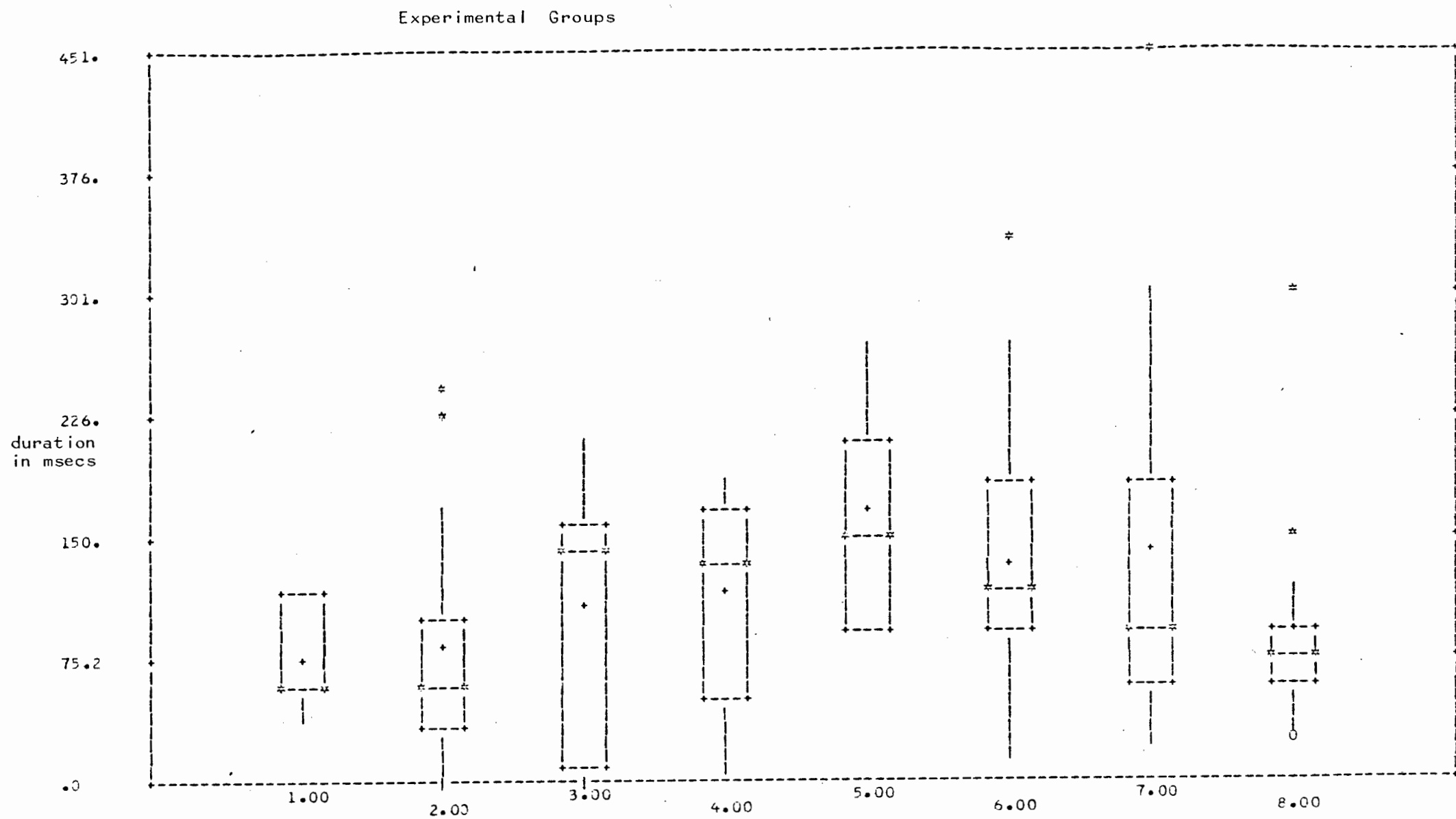


Fig. 32d Multiple box plots showing central tendency and distribution of the range for whole syllable duration of /ziz/

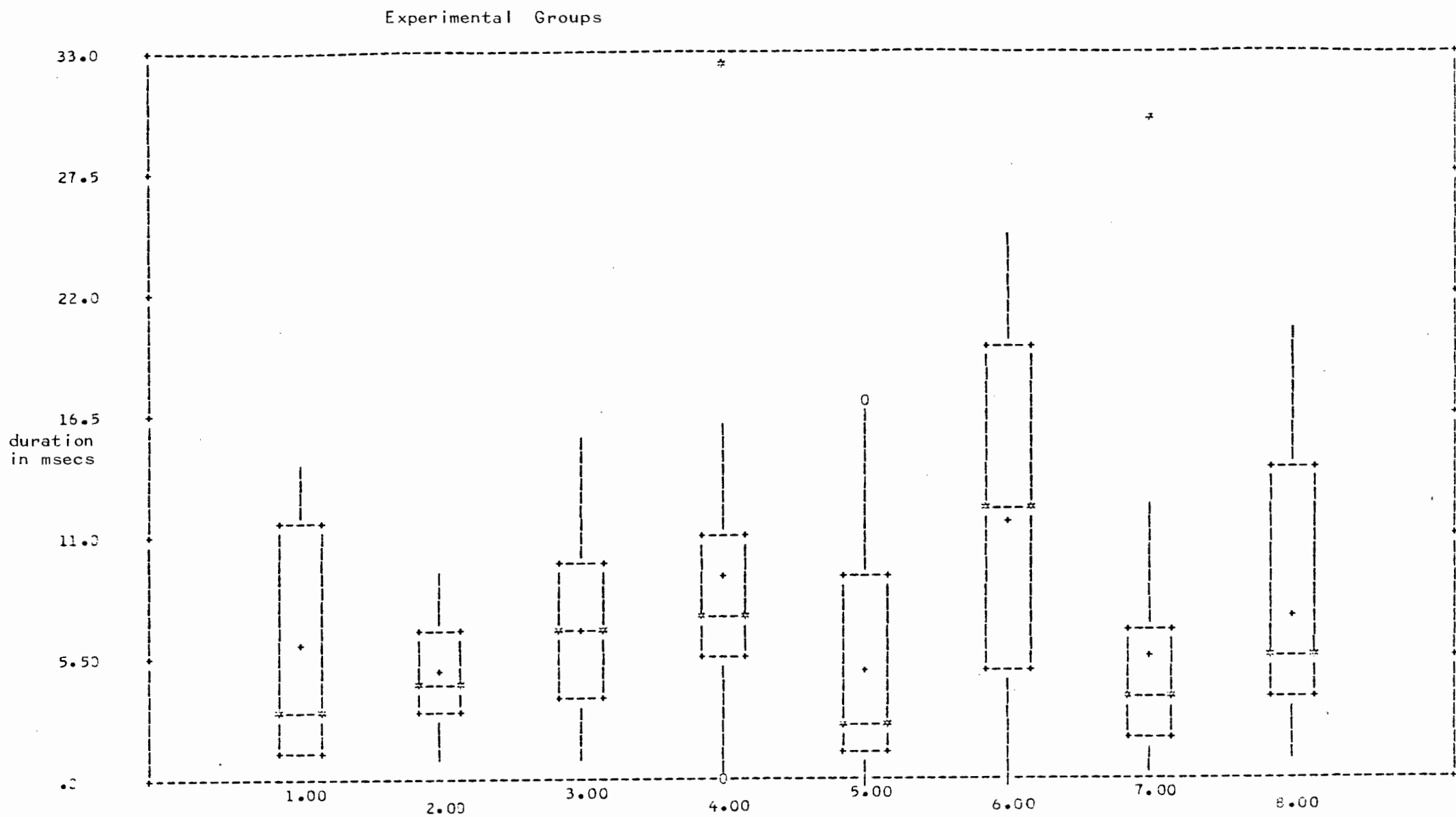


Fig. 33a Multiple box plots showing central tendency and distribution of the range for % vowel duration of /sas/

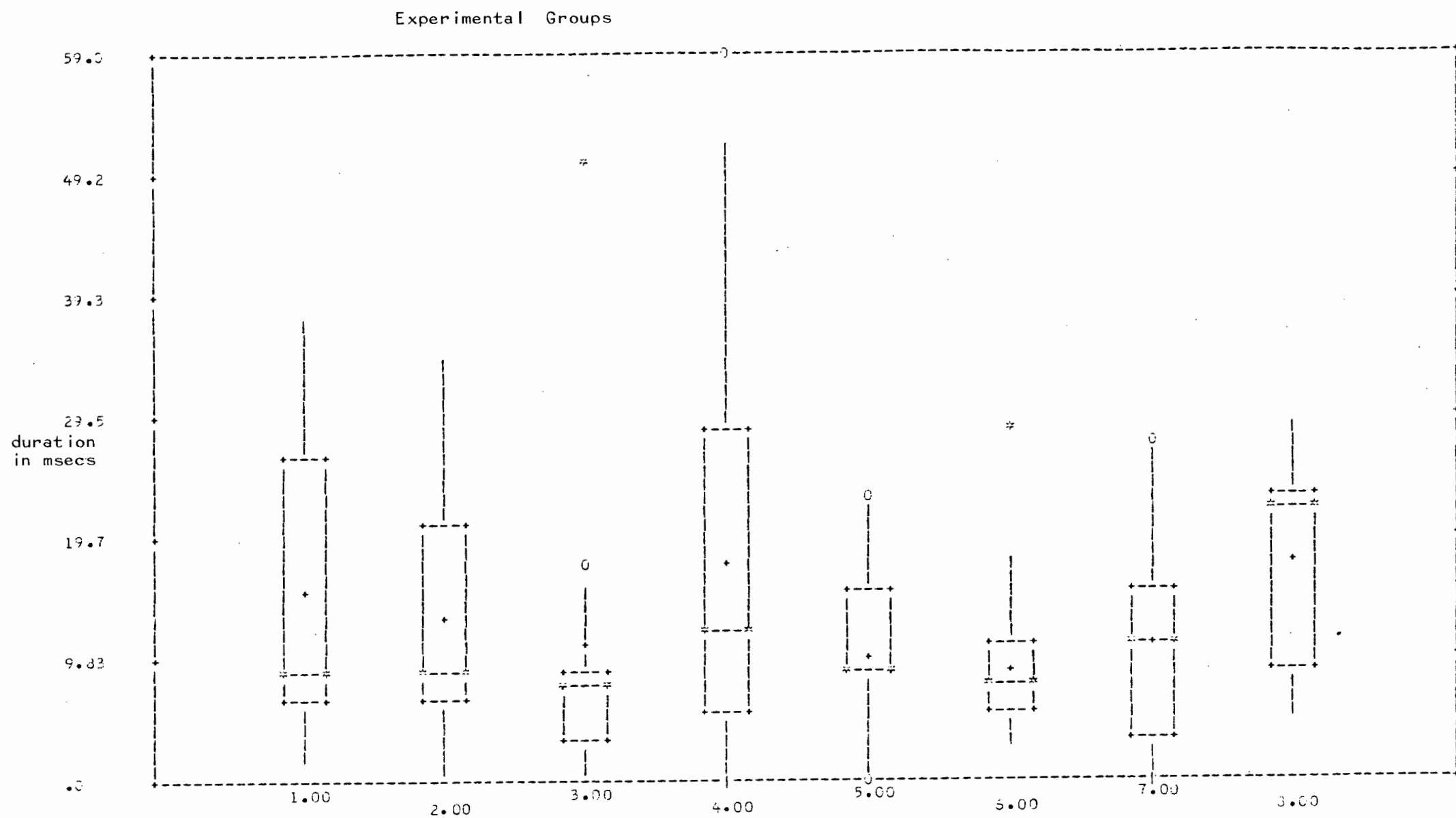


Fig. 33b Multiple box plots showing central tendency and distribution of the range for % vowel duration of /zaz/

Experimental Groups

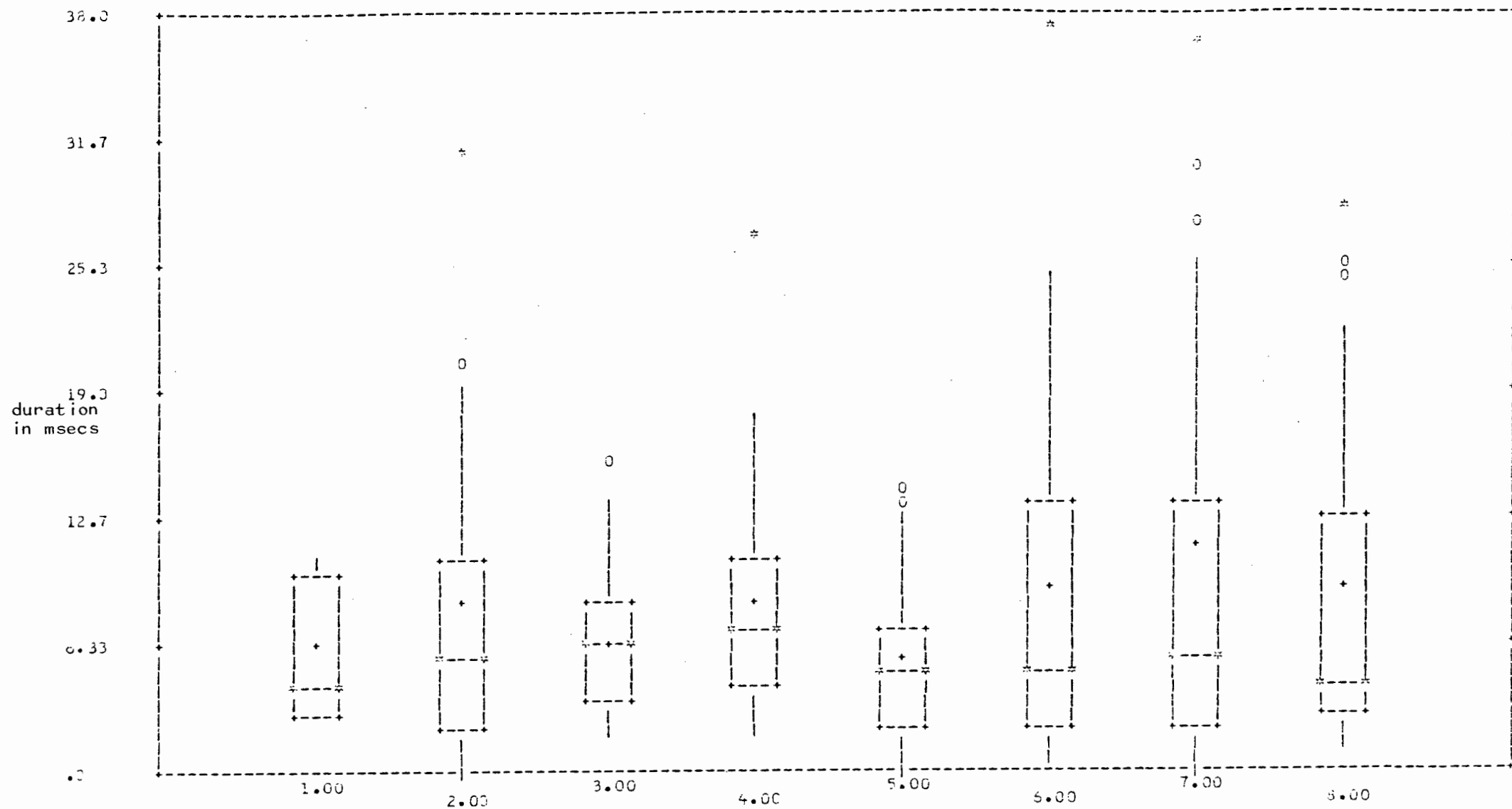


Fig. 33c Multiple box plots showing central tendency and distribution of the range for % vowel duration of /sis/

Experimental Groups

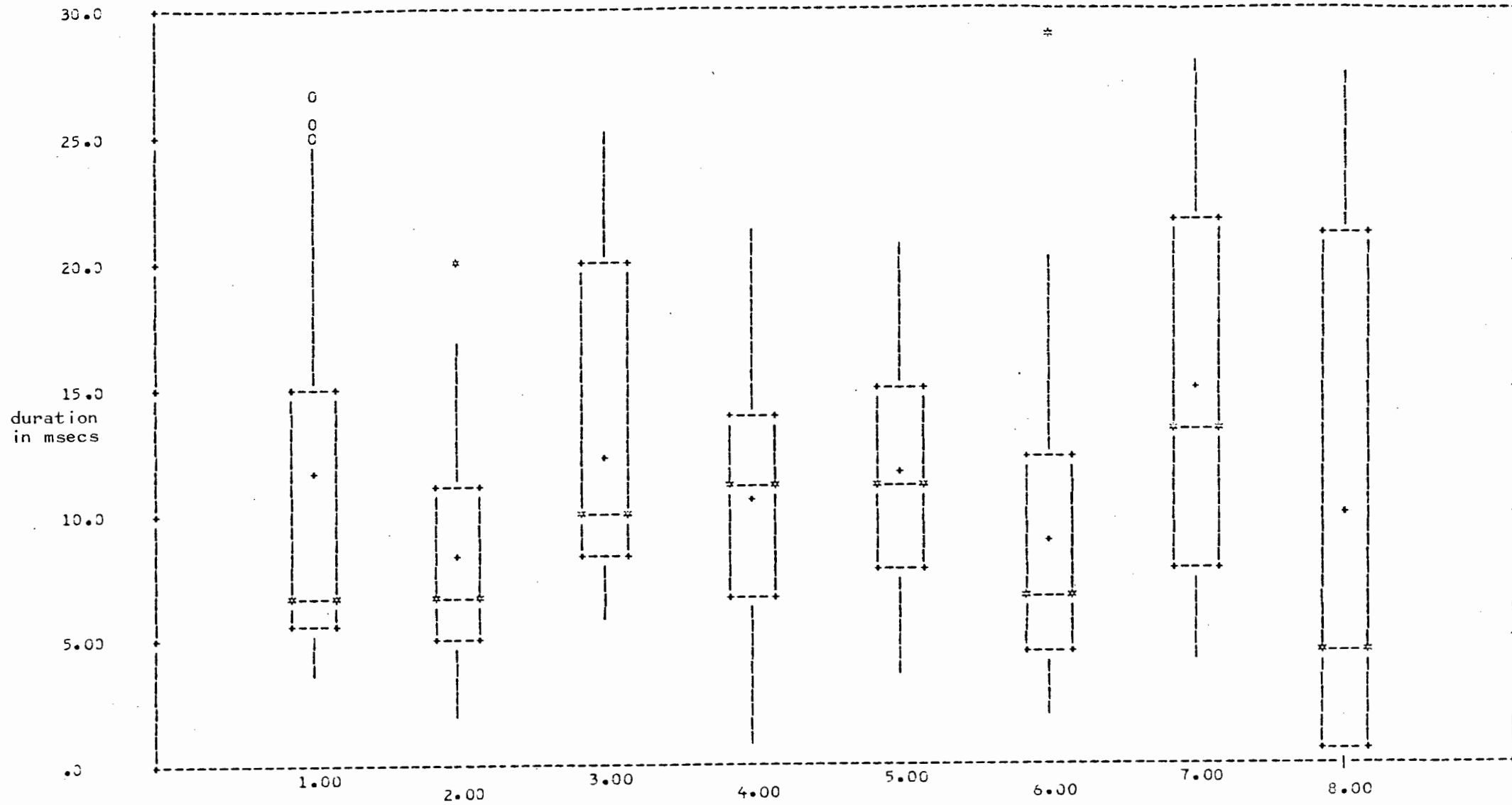


Fig. 33d Multiple box plots showing central tendency and distribution of the range for % vowel duration of /ɛɪz/

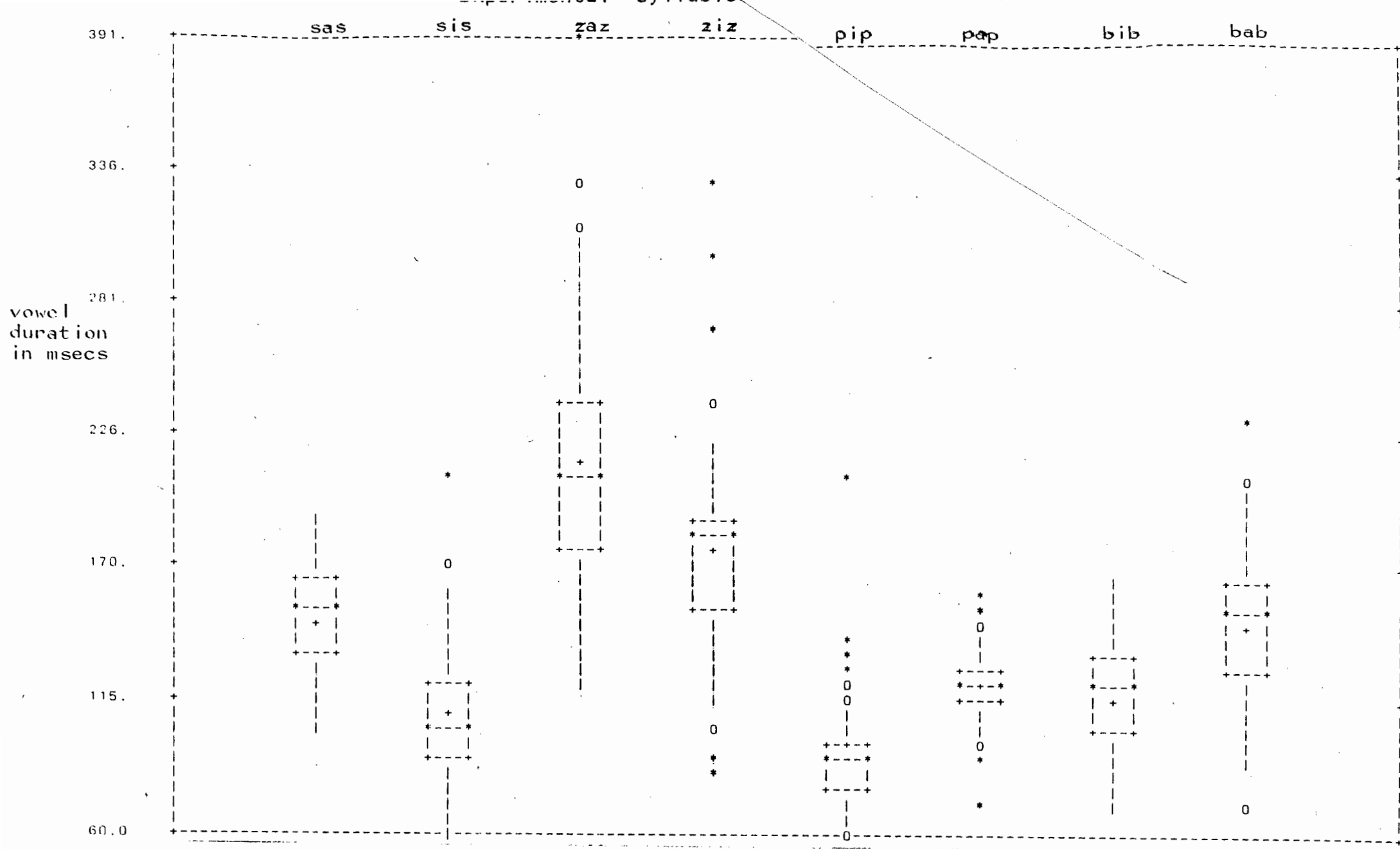


Fig. 34b Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 2.

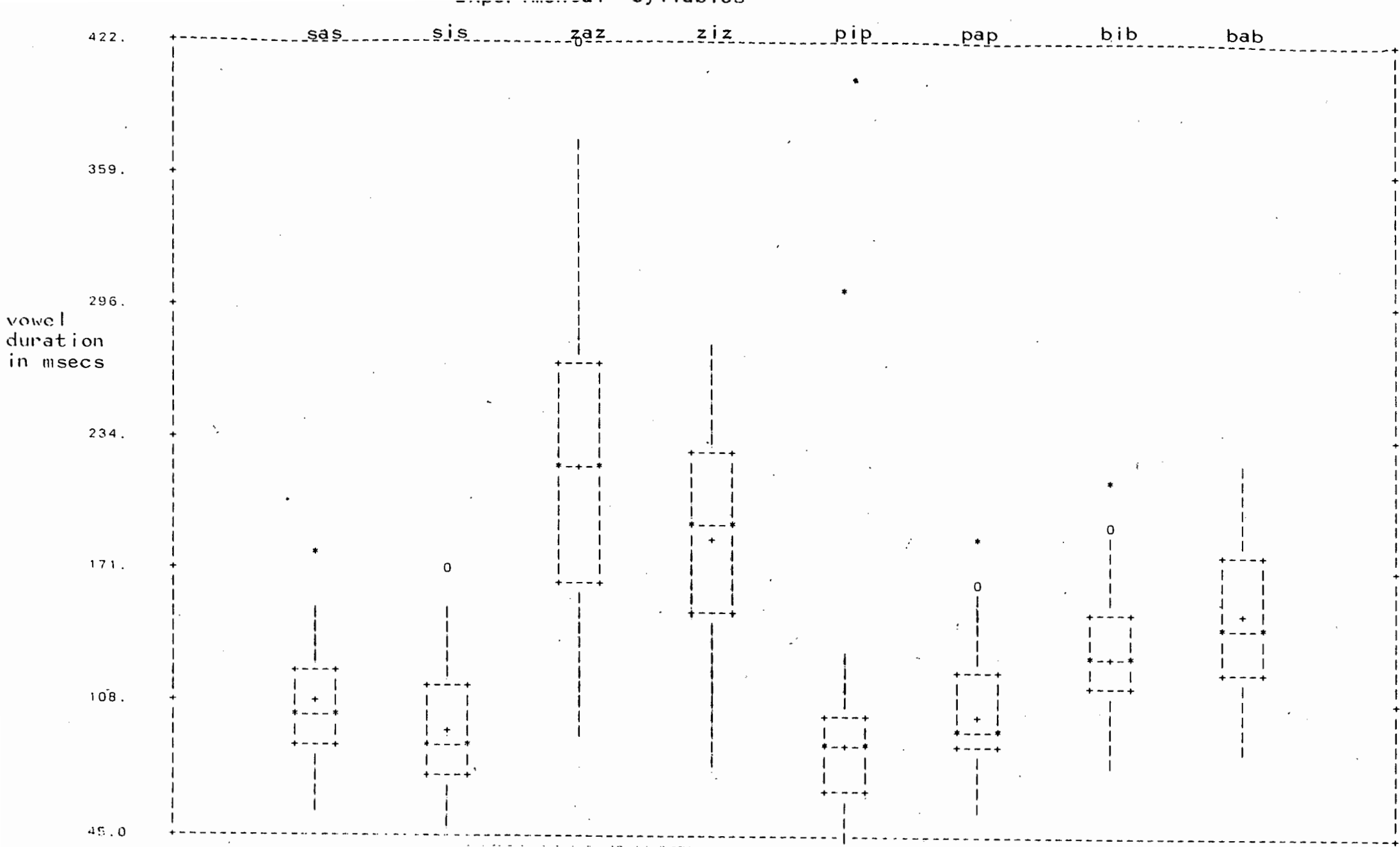


Fig. 34c Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 3.

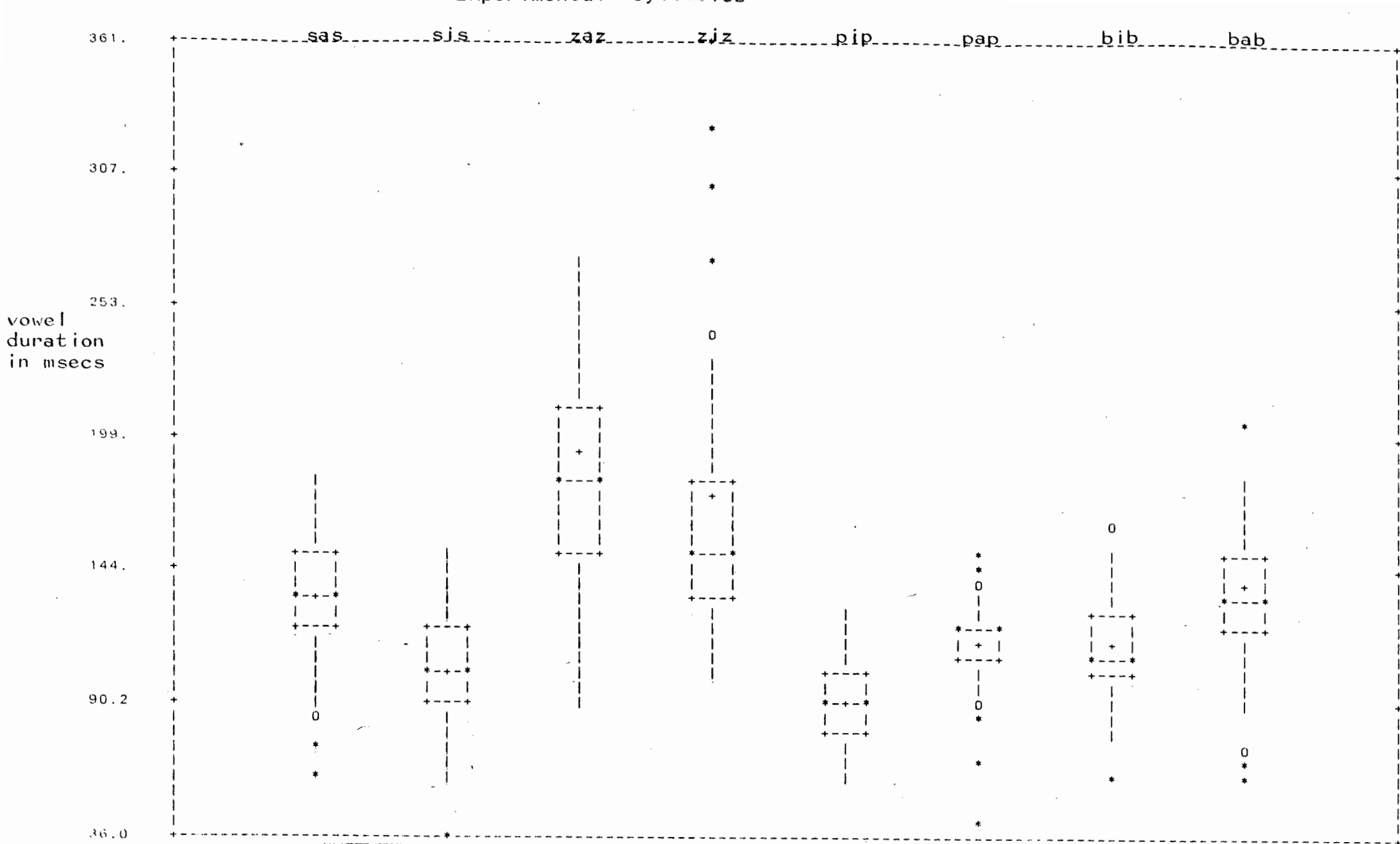


Fig. 34d Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 4.

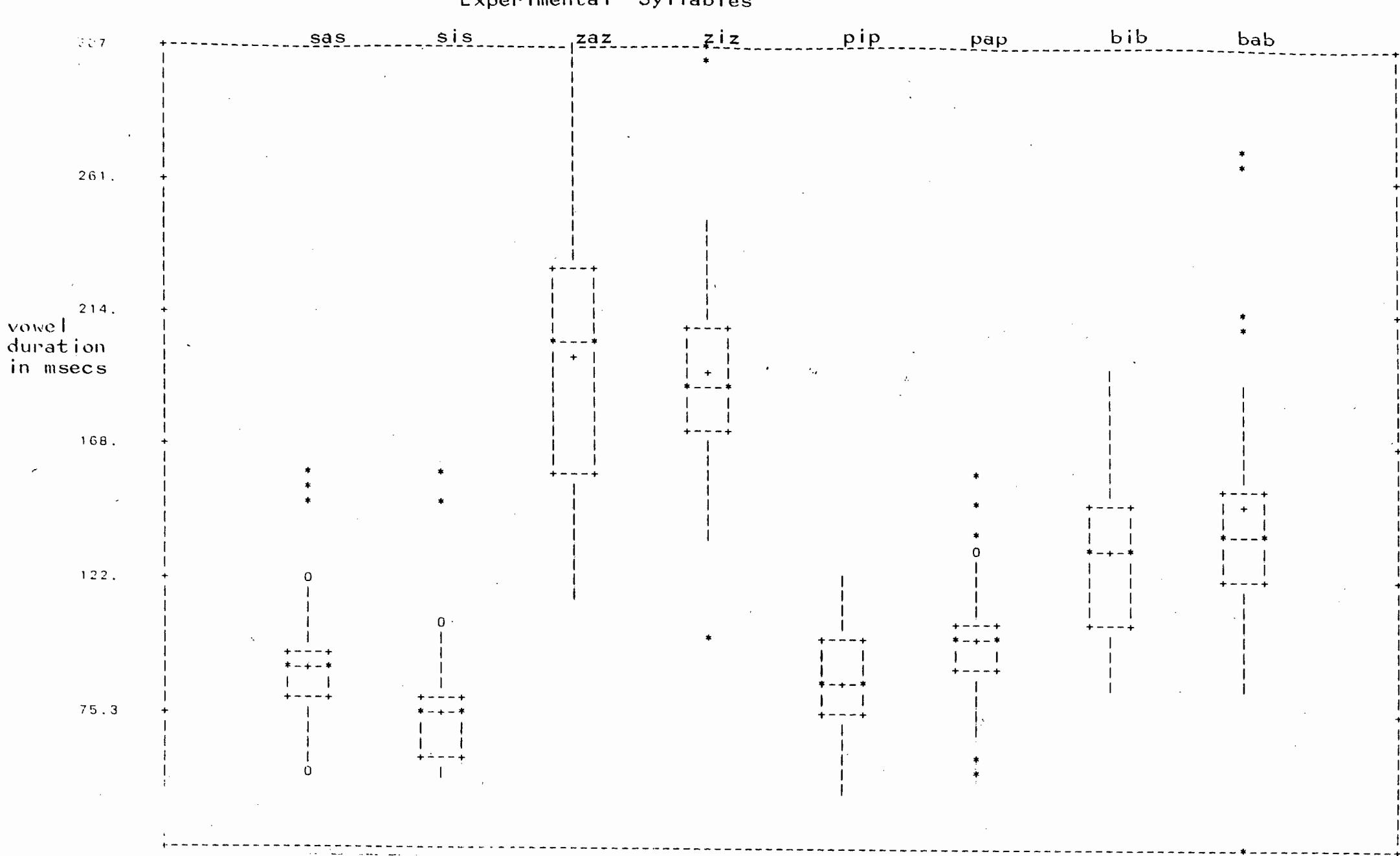


Fig. 34e Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 5.

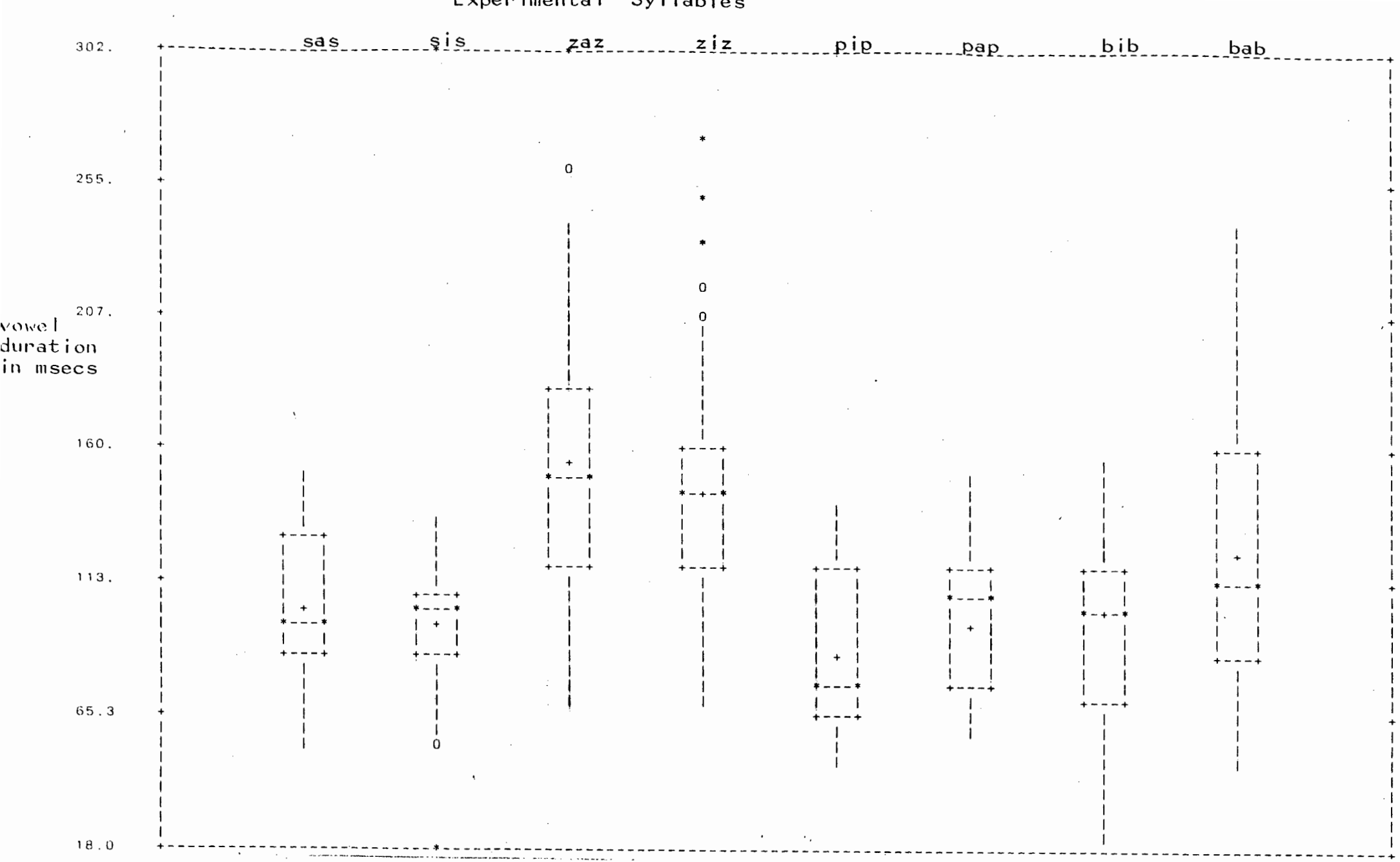


Fig. 34f Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 6.

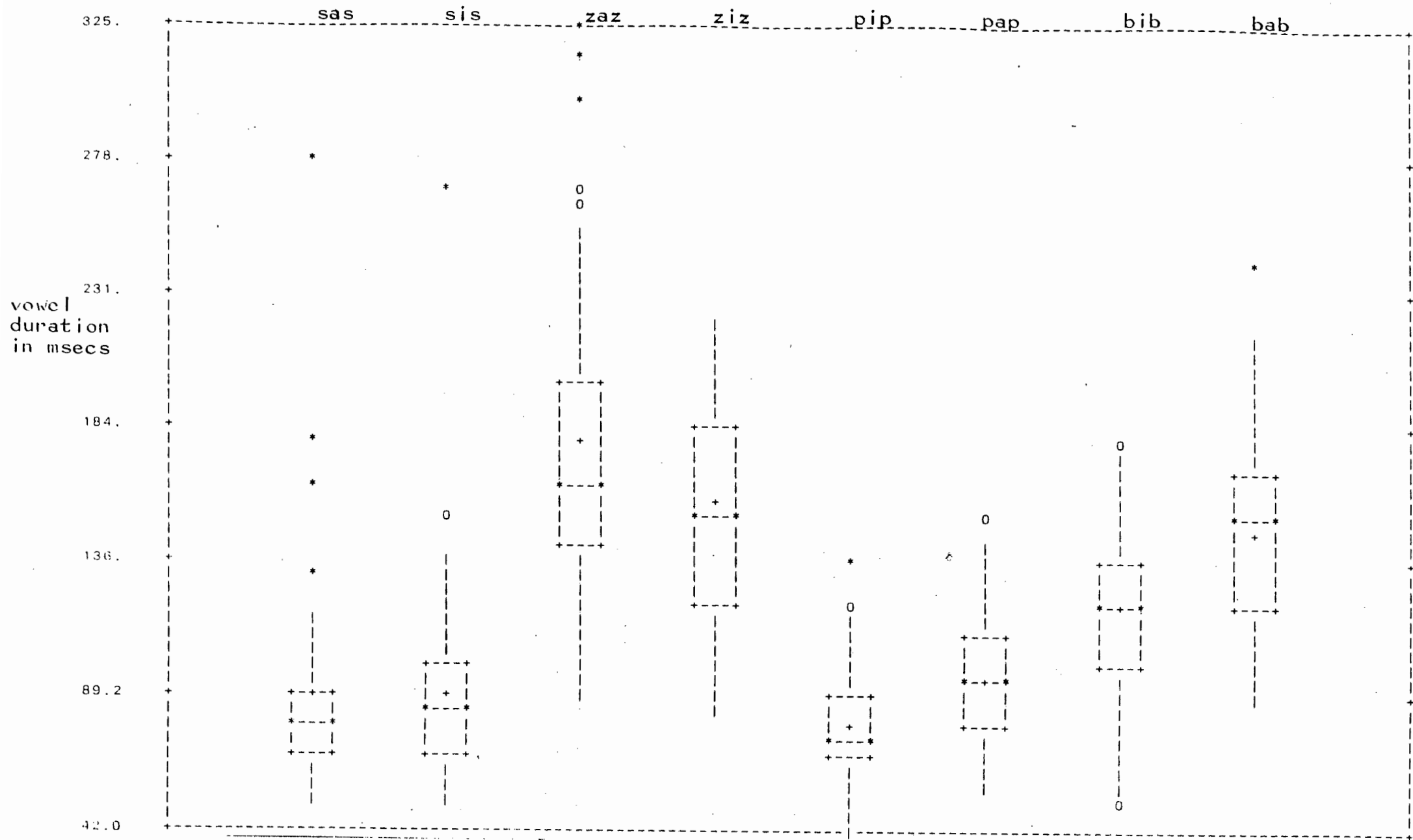


Fig. 34g Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 7.

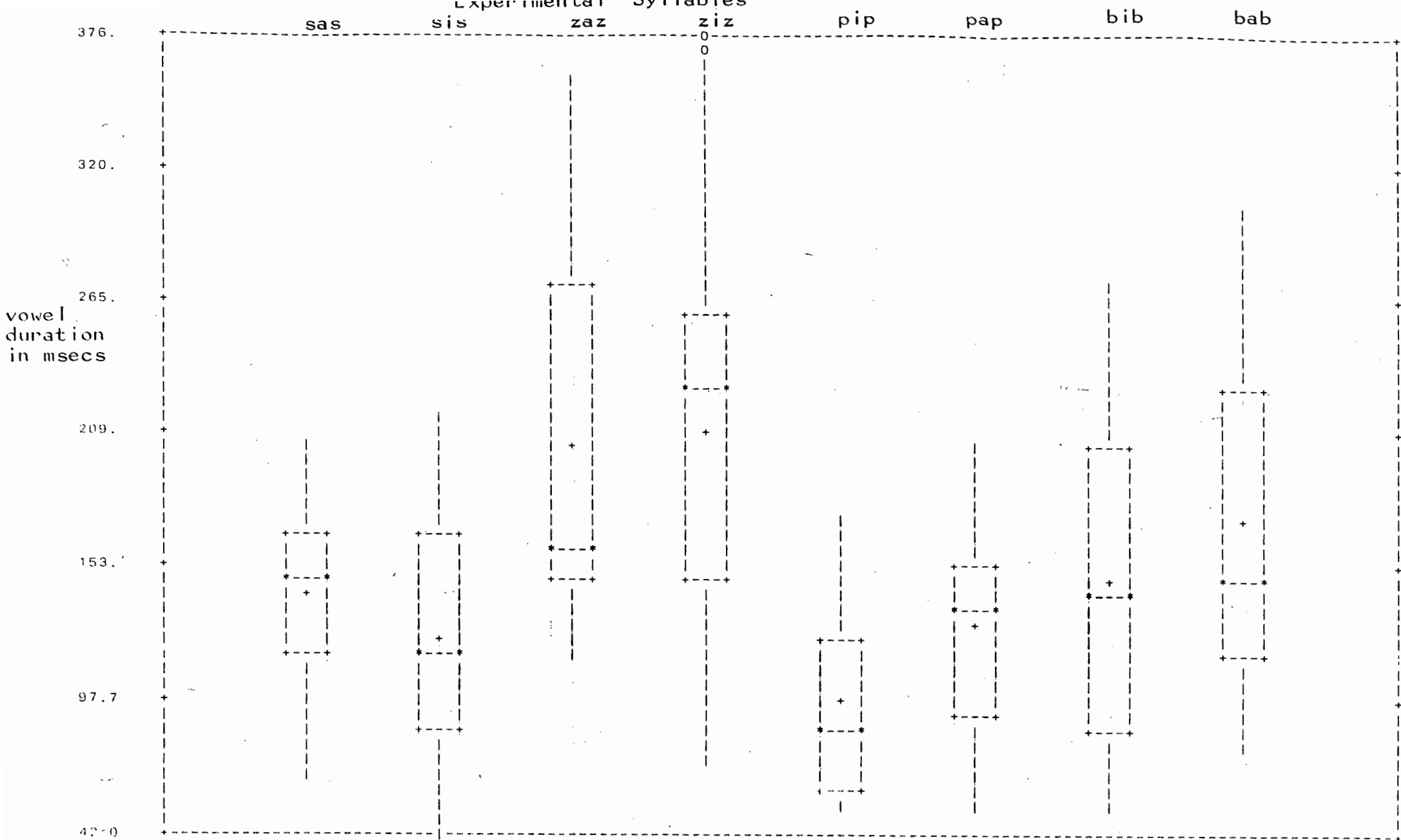


Fig. 34h Multiple box plots showing central tendency and distribution of vowel duration scores in the eight experimental syllables for Group 8.

VIII RESULTS

A Vowel duration

Table XIX shows the mean vowel durations and ranges for the eight CVC syllables in the respective experimental groups. In this case, the ranges were obtained by subtracting minimum from maximum scores.

Examination of the multiple box plots revealed the following information:

1 Cross-language comparisons

a) Central tendency of MM2

No consistent trends differentiated the Afrikaans- and English-speaking nonstutterers of both age levels. Similarly, the performance of older English and Afrikaans stutterers did not differ in any regular way. In the younger stuttering groups, vowel duration was longer in the case of Afrikaans-speakers.

b) No consistent trends were observed differentiating the two language groups in terms of spread of MM2, central tendency of the range or spread of the range.

2 Age-related comparisons

a) Central tendency of MM2

Slight and incomplete trends were observed, viz. older subjects tended to have longer vowel durations in the case of Afrikaans nonstutterers and English stutterers. The reverse was true of English nonstutterers and Afrikaans stutterers.

b) Spread of MM2

The only consistent trend was for a bigger spread in the case of young Afrikaans stutterers compared with older ones.

c) Central tendency of the range and spread of the range

Similarly, the only fairly consistent trend on this measure was for increased scores in the case of younger Afrikaans stutterers compared with older ones.

3 Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

No general trends crossing all groups were observed which might have differentiated stutterers from nonstutterers in terms of vowel duration. However, there was an inconsistent trend towards longer vowel durations in the case of older English stutterers and younger Afrikaans stutterers compared with their nonstuttering controls.

b) Spread of MM2

On the whole, there were no convincing trends separating stutterers from nonstutterers. An incomplete tendency was noted for increased scores in young Afrikaans stutterers.

c) Central tendency of the range

On the whole the groups performed very similarly.

d) Spread of the range

An inconsistent trend was noted toward increased spread in the case of young Afrikaans stutterers.

In summary, no convincing trends separated English- from Afrikaans-speakers, older from younger subjects, or stutterers from nonstutterers. Longer vowel durations were found in only two of the stuttering groups. The young Afrikaans stutterers seemed to be a heterogeneous group, with increased variability of production compared with English-speaking, older and nonstuttering controls. This may simply have been a feature of the particular sample of young Afrikaans stutterers used in this study.

B Whole syllable duration1 Cross-language comparisons

a) Central tendency of MM2

Afrikaans-speakers had longer whole syllable durations than did English-speakers in the older nonstuttering and younger stuttering groups. There were no consistent findings for the remaining groups. Thus, there were no pervasive trends differentiating the language groups.

b) Spread of MM2

In the older stuttering and nonstuttering groups, English-speakers tended to have a bigger spread of MM2 than did Afrikaans-speakers. Younger speakers were not characterized by language-related trends.

c) Central tendency of the range

No consistent trends differentiated the language groups.

d) Spread of the range

There was a trend, although not completely consistent, toward greater spread of the range for older Afrikaans speakers (stutterers as well as nonstutterers) compared with English-speakers. No consistent language-related trends were observed amongst younger speakers.

2 Age-related comparisons

a) Central tendency of MM2

No pervasive age-related trends were found. There was a small trend toward longer whole syllable durations in older Afrikaans nonstutterers compared with younger ones, with a smaller reverse trend in the Afrikaans stuttering groups. There were no consistent trends in the English-speaking groups.

b) Spread of MM2

The spread of MM2 was greater in the case of younger Afrikaans nonstutterers compared with older controls. No other consistent trends were observed.

c) Central tendency of the range

No consistent trends were observed. The groups did not differ much from one another on this measure.

d) Spread of the range

There was a trend toward greater spread of the range in younger English nonstutterers compared with older ones. No other consistent trends were observed.

3 Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

In the English groups and older Afrikaans speakers, nonstutterers tended to have longer whole syllable durations compared with stutterers. A reverse trend characterized young Afrikaans-speakers.

b) Spread of MM2

No consistent trends.

c) Central tendency of the range

No consistent trends.

d) Spread of the range

In the older English groups, stutterers tended to have bigger spread of the range than did nonstutterers. No other consistent trends were noted.

In summary, there were no consistent language-related findings differentiating the groups in terms of whole syllable duration. Except for isolated findings which failed to form a pattern leading to a general statement, English- and Afrikaans-speakers (both nonstutterers and stutterers) performed similarly in terms of whole syllable durations.

Similarly, there were no conclusive trends characterizing the two age levels which might have been interpreted as a developmental pattern. Isolated trends

lead one to tentatively suggest a greater degree of variability amongst younger speakers.

No pervasive trends differentiated stutterers from nonstutterers, although there was a suggestion of longer whole syllable durations in nonstutterers. There was also no evidence that stutterers were more variable in performance than nonstutterers.

C The percentage which vowel duration was of the whole syllable

1 Cross-language comparisons

a) Central tendency of MM2

There was a moderate trend towards longer percentage vowel durations on the part of older Afrikaans nonstutterers compared with English controls. No other consistent trends were noted.

b) Spread of MM2

Similarly, there was a moderate trend toward increased scores in older Afrikaans nonstutterers.

c) Central tendency of the range and spread of the range

No consistent trends were observed differentiating the groups.

2 Age-related findings

a) Central tendency of MM2

On the whole, the groups performed similarly. There was a slight trend toward longer percentage vowel durations in older Afrikaans nonstutterers compared with younger ones.

b) Spread of MM2

Young English nonstutterers tended to have greater spread of MM2 than did older ones. No other consistent trends were observed.

c) Central tendency of the range

Very few differences between the groups were found and those identified did not form a consistent pattern.

d) Spread of the range

Older English nonstutterers tended to have greater spread of the range than did younger ones. No other age-related trends could be identified.

3 Comparisons between stutterers and nonstutterers

a) Central tendency of MM2

There was a slight trend toward longer percentage vowel durations on the part of older English stutterers compared with nonstuttering controls. A slight reverse trend was noted for older Afrikaans-speakers. No consistent trends were found to characterize the younger groups.

b) Spread of MM2 and central tendency of the range

The only consistent trend observed was in the direction of increased scores for older English stutterers, and this may have been a function of their increased percentage durations.

c) Spread of the range

No consistent trends.

The findings on the percentage vowel duration measure largely agreed with those for vowel duration per se, which was to be expected, since whole syllable durations did not vary much between the groups. The percentage vowel duration measure will thus be excluded from further discussion.

D Vowel durations in voiced and voiceless consonant environments

Table XX illustrates group results for mean vowel duration values in voiced and voiceless consonant environments. It can be seen that all subjects showed a tendency to lengthen vowel duration in voiced consonant environments, but in differing degrees. In many instances this effect was greater for sibilants than for stop plosives.

Examination of the multiple box plots (Figs.34a to 34h) yielded the following information:

1 Central tendency

Medial vowel duration tended to be longer in voiced compared with voiceless consonant environments in all groups. This trend was greater for sibilants than for stops.

a) Cross-language comparisons

The trend toward longer vowels in voiced consonant environments and shorter vowels in voiceless ones was greater in the case of English-speakers than Afrikaans-speakers.

b) Age-related trends

Nonstutterers showed consistent, albeit small, age-related trends in that the voicing distinction as reflected in vowel duration was bigger in older than in younger speakers. A similar, but inconsistent, trend was seen in the case of English stutterers but not in Afrikaans ones.

c) Comparison between stutterers and nonstutterers

In the older subjects, nonstutterers showed greater differential vowel durations than did stutterers. A similar trend separated young English stutterers and nonstutterers, although it was more clearcut in the sibilant environments. No such trends differentiated young Afrikaans stutterers and nonstutterers.

2 Spread

There was an incomplete trend toward greater variability of vowel duration in voiced compared with voiceless consonant environments. This trend was more marked in sibilant than in plosive environments and probably reflected the longer durations involved. Amongst Afrikaans-speakers, bigger spread indicated greater variability of production in younger subjects. No age-related trends were apparent in the English groups. No other clear differences could be established between the groups.

E The influence of the manner-of-articulation of the consonant environment on medial vowel duration

Examination of the multiple box plots (Figs.34a to 34h) revealed a consistent trend in all groups toward longer vowel durations in voiced sibilant compared with voiced stop plosive environments. No consistent manner-of-articulation trend was observed for voiceless consonant environments.

When voiced consonant environments alone were taken into consideration, it became apparent that the manner-of-articulation effect of the consonant on vowel duration was greater in older subjects than in younger ones. In the older groups, the manner-of-articulation effect was longer for English-speakers, while no cross-language trends were apparent in the younger groups. It seemed, then, that vowel durational differentiation between voiced and voiceless environments increased with age and that English-speakers showed a greater degree of this phenomenon than did Afrikaans speakers.

No consistent trends could be found differentiating stutterers from nonstutterers in terms of the influence on vowel duration of manner-of-articulation of the consonant environment.

IX DISCUSSION

A Vowel duration

Relative, not absolute, durations of vowels and consonants are what is important in temporal compensation within syllables (Fliflet cited by Lehiste 1973). However, since the whole syllable durations did not differ between the groups in the present study it is valid to compare them in terms of vowel duration per se.

The lack of age-related trends is surprising in view of Kent's (1976) conclusion that segment duration decreases with age, but it confirms the finding in this regard in the previous experiment. Despite the fact that age-related trends were identified with respect of the influence of the

consonant environment, perhaps the younger and older subjects were too close in age to demonstrate developmental decrease in segment duration.

The results of this experiment do not support the idea that stutterers have longer vowel durations than do nonstutterers. Prosek and Runyan's (1982) finding that adult stutterers had longer vowel durations than nonstutterers might reflect secondary development of stuttering or, more likely, a learned technique for fluency enhancement, most of their subjects having completed a period of therapy and the rest still undergoing treatment. Increased phonation time, such as occurs during prolonged speech and singing, correlates with a decrease in stuttering frequency (Colcord and Adams 1979; Andrews et al 1982). DiSimoni (1974c) similarly found that, in the case of American English adult stutterers, their mean duration of medial vowels was considerably longer than those reported in the literature for nonstutterers. The present findings suggest that DiSimoni's results might reflect secondary development in the speech of his stuttering subjects. However, interpretation of his results is complicated by his failure to report on whole syllable durations so that it is not known whether his groups's articulation rates were comparable with the normative data. Nor did he mention whether or not the groups shared the same regional accents, which might have influenced the duration of subsegments.

Variability of production of vowel duration did not consistently differentiate the stutterers from the nonstutterers in the present study. The stutterers thus behaved differently to developmentally dysphasic children, who are reported to lack precise control over vowel duration compared to normals (Stark and Tallal 1979). Variability of production has also been reported to be greater for nonaphasic language disordered children than for normal controls (Bord and Wilson 1980).

B Whole syllable duration

Prosek and Runyan's adult stutterers used overall slower speech rates than did controls. This contrasts with the present study, in which whole syllable duration measures did not differ between stutterers and nonstutterers and suggests once again that Prosek and Runyan's findings may reflect secondary development of stuttering or a deliberate strategy to enhance fluency. At any rate there was no indication that the child stutterers in the present study were using slower articulation rates than were nonstutterers, either as a result of a sluggish speech mechanism or a voluntary tactic.

Starkweather and Myers (1979) found that duration of steady state segments did not differ between stutterers and nonstutterers whereas transitions were slower in stutterers. It is unlikely that their findings regarding transitions extend to those inherent in the CVC syllables produced by child stutterers. In the present study neither whole syllable nor vowel durations differentiated stutterers from nonstutterers. Had transition time been increased, one would have expected either an increase in whole syllable duration or, if that remained stable, a compensatory shortening of the steady state segments.

The present study contrasts further with adult data on CVC syllable production from a study by Zimmermann (1980). Using measurements taken from cinefluorographic recordings, Zimmermann found that stutterers exhibited

longer durations than did nonstutterers on temporal measures of transition, steady state duration, total syllable duration and duration between movement onset and voice onset. Zimmermann later (1980b; 1980c) proposed that by slowing movement velocity and reducing range of movement, his stuttering subjects may have kept below the threshold of neural excitability which, if exceeded, might lead to breakdown of reflexive brainstem coordination and, consequently, speech fluency. The results on stuttering children in the present study support the idea that the temporal findings in Zimmermann's adult subjects reflected fluency-enhancing strategies.

The failure to demonstrate differences between English- and Afrikaans-speakers in terms of whole syllable duration in this experiment implies that the differences noted in experiment three were probably due to random variation and not indicative of any systematic differences between the two groups in terms of speech rate.

C The effect on vowel duration of the voicing and manner-of-articulation of the consonant environment

1 The voicing distinction

House and Fairbanks (1953) and Peterson and Lehiste (1960) showed that vowels preceding voiced stops were approximately 100 msec longer than those preceding final voiceless stops in adults. Krause (1982), Naeser (1970) and Smith (1978) demonstrated similar vowel durational differences in normal 2-3 year old American English children. DiSimoni (1974) demonstrated this phenomenon in older normal children and indicated that development was in the direction of vowel lengthening for voiced consonants rather than vowel shortening for voiceless consonants. In the present study, nonstuttering English-speaking South African children were found to use greater vowel durational differences relative to the voicing of consonant environment than did Afrikaans-speakers. This might be attributed to the relative rarity of voiced final stop plosives and sibilants in Afrikaans, which exist mainly in words which are uncommon in the speech of young children. The Afrikaans-speaking subjects would not have had the same opportunity as the English-speakers to develop this cue to consonant voicing. Similarly, Mack (1982), in comparing English and French monolinguals, found larger voice context-dependent vowel durations in the former group.

Although small, the age-related trend in terms of the voicing distinction in the nonstutterers of the present study suggested that children learn to make the differential vowel duration. In the case of the stutterers, an age-related trend was only apparent in sibilant environments in English-speakers, while Afrikaans-speakers failed to exhibit clear age trends.

The box plot data revealed small, but consistent superiority of nonstutterers over stutterers in making the voicing distinction in all but the younger Afrikaans-speaking groups. In summary, it seemed that English-speakers were acquiring the voicing distinction, as expressed in differential vowel duration, more quickly or to a greater degree than were Afrikaans-speakers. There appeared to be a developmental pattern in that the vowel durational differences between voiced and voiceless environments were greater in older than in younger speakers. Vowel durational differences also tended to be

smaller in stutterers compared with nonstutterers. The central tendency of the groups is compared schematically in Fig.36.

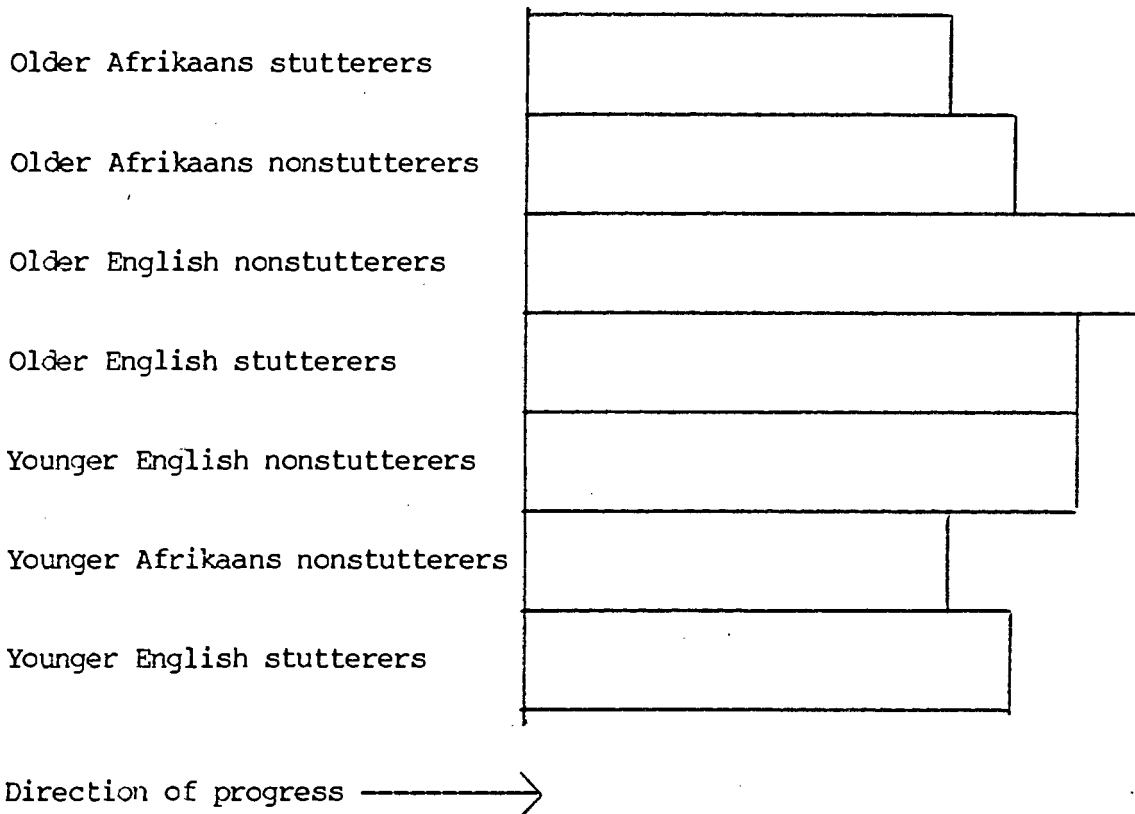


Fig.36 Schematic diagram illustrating the relative progress of seven of the experimental groups in acquiring the voicing distinction as expressed in vowel duration.

The young Afrikaans stuttering group could not conveniently be placed in such a schema since their vowel durations were too variable to allow for clear comparison with the other groups. It can be seen that older English and Afrikaans stutterers performed similarly to their younger nonstuttering controls. Although the differences between younger and older subjects and between stutterers and nonstutterers was less marked than was the case in experiment three, a similar pattern emerged. It appeared as if the stuttering children might have a small developmental lag in terms of the voicing distinction. However, DiSimoni's (1974c) data suggested that these differences between stutterers and nonstutterers may no longer be apparent in adulthood. The right-to-left coarticulatory effect which is active in differential vowel duration relative to the voicing of the following consonant seems to be influenced more by the phonological contrasts employed by a given language than by mechanical coarticulatory effects. This was proposed by Zimmermann and Sapon (1958) and upheld by Danilooff (1973). It seems likely that stuttering children may have difficulty at the phonological level with making vowel durational differences involving the voicing distinction of the following consonant.

2 The influence of manner-of-articulation of the consonant environment

It will be recalled that no consistent trends emerged differentiating the experimental groups in terms of vowel duration in voiceless consonant environments. If the central tendency of the groups in terms of the influence of voiced sibilant and plosive environments alone are considered, the following schematic representation may be derived (Fig.37):

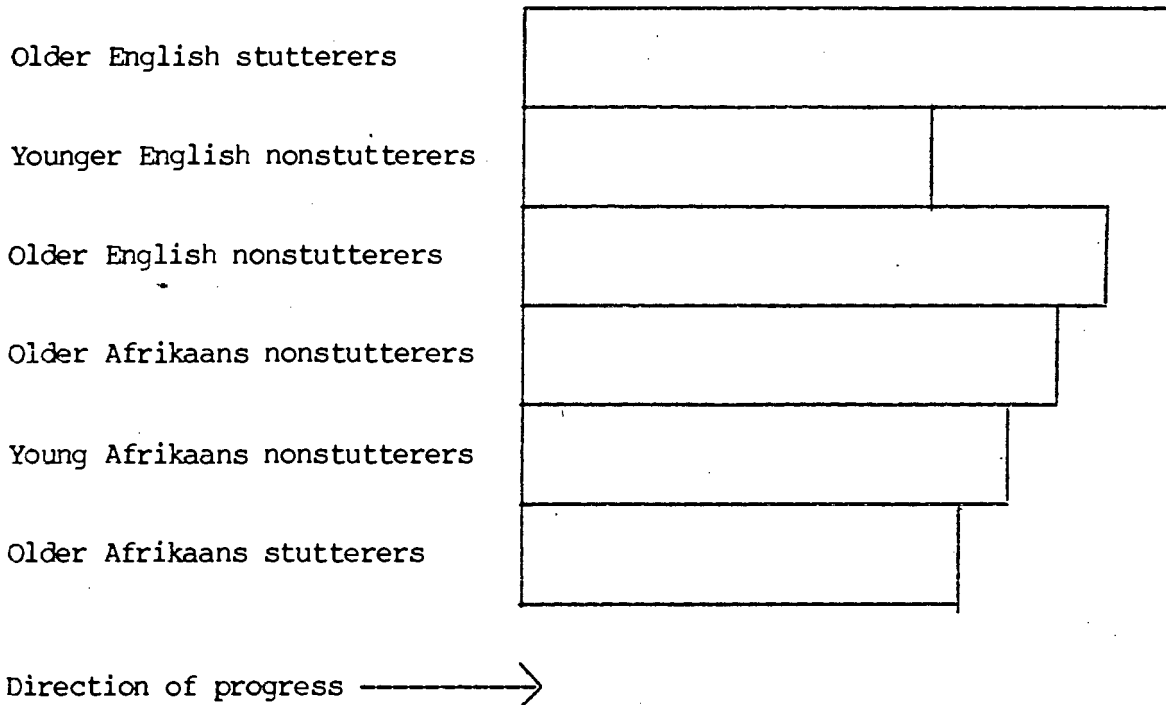


Fig.37 Schematic diagram illustrating the relative progress of six of the experimental groups in terms of acquisition of differential vowel durations in voiced sibilant and plosive environments.

The younger English and Afrikaans stuttering groups were too variable in production to allow for placement on the schema. A developmental pattern seemed to emerge in the nonstutterers in that the degree of vowel durational differentiation between plosive and sibilant environments was greater in older than in younger speakers. No clearcut trends emerged separating speakers from the two language groups nor stutterers from nonstutterers. The findings agree with those for adults by DiSimoni (1974c), ie. stutterers show the normal trend toward longer vowel durations in sibilant than in plosive environments. Whether they do so to the same degree as nonstutterers is an open question. In the present study, older Afrikaans stutterers performed less well than did nonstutterers and the high degree of variability in the younger stuttering groups suggests a lack of competence at making the durational differences. However, the older English stutterers performed well, rendering the findings regarding differences between stutterers and nonstutterers equivocal.

X CONCLUSIONS

A Cross-language comparisons

Hypothesis 1 (a) was verified, since whole syllable and vowel durations were found to be comparable for English- and Afrikaans-speakers, both non-stutterers and stutterers.

Part (b) of hypothesis 1 was partially borne out. English- and Afrikaans-speakers did, indeed, show similar trends in that they lengthened vowel duration in voiced and voiced sibilant environments. The degree of durational differentiation varied between the two groups for the voicing distinction, however, being greater in the case of English-speakers, probably owing to their relatively large amount of practice with the distinction.

B Age-related comparisons

Hypotheses 2 (a) and (b) were rejected in favour of the null hypothesis, since older and younger speakers were not found to differ in terms of whole syllable or vowel duration. Hypothesis 2 (c) was partly borne out - older speakers tended to have greater voicing distinctions as reflected in vowel duration relative to the consonant environment. A similar age-related trend characterized the groups with respect of voiced sibilant and plosive environments, differential vowel duration being greater in older speakers. Hypothesis 2 (d) was also partially validated. Younger speakers were more variable in their performance than were older ones on measures of whole syllable duration. A similar age trend was noted in Afrikaans-speakers only with respect of the influence on vowel duration of the consonant environment. Perhaps the age gap between older and younger subjects was too narrow to demonstrate more clearcut age trends.

C Comparisons between stutterers and nonstutterers

Hypothesis 3 dealt with comparisons between stutterers and nonstutterers. Predictions (a) and (b) were not confirmed by the data, since the groups did not differ in terms of whole syllable durations, nor were stutterers more variable in performance than nonstutterers. Parts (c) and (d) were verified. The two groups did not differ in terms of vowel durations per se. They also showed similar trends in terms of the influence on vowel duration of the consonant environment, viz. longer vowels in voiced and voiced sibilant environments. As expected, the results indicated that the stutterers had not acquired the same degree of acquisition of differential vowel duration in relation to the consonant context as had nonstutterers of comparable ages. This was interpreted as indicating a possible lag on the part of stutterers and, while it was marked in relation to the voicing feature, with respect to manner-of-articulation of the consonant the results were less clearcut.

XI SUMMARY OF RESULTS AND CONCLUSIONS

1. English- and Afrikaans-speakers performed similarly on measures of whole syllable and vowel duration as well as the influence on medial vowel duration of manner-of-articulation of the consonant environment (vowels being longer in sibilant than in stop plosive contexts). The two groups showed the same trend towards longer vowel durations in voiced than voiceless consonant environments but English-speakers demonstrated a greater degree of differentiation, probably because of the rarity of voiced final stops and sibilants in Afrikaans.

2. a) Contrary to other reports (reviewed by Kent 1976) segment duration (ie. vowel and whole syllable durations) did not decrease with age.

b) An age-related trend was identified, however, in the increasing differential vowel duration relative to the voicing of the consonant environment and to the manner-of-articulation of voiced consonants.

c) Eguchi and Hirsh (1969) and DiSimoni (1974d) found decreasing variability of performance with age. This was demonstrated in the present study on some of the measures only, viz. whole syllable duration in speakers from both language groups, and the influence of consonant environment in Afrikaans-speakers only.

3. Stutterers were not found to differ from nonstutterers in terms of vowel duration per se, whole syllable duration nor degree of variability of production. It seems unlikely, then, that the stutterers were using a slower speech rate than were controls, either as a deliberate strategy or because of a sluggish vocal tract. However, interesting differences were noted between the groups when coarticulatory effects thought to be indicative of phonological and neuromotor programming were examined. Stutterers seemed to have a developmental lag relative to nonstutterers in terms of the acquisition of differential vowel duration according to the voicing feature and, possibly, manner-of-articulation of the consonant environment. While they showed the normal trend toward longer vowel durations in voiced and voiced sibilant contexts, the stutterers showed it to a lesser degree than did nonstuttering controls, older stutterers behaving like younger nonstutterers. The voicing feature seemed to present more difficulty to the stutterers than did manner-of-articulation. It seems likely that stutterers may have difficulty with the development of speech timing affecting phonological rules, but whether the level of breakdown is actually a phonological one has not been established.

CHAPTER SIX

GENERAL DISCUSSION

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- I Summary of normative data obtained from the study
 - II Summary of results obtained for the stuttering children
 - III Speculations regarding the level of the difficulty underlying the results on stutterers in the present investigation
 - IV Research implications
 - V Concluding remarks

I SUMMARY OF NORMATIVE DATA OBTAINED FROM THE STUDY

A Voice onset time

The results of experiment one indicated that the white South African English children used short- and long-lag VOT categories to express voiced and voiceless initial stops respectively. They showed a developmental trend toward lengthening of VOT for voiceless stops, with a corresponding increase in variability of production. The English-speaking children had longer VOTs for voiceless initial stops than did Afrikaans-speakers, the trend being more marked in older than in younger speakers. In general, the long-lag VOTs used by the English-speakers were shorter than those of American and Canadian English speakers reported in the literature and this might reflect second-language influence on the local dialect.

The Afrikaans-speaking children used two sets of short-lag unaspirated stop categories in order to produce voiced and voiceless initial stops. Prevoicing occurred randomly in voiced stops and this was thought to account for the increased variability of production of voiced stops which occurred in older speakers. Variability of production of voiceless stops decreased with age and this was attributed to improved neuromuscular skills. Afrikaans-speakers did not show VOT lengthening with age for voiceless stops, since they did not employ the long-lag category.

B Categorical labelling

Experiment two dealt with receptive language skills involved in the categorical labelling of nonsense syllables employing initial voicing contrasts. Cross-language differences were evident in the younger subjects, English-speakers performing better than Afrikaans-speakers. This was attributed to the greater number of perceptual cues which are available to English listeners, making the task relatively easy for them. A developmental trend was identified in both language groups in the direction of improved categorical labelling skills with age. Younger speakers required much additional training and, despite this, many failed to achieve correct labelling by the time testing was discontinued. In the 6 and 7 year age

groups of both languages, however, few subjects needed extra training and none failed to achieve correct labelling.

C Medial stop closure duration in VCV syllables

In experiment three stop closure duration per se was found to be comparable for English- and Afrikaans-speakers. Furthermore, both groups demonstrated similar trends toward longer closure durations for voiceless than for voiced stops, and in /i/ compared with /a/ environments. A normal developmental trend was identified in the direction of lengthening of stop closure duration for voiceless stops and in /i/ environments.

D Medial vowel duration in CVC syllables

Whole syllable and vowel durations per se were found in experiment four to be comparable for English- and Afrikaans-speakers. The two groups also showed similar trends in that vowel duration was lengthened in voiced and voiced sibilant consonant environments, English-speakers showing a greater degree of vowel lengthening for voiced environments. A developmental pattern was identified in that older speakers showed greater vowel durational differences between voiced and voiceless environments and between voiced sibilant and plosive environments than did younger speakers. Contrary to expectations based on the literature, segment duration did not decrease with age and decreasing variability of production with age was only found on some of the measures. This may have been due to the fact that the older and younger groups were not widely separated in age.

II SUMMARY OF RESULTS OBTAINED FOR THE STUTTERING CHILDREN

A Voice onset time

On the whole, the stuttering children demonstrated longer VOTs than did nonstutterers in experiment one, a finding which is in agreement with Agnello et al (cited by Starkweather 1983). English-speaking stutterers also failed to show the normal developmental trend toward lengthening of VOT for voiceless stops. Since the Afrikaans stutterers, who did not have to contend with the greater physiological demands of the long-lag category, clearly distinguished between voiced and voiceless stops, the poor performances of older English stutterers probably reflected a neuromuscular level of difficulty with speech timing, rather than a phonological one.

Afrikaans stutterers, in accordance with their nonstuttering controls, showed increased variability of VOT production with age, as a result of the development of voicing lead as a stylistic variant of voiced stops. However, stutterers from both language groups tended to be more variable in VOT production than were nonstutterers and this might indicate physiological immaturity in the pathological speakers.

B Categorical labelling

Differences between stutterers and nonstutterers in terms of their performance on the categorical labelling task employed in experiment two were evident in the older groups. English-speaking stutterers required more training than did their nonstuttering controls in order to achieve correct

labelling. Afrikaans stutterers performed considerably poorer than did the nonstutterers, nearly half of them requiring additional training trials and, despite this, over a quarter of the group failing to achieve correct labelling. It was postulated that in order to label correctly, stutterers might be dependent on perceptual cues which might be redundant for normal listeners. Afrikaans stutterers would be particularly handicapped on this task, since there are fewer perceptual cues available to them than to English-speakers. It is not known whether stuttering children would experience similar difficulty with categorical labelling tasks employing contrasts other than the voicing distinction.

C Medial stop plosive closure durations and vowel durations

In experiments three and four stutterers could not be differentiated from nonstutterers on measures of whole syllable duration, vowel duration and of stop closure duration per se. Since the stop closure duration measure included the VOT transition, there was no evidence that stutterers moved their vocal mechanisms more slowly than did nonstutterers. The results of experiment one could thus not be extended to the syllable-medial position. These findings are supported by two studies of adult American English speakers. The first, by Healey and Gutkin (1984), demonstrated that, on the whole, VOTs for fluent utterance-initial positions were longer for stutterers than for nonstutterers although the difference did not quite reach statistical significance in the case of voiceless stops. In the second study (Metz et al 1979) it was found that there was little difference between the VOTs of stutterers and nonstutterers on fluent syllables embedded in carrier phrases. A further finding by Healey and Gutkin which is in agreement with the present study was that their stuttering subjects did not differ from the nonstutterers in terms of utterance duration and this led them to conclude that their VOT findings could not be attributed to differences in the articulation rates used by the two groups.

In the present study, interesting findings emerged with regard to right-to-left coarticulatory timing effects. Stutterers performed poorly compared with nonstutterers in that, while they showed the normal trends, they appeared to have a developmental lag in acquiring the following:

1. Lengthening of medial stop closure duration in voiceless stops.
2. Lengthening of medial stop closure in /i/ vowel environments.
3. Lengthening of medial vowels in voiced consonant environments.
4. Lengthening of medial vowels in voiced sibilant consonant environments (this manner-of-articulation feature being less affected than that of voicing however).

The differences between stutterers and nonstutterers appeared to be quantitative, rather than qualitative.

III SPECULATIONS REGARDING THE LEVEL OF THE DIFFICULTY UNDERLYING THE RESULTS ON STUTTERERS IN THE PRESENT INVESTIGATION

Kent (1976) proposed that "...the acquisition of motor programs for speech is conditioned by the learning of phonological regularities" (p 439). He claimed support for this contention from Tingley and Allen's (1975) failure to demonstrate peripheral feedback as a means of speech timing control in children 5 years and older, as well as from DiSimoni's (1974a; 1974b) findings of regularities in phonological speech timing rules by 6 years of age. These studies showed that, at a similar age, motor planning for speech occurs and phonological regularities in timing appear. Kent consequently suggested that motor strategies for speech and phonological patterns develop in parallel fashion.

If one accepts that anticipatory temporal coarticulation reflects neural preplanning, then the results of the present study, together with those of DiSimoni (1974a; 1974b), Krause (1982), Naeser (1970) and Smith (1978) demonstrated that some preprogramming exists in the speech of normal children as young as 2 and 3 years of age, although, according to Tingley and Allen's data, these skills could continue to be refined until about 9 or 10 years of age. In experiments three and four of this study stuttering children performed poorly relative to nonstutterers, the data giving the impression of a developmental lag, particularly when the voicing feature was the determining influence.

The development of long-lag VOT, on the other hand, which was shown in experiment one to be poorer in English-speaking stutterers than in nonstutterers, may be dependent on the use of peripheral feedback. It may reflect aerodynamic and neurophysiological processes operating at a lower level than the neural preplanning of anticipatory coarticulation, although Hirose et al (1983) argue that some preprogramming is evident in the smooth reciprocal action of the posterior cricoarytenoid and interarytenoid muscles which accompanies initial voiceless plosives. At the time of release from a long-lag VOT, the vocal folds are abducted so as to permit the airflow producing aspiration. A neural command is then required in order to initiate vocal fold adduction within approximately 80 msec after release of the stop consonant by the supralaryngeal articulators (Cooper 1977). Klatt (cited by Cooper 1977) suggested that children learn to use peripheral feedback from the oral air pressure drop that automatically accompanies the release of the stop. Certainly, the larynx is equipped with the necessary mechanoreceptors and reflex pathways to enable this to occur, as has been demonstrated by the work of Wyke (1974a). Klatt proposed that when the pressure drop is detected there is reflexive triggering of a command to adduct the vocal folds. As was mentioned in chapter one, Wyke postulated that stutterers may have defective reflex control of timing of laryngeal adduction and abduction. This might take two forms - improper presetting of laryngeal tension prior to phonation or random fluctuations in the position and tension of the folds during exhalation. Wyke's proposals remain speculative, but it is interesting to note that, only on experiment one, ie. the only part of the present study which dealt with the aerodynamic level of speech production, was the performance of stutterers more variable compared with that of nonstutterers, and this might be a sign of neuromuscular immaturity. Specifically, there was increased variability of production of the long-lag VOT category by stutterers. Zimmermann (1980) suggested that excessively variable

articulatory dynamics (kinematics) and timing might alter the excitability of the brainstem nuclei subserving respiratory, phonatory and articulatory structures, jeopardizing proper modulation of reflexive interactions in the central nervous system. This, he proposed, sets up the oscillatory and tonic movement patterns associated with stuttering.

Starkweather and Myers (1979) found no difference between adult stutterers and nonstutterers in terms of the duration of steady state segments, but longer transition time in the stutterers suggested slower-moving speech mechanisms in this group. The VOT data of experiment one supports this notion, but the lack of positive findings to differentiate stutterers from nonstutterers on measures including transitions of medial sounds (experiments three and four) implies that slow transitions in the stuttering group may be confined to word- or utterance-initial positions and this conclusion is in agreement with Healey and Gutkin (1984). It seems more likely that stutterers experience difficulty with complex laryngeal coordinations involving voice initiation at the beginnings of utterances than that they have an overall inability to move their vocal mechanisms quickly. Healey and Gutkin (1984) proposed two possible interpretations of the VOT data on stutterers:

1. They cite Prosek et al (1979) who suggested that stutterers may have difficulty in initiating phonation because of temporal mismanagement of airflow onset and/or release of the prephonatory laryngeal posture.
2. Longer VOTs may reflect excessive articulatory tension which stutterers may have experienced during the closure phase of utterance-initial stops. Tight airflow blockage with a concomitant increase in intraoral pressure could contribute to a delay in voice onset. This description concurs with Adams' (1974) suggestions regarding the aerodynamic processes underlying stuttering, which were referred to in chapter one of this report.

While it is true that the most successful fluency-enhancing techniques appear to be those which involve, inter alia, slowing down of speech rate (Andrews et al 1983), it may be that the effect of reduced rate is to normalize timing relations amongst the articulators, as has been suggested by Metz et al (1983), perhaps by reducing uncertainty in the timing pattern of motor speech control (Kent 1983).

In addition to the VOT results, the data from experiments three and four suggested a developmental lag in stutterers relative to nonstutterers in terms of the acquisition of temporal phonological rules which probably depend on neural preplanning for their execution. There seems to be a strong possibility that the speech timing difficulties of stutterers form a syndrome, at least implicating neuromuscular-aerodynamic and phonological levels of planning and particularly, but perhaps not exclusively, involving the voicing feature. The results of experiment two, which indicated that the performance of stutterers was inferior to that of nonstutterers on categorical labelling tasks involving the voicing feature, confirmed the necessity to examine cognitive levels of speech timing. The selection of levels to be studied could probably benefit from linkage with a model of the processes underlying speech production, such as that proposed by Dalton and Hardcastle (1977). Their model is a functional one, with little attempt as yet, at correlation with a neurophysiological model. They postulated five

basic functions or stages in the generation of a spoken utterance.

1. IDEATION: the initiation of a central idea or intention to say something.
2. NEUROLINGUISTIC PROGRAMME PLANNING FUNCTION: Where the expression of the idea takes shape in the form of a "blueprint" of phonological, syntactic and semantic rules. Inter alia, words are selected from the lexicon. While this level is probably hierarchically organized, some sort of sequential ordering of the message is assumed, although the basic programming unit is unknown and controversial.
3. MOTOR REGULATOR FUNCTION: where the neurolinguistic programme is converted into temporal sequences of motor commands to the appropriate speech muscles. Motor and sensory information is sent to the regulator as well. Target movements are plotted with reference to an internalized spatial representation of the vocal tract. Dalton and Hardcastle proposed that the motor specifications, or motor schema, include information concerning which sets of muscles are to contract or relax, the degree of force of contraction, and velocity of articulatory movement. While they do not specifically state as much, it is implicit that durational information must be specified at this level as well. An appropriate sensory schema is also thought to be specified, containing information regarding the expected tactile, proprioceptive, and possibly even auditory consequences of the target movements.
4. MYODYNAMIC-EXECUTION FUNCTION: This refers to the response of the speech organs to the motor commands issued by the motor regulator system. Appropriate movements consequently occur in respiratory, laryngeal and articulatory structures.
5. MONITORING FUNCTION: for error detection and the development of strategies for error detection. This system probably operates simultaneously during the previous four stages.

Dalton and Hardcastle suggested that a breakdown at the ideation level occurred in frontal lobe lesions. Neurolinguistic programme planning disorders comprise, at least, dysnomia and dyspraxia and this suggests that a wide cortical area including the temporo-parieto-occipital association area and Broca's area, as well as their connecting fibrotracts subserve this function. Clearly, there is much scope for refinement and expansion of the model to provide a more detailed description at each level. The authors suggested that disturbances of the myodynamic-execution function produced dysarthria, by implication localizing this function broadly to bilateral subcortical motor nuclei and tracts. Monitoring function disturbances would occur with cerebellar and certain brainstem lesions.

It is difficult to integrate the findings of the present study into an existing model such as that of Dalton and Hardcastle. The VOT data may relate to the myodynamic execution and monitoring functions (levels 4 and 5), yet McNeilage and DeClerk's description of motor speech production processes allows for a disturbance in, say, laryngeal presetting (such as has been suggested by Wyke 1974b) to occur as a result of messages emanating from the

cortex at an early stage in the encoding process.

Anticipatory coarticulation may be the result of:

1. Anticipatory presetting of muscles prior to the motor phonemic command reaching the primary motor cortex from Broca's area. McNeilage and De Clerk (1969) state that a voluntary command can, by means of transmission via subcortical centres, influence muscle contraction at the peripherae prior to mediation of the motor command in the primary motor cortex. Even the intention to move apparently produces an increase in muscle tone at the peripherae.
2. Organization of motor commands, not in terms of discrete phonemes, but higher-order structures which are probably at least syllabic in extent. McNeilage and DeClerk's findings support Kozhevnikov and Chistovich's (cited by Cooper 1977) claim that the syllable is the simplest and most basic articulatory unit; however this is not universally accepted (Sussman and Westbury 1981).

The phonological timing level of developmental lag demonstrated by stutterers in experiments two, three and four may relate to the neurolinguistic-planning or motor regulator functions (levels 2 and 3) of the Dalton and Hardcastle model. If this is the case, stutterers share the same functional level(s) of difficulty as dysphasics and dyspraxics and it remains to be demonstrated how these groups differ from one another, even though they may share some characteristics (Caplan 1972). If a phonological level of timing difficulty in stutterers can be confirmed by other investigators this would not necessarily imply a disturbance at syntactic or semantic levels as well, since phonology has not been unequivocally demonstrated to be an integral part of language; there is evidence that coherent linguistic communication can take place without phonological mediation, whereas this is not true of syntax or semantics (Schnitzer 1976).

Furthermore, the nature of the relationship between the aerodynamic-neuromuscular and phonological levels of speech timing difficulty in stutterers awaits explanation. It is not clear whether a mechanical-peripheral level difficulty could result in a developmental lag at the phonological level, in which case the results of experiment two would have to be explained on the basis of the 'motor theory' of speech perception (Liberman et al 1967) or whether difficulties at the two levels could exist independently, yet interact to bring about fluency breakdown. It does seem to be important to pursue the matter; as Perkins (1983) has stated "...whether disfluencies are linguistic or motor could make a profound difference in how we approach the study of stuttering" (p 247). In addition, a disturbance in speech timing, which may be confirmed as operating at either or both of these levels, will need to be clearly linked with that fluency breakdown which is characteristic of stuttering.

The possibility also exists that there may be a common, central timing mechanism for both the reception and production of speech. This has long been suspected and there is some preliminary evidence that this idea may be valid (Kent 1983). Thus, speech timing disorders which may be identified at one or more functional levels might be linked to such a central mechanism. Kent suggests that a central timing mechanism in the central nervous systems

of stutterers may be unable to contend with the processing of the simultaneous temporal patterns inherent in speech. Such timing breakdowns have been demonstrated to occur on limb tapping tasks (Ibbotsen and Morton cited by Kent 1983).

IV RESEARCH IMPLICATIONS

Several important implications for further research have emerged from this study:

1. The general conclusion that stuttering children show a developmental lag in the acquisition of normal speech timing, particularly involving the voicing feature, at phonetic and phonological levels of processing points to the need for continued exploration of the development of speech timing control in this group.
2. Investigators should pay more attention to studying the fluent speech of stutterers. The present data, together with that of Healey and Gutken (1984) and Love and Jeffress (1971), indicate that, even in their fluent speech, stutterers do not perform as well as do non-stutterers with regard to speech timing. This challenges the idea that stuttering develops as an outgrowth of normal nonfluency.
3. Apart from a continued exploration of timing features in the speech of stutterers, researchers should pay attention to the development of control of the muscular forces required for accurate articulation. This dimension may be found to show similar developmental trends in normals as do neural timing control mechanisms (Kent 1976). The interaction between control over muscular forces and speech timing control merits further investigation. With regard to the vowel durational data of experiment four, for instance, there is some evidence (reviewed by Cooper 1977) that final voiced stops develop later than do final voiceless stops. Peak EMG activity on the vowel must also be sustained longer prior to voiced stops. Thus, final voiced stops may be more difficult neuromuscularly for children to produce than are final voiceless ones. One can speculate that the relatively late or poor development of vowel lengthening prior to voiced stops on the part of stutterers may reflect difficulty in sustaining the required muscular pressure. Such a finding would lead to a reinterpretation of the present data, including the conclusions regarding anticipatory coarticulation effects.
4. In order to identify features unique to each group, comparative investigations of speech timing and neuromuscular abilities need to be done in order to differentiate between stuttering children and other pathological child speakers, such as those with phonological articulation disorders, developmental dyspraxia, and dysarthria, who have been reported to have difficulty with both dimensions.
5. Cross-linguistic research is important, since it enables a link to be established between the characteristic phonetic and phonological

demands of given languages and the abilities of stutterers and helps to counteract the danger of overinterpretation of results.

6. One of the most important implications to be derived from the present study is that it is vital to investigate the developing speech of very young stutterers. Many of the conclusions which have been drawn from studies of speech timing using adult stuttering subjects have been called into question by this study, since it appears that their results may have been influenced by the secondary development of stuttering behaviours or by the effects of therapy.

V CONCLUDING REMARKS

The present study clearly demonstrated an inability on the part of stuttering children to achieve the same degree of developmental patterns of speech timing in their perceptually fluent speech as did their nonstuttering peers. This relative inferiority on the part of stutterers was interpreted as a developmental lag and seemed to pertain particularly, but not exclusively, to the voicing feature. The data pointed to aerodynamic-neuromuscular as well as phonological levels of difficulty on the part of stutterers, but the possibility exists, and is strengthened by the results of the categorical labelling task, that these may merely reflect some more central timing mechanism disorder. Furthermore, it is unknown whether the demonstrated timing disorder is at the core of the fluency breakdown characteristic of stuttering, or whether it is associated with other factors, such as an inability to control articulatory muscular force. At the very least, and quite apart from considerations of secondary learning and emotional factors, the data supports a rejection of simplistic physiological explanations of the core of stuttering.

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APPENDIX

ORDER OF CONTENTS:

- * Motivation for using graphical statistical methods for analysing the three-way experimental layout of temporal features of speech recording variables.
- * Texts accompanying picture stories used to elicit productions of the experimental stimuli in experiment one.
- * Fig. 9 Sketches illustrating the four stimulus objects used in experiment two.
- * Table XIV Lists of randomized nonsense syllables employed in experiment three.
- * Table XVIII Lists of randomized nonsense syllables employed in experiment four.
- * Table XXI Dysfluency rates in the stuttering subjects' pretesting speech samples.
- * Fig. 19 Results of the Spearman's correlations for experiment three.
- * Fig. 35 Results of the Spearman's correlations for experiment four.

MOTIVATION FOR USING GRAPHICAL STATISTICAL METHODS FOR ANALYSING THE THREE-WAY EXPERIMENTAL LAYOUT OF TEMPORAL FEATURES OF SPEECH RECORDING VARIABLES

Two major topics in statistics are estimation and inferential methods. In inferential statistics the aim is to make a choice between hypotheses (usually two) on probability grounds. These hypotheses are in general very limited and are restricted to one type of statistic e.g. the mean.

Most of the experimentation was done on a group of 120 subjects which was divided into eight subgroups of 15 each by the following three binary factors: age (younger or older), language (Afrikaans or English) and stuttering (absent or present). A three-way layout like this is usually analysed by means of analysis of variance with which hypotheses concerning the means are associated.

Although the total sample size of 120 exceeds the sizes of nearly all published studies of this nature, the 15 cases per subgroup may be regarded as too few to be able to establish distributional characteristics. Distributional characteristics enable one to select a suitable test e.g. a parametric or non-parametric test, or to decide how to transform the data, if necessary.

In applying any statistical test it is necessary to check whether most of the underlying assumptions are satisfied. The data was inspected to determine the extent to which it satisfied the following assumptions of analysis of variance:

1. Homogeneity of variances: This was violated on numerous occasions as can be seen from the side-by-side box plots included in the thesis. One of the examples of heterogeneity of variance can be seen in Figure 6a (iii).
2. Symmetry of distributions: This was not the case with many of the variables compared in the various subgroups. In Figure 6c (iv) examples of such skew distributions can be found. The assumption of normality is even more restrictive. The question must now arise whether the problem of skewness can be resolved by means of a transformation such as the logarithmic function. There exist examples of skewness in two directions, a situation which will be aggravated by taking logarithms. (For an example of skewness in two directions, see Figure 6a (iii).)
3. In Figures 7a-7d where the range of the repeat measurements is plotted against the quantity $(\text{Max}-\text{Min})/2$, there is some evidence that the dispersion increases as the size of the measurement increases. If these graphs are studied in greater detail it will be observed that in some instances, clustering of individuals belonging to certain subgroups occurs, and that the lower boundary points form a horizontal line. Thus the evidence of a structure in the dispersion is not conclusive.
4. Where two or more subgroups have the same mean or median but grossly different spread or dispersion, taking logarithms will also not be able to improve the situation. For an example see Figure 6a (iv).
5. The numerous outliers present in the data set will not be alleviated by a logarithmic transformation. This is another reason why parametric methods could not be applied.

6. Methods exist by which main effects can be tested when heteroschedasticity is present. These methods can however not test for interaction which is common in three-way layouts.

The relative value of inferential statistics (or the establishment of statements to which a probability value is attached) is dubious, when the assumptions are violated. The median test would be a reasonable method to use to analyse the data, but it results in a serious loss in statistical power, and will only provide an approximate statement about group means. It will thus utilise the information contained in the three-way layout of data poorly.

The value of the graphical methods used is that they show the location as well as the spread of the data within each subgroup. In this way differences between groups can be seen. The graphical approach is particularly suited to the exploratory nature of this study.

Reference:

Scheffe, Henry (1959) The Analysis of Variance. John Wiley & Sons, New York.

TABLE XIV Lists of randomized nonsense syllables employed in experiment three

1.	2.	3.
apa	iti	aba
ada	ibi	ata
ata	idi	idi
idi	ipi	ipi
ipi	ata	ada
aba	ada	iti
iti	aba	apa
ibi	apa	ibi

TABLE XVIII Lists of randomized nonsense syllables employed in experiment four

1.	2.	3.
pip	sas	ziz
sis	bib	sis
bib	pip	bib
ziz	sis	pap
pap	bab	bab
bab	zaz	sas
sas	ziz	zaz
zaz	pap	pip

Texts accompanying picture stories, used to elicit productions of the experimental stimuli in experiment one.

Fig. 1a Stories used with younger English-speaking subjects:

1. Jack and Jill have a little dog called Paf.
 - a. Jack and Jill went to find a Christmas tree. (Point to dog)
Look who went to help them. Their little dog.
What was the dog's name?
 - b. Jill said to Paf: "It's too cold outside. Go inside, Paf."
Who is going inside? (Point to dog)
 - c. Jack and Jill cut down the Christmas tree and took it back
to the house. Who is not in this picture? (Point to picture)
 - d. Look who's inside! It's little...(point to dog)
2. Once there was a squirrel called Baf.
 - a. Who is walking in the garden? (Point)...That's right.
Baf is walking over the bridge.
 - b. Baf saw a rabbit. "Hello, Baf" said the rabbit. What did
the rabbit say? He said "Hello..."
 - c. Then Baf saw a frog. The frog said "Hello, Baf." What
did the frog say? He said "Hello..."
 - d. Splash! The frog jumped into the water. Baf got a big
fright. (Point to squirrel) Who got a big fright?
3.
 - a. Once there was a little girl and her name was Taf.
Taf had a pink bunny.
 - b. Look who's playing with a kite. It's little...
That's right. And the bunny is watching her.
 - c. Who is picking flowers? That's right. Perhaps she's going
to take them home to Mommy.
 - d. Ooh, look! There's the sea. Who is swimming in the water?
(Point to girl) Yes, and bunny is swimming too.
 - e. One day it was raining and they went outside.
Who is wearing boots?

4.
 - a. Once there was a little bear called Daf.
 - b. Daf went to visit his friends, the rabbits.
When he knocked on the door the rabbits looked out of the windows. This rabbit said "Hello, Daf." This rabbit said "Hello..." And this rabbit also said, "Hello..."
 - c. Daf got some wood and a saw. He said, "I'm going to build a house." Who is cutting the wood?
 - d. Look at that lovely house! Do you know who built it?
That's right, it was Daf.

Fig. 1b Stories used with younger AFrikaans-speaking subjects:

1. Piet en Sarie het 'n klein hondjie met die naam Paf.
 - a. Piet en Sarie het 'n Kersfeesboom gaan seek. (Wys na hond)
Kyk wie het saamgegaan om te help - hulle klein hondjie.
Wat was die hondjie se naam?
 - b. Sarie sê vir Paf: "Dis te koud buitekant. Gaan binne, Paf."
Wie gaan binnekant? (Wys na hond)
 - c. Piet en Sarie het die Kersfeesboom uitgehaal en dit
teruggeneem huis toe. Wie is nie in hierdie prentjie nie?
(Wys na prentjie)
 - d. Kyk net wie is binnekant! Dit is klein...(Wys na hond)
2.
 - a. Eendag was daar 'n eekhoringsjapie met die naam Baf.
 - b. Wie stap in die tuin? (Wys) Dis reg. Baf stap oor die brug.
 - c. Baf het 'n hasie gesien. "Hello, Baf." het die hasie gesê.
Wat het die hasie gesê? "Hello..."
 - d. Toe het Baf 'n padda gesien. Die padda sê: "Hello, Baf."
Wat se die padda? Hy sê "Hello..."
 - e. Pardoemps! Die padda het in die water gespring. Baf het
groot geskrik. (Wys na eekhoringsjapie) Wie het groot geskrik?
3.
 - a. Eendag was daar 'n dogtertjie en haar naam was Taf. Taf
het 'n pienk hasie gehad.
 - b. Kyk wie speel met 'n vlieër. Dit is die dogtertjie met die
naam van... Dis reg. En die hasie kyk vir haar.
 - c. Wie pluk nou blomme? Dis reg. Miskien gaan sy hulle huis
toe neem om vir Mamma te gee.
 - d. O, kyk daar! Daar's die see. Wie swem in die water? (Wys
na dogtertjie). Ja, en hasie swem ook.
 - e. Eendag het dit gereën en hulle het na buite gegaan. Wie
dra steuwels?

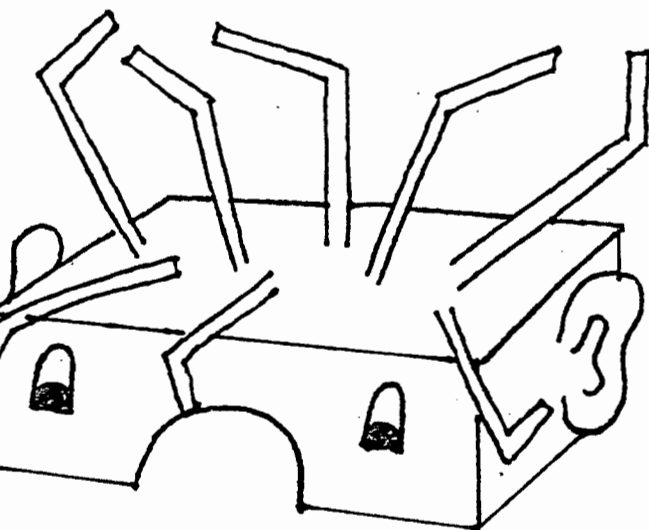
4. a. Eendag was daar 'n klein beertjie met die naam Daf.
- b. Daf het by sy vriende, die hasies, gekuier. Toe hy op die deur geklop het, het die hasies by die vensters uitgekyk. Hierdie hasie sê: "Hello, Daf." Hierdie hasie sê: "Hello...."
- c. Daf het hout en 'n saag gaan haal. "Ek gaan vir my 'n huis bou," het hy gesê. Wie is besig om die hout te saag?
- d. Kyk vir daardie pragtige huis. Weet jy wie het dit gebou? Dis reg, dit was Daf.

Fig. 1c Stories used with older English-speaking subjects:

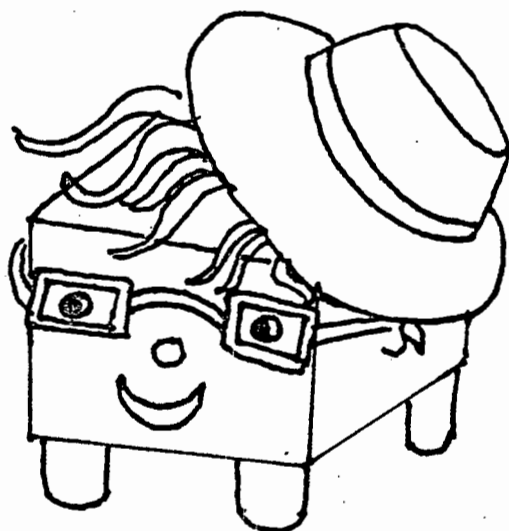
1.
 - a. (Point) Paf, the otter, lived in a tree. Who lived in the tree? That's right. One day, his friend, Baf the bird, came to visit. What was the bird's name?
 - b. Paf and Baf went to visit Jane. Oh, look who's sitting on Paf's head (point) - it is...? Jane said: "Oh dear, it's raining. Come inside, Baf" (point to bird). "Come inside..." (Point to otter).
 - c. Jane filled a tub of water because she knew Paf liked it.
 - d. Splash! Look who jumped into the water. Who was it?
 - e. Afterwards, Jane put on her raincoat to go outside. Who is flying out of the door? (Point to bird).
 - f. Soon they were all playing outside in the rain. Who was splashing in the puddles? Jane (point) and...(point to otter) and...(point to bird). Sometimes birds like water too.
2.
 - a. This is Mr. Taf and this is his friend, Mrs. Daf. Who is washing the clothes? Mrs....That's right. And who is coming inside? Mr...
 - b. Mr. Taf said: "I'll do the washing for you, Mrs. Daf."
 - c. Who is doing the washing now? Mr...
 - d. When the washing was finished, Mr. Taf carried it outside. Who wants to help him? It's Mrs...
 - e. Who is hanging up the washing? Who is watching him? Mrs. Daf said: "My goodness! You did the washing so quickly, I feel quite tired from watching you."
 - f. Look who's sitting down - it's Mrs..."Aren't you tired too, Mr. Taf?" she asked, "No, I'm not tired," said Mr...

Fig. 1d. Stories used with older Afrikaans-speaking subjects:

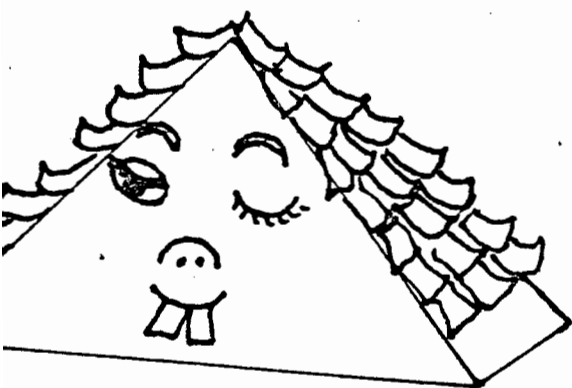
1.
 - a. (Wys) Paf, die otter, het in 'n boom gewoon. Wie het in 'n boom gewoon? Dis reg. Op 'n dag het sy maatjie, Baf die voel, vir hom kom kuier. Wat was die voëltjie se naam?
 - b. Paf en Baf het vir Marie gaan kuier. O, kyk wie sit op Paf se kop (wys). Dit is...Marie sê: "Liewe land, kyk hoe reën dit. Kom binne, Baf." (Wys na voel) "Kom binne..." (wys na otter).
 - c. Marie het 'n bad vol water gegooi, want sy't geweet Paf hou daarvan.
 - d. Pardoemps! Kyk wie't in die water gespring. Wie was dit?
 - e. Daarna het Marie haar reënjas aangetrek om na buite te gaan. Wie vlieg by die deur uit? (Wys na voel).
 - f. Binnekort het hulle almal heerlik buite in die reën gespeel. Wie het in die poele gespring? Marie (wys) en...(wys na otter) en...(wys na voel). Soms hou voëltjies ook van water.
2.
 - a. Dit is Mnr. Taf en dit is sy vriendin, Mev.Daf. Wie is besig om die klere te was? Mev...Dis reg. En wie stap na binne? Mnr...(wys)
 - b. Mnr. Taf sê: "Ek sal die wasgoed vir jou doen, Mev.Daf."
 - c. Wie doen nou die wasgoed? Mnr...
 - d. Toe die wasgoed klaar was, het Mnr. Taf dit na buite gedra. Wie wil vir hom help? Mev...
 - e. Wie hang nou die wasgoed op? Wie kyk vir hom? Mev. Daf sê: "My wêreld. Jy't die wasgoed so vinnig gewas dat dit my moeg maak net om na jou te kyk."
 - f. Kyk wie sit nou - dis Mev...(wys). "Is jy nie ook moeg nie, Mnr. Taf?" vra sy. "Nee, ek is glad nie moeg nie," sê Mnr...



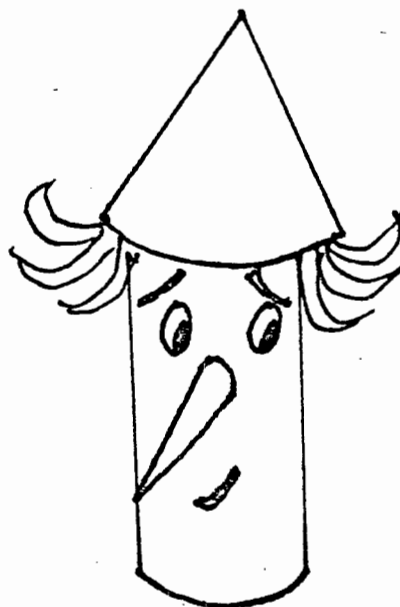
/b3f/
Basic form: Blue rectangle.



/d3f/
Basic form: Yellow cube.



/t3f/
Basic form: Red pyramid.



/p3f/
Basic form: Green cylinder.

Fig. 9 Sketches illustrating the four stimulus objects used in experiment two.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 15

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000	0.12197 0.6650	0.39462 0.1455	0.31900 0.2465	0.35082 0.1998	0.59120 0.0203	0.58782 0.0212	0.18705 0.5044	0.26930 0.3317	0.49507 0.0606	0.13297 0.6366	0.29058 0.2934
APA2PCT	0.12197 0.6650	1.00000 0.0000	0.20572 0.4620	0.21805 0.4350	0.15961 0.5699	0.20699 0.4592	0.35746 0.1908	0.27623 0.3190	0.22560 0.4188	0.06261 0.8246	0.11559 0.6816	-0.34168 0.2126
APA3PCT	0.39462 0.1455	0.20572 0.4620	1.00000 0.0000	0.21448 0.4427	0.06493 0.8182	0.58244 0.0227	0.33065 0.2287	0.32736 0.2336	0.28738 0.2990	0.24150 0.3859	0.30287 0.2725	0.01610 0.9546
ADA1PCT	0.31900 0.2465	0.21805 0.4350	0.21448 0.4427	1.00000 0.0000	0.59822 0.0185	0.52462 0.0447	0.56786 0.0272	0.69176 0.0043	0.57961 0.0235	0.64164 0.0099	0.75739 0.0011	0.58088 0.0232
ADA2PCT	0.35082 0.1998	0.15961 0.5699	0.06493 0.8182	0.59822 0.0185	1.00000 0.0000	0.41374 0.1253	0.83066 0.0001	0.27216 0.3264	0.54965 0.0338	0.61499 0.0147	0.34779 0.2040	0.63663 0.0107
ADA3PCT	0.59120 0.0203	0.20699 0.4592	0.58244 0.0227	0.52462 0.0447	0.41374 0.1253	1.00000 0.0000	0.59445 0.0194	0.61635 0.0144	0.73901 0.0016	0.77240 0.0007	0.55386 0.0322	0.46774 0.0787
ATA1PCT	0.58782 0.0212	0.35746 0.1908	0.33065 0.2287	0.56786 0.0272	0.83066 0.0001	0.59445 0.0194	1.00000 0.0000	0.42832 0.1112	0.49195 0.0625	0.76854 0.0008	0.36706 0.1784	0.46113 0.0836
ATA2PCT	0.18705 0.5044	0.27623 0.3190	0.32736 0.2336	0.69176 0.0043	0.27216 0.3264	0.61635 0.0144	0.42832 0.1112	1.00000 0.0000	0.57361 0.0254	0.54709 0.0348	0.88949 0.0001	0.51839 0.0477
ATA3PCT	0.26930 0.3317	0.22560 0.4188	0.28738 0.2990	0.57961 0.0235	0.54965 0.0338	0.73901 0.0016	0.49195 0.0625	0.57361 0.0254	1.00000 0.0000	0.64458 0.0095	0.63767 0.0105	0.54073 0.0374
IDI1PCT	0.49507 0.0606	0.06261 0.8246	0.24150 0.3859	0.64164 0.0099	0.61499 0.0147	0.77240 0.0007	0.76854 0.0008	0.54709 0.0348	0.64458 0.0095	1.00000 0.0000	0.51434 0.0498	0.61717 0.0142
IDI2PCT	0.13297 0.6366	0.11559 0.6816	0.30287 0.2725	0.75739 0.0011	0.34779 0.2040	0.55386 0.0322	0.36706 0.1784	0.88949 0.0001	0.63767 0.0105	0.51434 0.0498	1.00000 0.0000	0.65233 0.0084
IDI3PCT	0.29058 0.2934	-0.34168 0.2126	0.01610 0.9546	0.58088 0.0232	0.63663 0.0107	0.46774 0.0787	0.46113 0.0836	0.51839 0.0477	0.54073 0.0374	0.61717 0.0142	0.65233 0.0084	1.00000 0.0000
IPI1PCT	0.26906 0.3322	0.47585 0.0730	0.20036 0.4740	-0.13941 0.6202	-0.17223 0.5393	0.12455 0.6583	0.28776 0.2983	0.17220 0.5394	0.11638 0.6796	0.17174 0.5405	0.03047 0.9142	-0.30411 0.2705
IPI2PCT	-0.49775 0.0590	0.07527 0.7898	-0.08781 0.7557	-0.29185 0.2912	-0.48962 0.0640	-0.52244 0.0457	-0.39033 0.1503	0.13477 0.6320	-0.25291 0.3631	-0.50717 0.0536	0.11849 0.6741	-0.33513 0.2221
IPI3PCT	-0.08266 0.7696	0.09409 0.7387	0.26165 0.3462	-0.51925 0.0473	-0.14634 0.6028	-0.05925 0.8339	0.15219 0.5882	-0.16262 0.5625	-0.33453 0.2229	-0.03943 0.8891	-0.29264 0.2898	-0.20968 0.4532
ABA1PCT	0.38745 0.1536	0.28265 0.3074	0.72451 0.0023	0.15192 0.5889	0.33364 0.2243	0.43548 0.1047	0.60054 0.0179	0.22422 0.4218	0.01253 0.9646	0.32021 0.2446	0.18996 0.4977	0.09481 0.7368
ABA2PCT	0.82153 0.0002	0.21288 0.4462	0.59571 0.0191	0.60947 0.0159	0.44185 0.0991	0.69355 0.0041	0.61841 0.0140	0.33722 0.2190	0.38675 0.1544	0.59928 0.0182	0.41398 0.1250	0.35957 0.1881

Fig. 19a(i) Results of the Spearman's correlations for experiment three in Group 1.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 15

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
ABA3PCT	0.39677 0.1431	0.63563 0.0109	0.02686 0.9243	0.42934 0.1103	0.24369 0.3815	0.40807 0.1310	0.37746 0.1654	0.40485 0.1344	0.46237 0.0827	0.35631 0.1924	0.40090 0.1386	0.02149 0.9394
II11PCT	0.51613 0.0489	-0.12869 0.6476	0.05541 0.8445	0.28571 0.3019	-0.08649 0.7592	0.37780 0.1650	0.09286 0.7420	0.13979 0.6193	0.38819 0.1528	0.42895 0.1106	0.15757 0.5749	0.20733 0.4584
II12PCT	0.19390 0.4887	0.82184 0.0002	-0.10116 0.7198	0.16279 0.5621	0.42420 0.1151	0.15426 0.5831	0.56708 0.0275	0.12478 0.6577	0.29032 0.2939	0.25962 0.3501	-0.00987 0.9722	-0.13250 0.6378
II13PCT	-0.05740 0.8390	0.11717 0.6775	0.46959 0.0774	-0.12690 0.6522	-0.46981 0.0772	-0.06900 0.8070	-0.21448 0.4427	0.26188 0.3457	-0.30170 0.2745	-0.27013 0.3302	0.23477 0.3997	-0.18605 0.5068
II21PCT	-0.11121 0.6932	0.14132 0.6154	-0.06440 0.8196	0.71492 0.0027	0.25790 0.3534	0.26344 0.3428	0.29133 0.2921	0.81973 0.0002	0.42435 0.1149	0.40161 0.1379	0.78584 0.0005	0.42308 0.1161
II22PCT	-0.11670 0.6787	0.23814 0.3927	0.40286 0.1365	0.27370 0.3236	0.26896 0.3324	0.17848 0.5245	0.36673 0.1788	0.32226 0.2414	0.09498 0.7363	0.26589 0.3381	0.29058 0.2934	0.24261 0.3836
II13PCT	0.76772 0.0008	0.09123 0.7464	0.24150 0.3859	0.43610 0.1041	0.57531 0.0248	0.54301 0.0365	0.74888 0.0013	0.24574 0.3773	0.49955 0.0580	0.68605 0.0047	0.22849 0.4127	0.38193 0.1601
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.26906 0.3322	-0.49775 0.0590	-0.08266 0.7696	0.38745 0.1536	0.82153 0.0002	0.39677 0.1431	0.51613 0.0489	0.19390 0.4887	-0.05740 0.8390	-0.11121 0.6932	-0.11670 0.6787	0.76772 0.0008
APA2PCT	0.47585 0.0730	0.07527 0.7898	0.09409 0.7387	0.28265 0.3074	0.21288 0.4462	0.63563 0.0109	-0.12869 0.6476	0.82184 0.0002	0.11717 0.6775	0.14132 0.6154	0.23814 0.3927	0.09123 0.7464
APA3PCT	0.20036 0.4740	-0.08781 0.7557	0.26165 0.3462	0.72451 0.0023	0.59571 0.0191	0.02686 0.9243	0.05541 0.8445	-0.10116 0.7198	0.46959 0.0774	-0.06440 0.8196	0.40286 0.1365	0.24150 0.3859
ADA1PCT	-0.13941 0.6202	-0.29185 0.2912	-0.51925 0.0473	0.15192 0.5889	0.60947 0.0159	0.42934 0.1103	0.28571 0.3019	0.16279 0.5621	-0.12690 0.6522	0.71492 0.0027	0.27370 0.3236	0.43610 0.1041
ADA2PCT	-0.17223 0.5393	-0.48962 0.0640	-0.14634 0.6028	0.33364 0.2243	0.44185 0.0991	0.24369 0.3815	-0.08649 0.7592	0.42420 0.1151	-0.46981 0.0772	0.25790 0.3534	0.26896 0.3324	0.57531 0.0248
ADA3PCT	0.12455 0.6583	-0.52244 0.0457	-0.05925 0.8339	0.43548 0.1047	0.69355 0.0041	0.40807 0.1310	0.37780 0.1650	0.15426 0.5831	-0.06900 0.8070	0.26344 0.3428	0.17848 0.5245	0.54301 0.0365
ATA1PCT	0.28776 0.2983	-0.39033 0.1503	0.15219 0.5882	0.60054 0.0179	0.61841 0.0140	0.37746 0.1654	0.09286 0.7420	0.56708 0.0275	-0.21448 0.4427	0.29133 0.2921	0.36673 0.1788	0.74888 0.0013
ATA2PCT	0.17220 0.5394	0.13477 0.6320	-0.16262 0.5625	0.22422 0.4218	0.33722 0.2190	0.40485 0.1344	0.13979 0.6193	0.12478 0.6577	0.26188 0.3457	0.81973 0.0002	0.32226 0.2414	0.24574 0.3773
ATA3PCT	0.11638 0.6796	-0.25291 0.3631	-0.33453 0.2229	0.01253 0.9646	0.38675 0.1544	0.46237 0.0827	0.38819 0.1528	0.29032 0.2939	-0.30170 0.2745	0.42435 0.1149	0.09498 0.7363	0.49955 0.0580

Fig. 19a(ii) Group 1 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 15

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
ID11PCT	0.17174 0.5405	-0.50717 0.0536	-0.03943 0.8891	0.32021 0.2446	0.59928 0.0182	0.35631 0.1924	0.42895 0.1106	0.25962 0.3501	-0.27013 0.3302	0.40161 0.1379	0.26589 0.3381	0.68605 0.0047
ID12PCT	0.03047 0.9142	0.11849 0.6741	-0.29264 0.2898	0.18996 0.4977	0.41398 0.1250	0.40090 0.1386	0.15757 0.5749	-0.00987 0.9722	0.23477 0.3997	0.78584 0.0005	0.29058 0.2934	0.22849 0.4127
ID13PCT	-0.30411 0.2705	-0.33513 0.2221	-0.20968 0.4532	0.09481 0.7368	0.35957 0.1881	0.02149 0.9394	0.20733 0.4584	-0.13250 0.6378	-0.18605 0.5068	0.42308 0.1161	0.24261 0.3836	0.38193 0.1601
IP11PCT	1.00000 0.0000	0.40412 0.1352	0.42921 0.1104	0.18247 0.5151	0.08229 0.7706	0.43957 0.1011	0.33423 0.2234	0.53984 0.0378	0.28801 0.2979	0.05993 0.8320	0.07431 0.7924	0.34436 0.2088
IP12PCT	0.40412 0.1352	1.00000 0.0000	0.16248 0.5629	-0.18996 0.4977	-0.53226 0.0411	-0.05381 0.8489	-0.25425 0.3605	-0.06726 0.8117	0.53853 0.0383	0.25627 0.3565	-0.01256 0.9646	-0.37634 0.1668
IP13PCT	0.42921 0.1104	0.16248 0.5629	1.00000 0.0000	0.54480 0.0357	-0.17384 0.5355	-0.32825 0.2323	-0.30260 0.2730	0.18296 0.5140	0.39068 0.1499	-0.36470 0.1814	0.50852 0.0529	-0.09946 0.7243
ABA1PCT	0.18247 0.5151	-0.18996 0.4977	0.54480 0.0357	1.00000 0.0000	0.57424 0.0252	0.05730 0.8393	-0.31814 0.2478	0.13966 0.6196	0.37388 0.1698	-0.08497 0.7633	0.51835 0.0478	0.21020 0.4521
ABA2PCT	0.08229 0.7706	-0.53226 0.0411	-0.17384 0.5355	0.57424 0.0252	1.00000 0.0000	0.41540 0.1236	0.37891 0.1637	0.11459 0.6843	0.02862 0.9193	0.06172 0.8270	0.10116 0.7198	0.64311 0.0097
ABA3PCT	0.43957 0.1011	-0.05381 0.8489	-0.32825 0.2323	0.05730 0.8393	0.41540 0.1236	1.00000 0.0000	0.25939 0.3505	0.57527 0.0249	0.03581 0.8992	0.31961 0.2456	-0.06004 0.8317	0.29991 0.2775
IT11PCT	0.33423 0.2234	-0.25425 0.3605	-0.30260 0.2730	-0.31814 0.2478	0.37891 0.1637	0.25939 0.3505	1.00000 0.0000	-0.00179 0.9950	-0.18767 0.5030	0.10724 0.7036	-0.22004 0.4307	0.53262 0.0409
IT12PCT	0.53984 0.0378	-0.06726 0.8117	0.18296 0.5140	0.13966 0.6196	0.11459 0.6843	0.57527 0.0249	-0.00179 0.9950	1.00000 0.0000	-0.22560 0.4188	0.09311 0.7414	0.18996 0.4977	0.37780 0.1650
IT13PCT	0.28801 0.2979	0.53853 0.0383	0.39068 0.1499	0.37388 0.1698	0.02862 0.9193	0.03581 0.8992	-0.18767 0.5030	-0.22560 0.4188	1.00000 0.0000	-0.00358 0.9899	0.46016 0.0844	-0.35242 0.1976
IBI1PCT	0.05993 0.8320	0.25627 0.3565	-0.36470 0.1814	-0.08497 0.7633	0.06172 0.8270	0.31961 0.2456	0.10724 0.7036	0.09311 0.7414	-0.00358 0.9899	1.00000 0.0000	0.13966 0.6196	0.11986 0.6705
IBI2PCT	0.07431 0.7924	-0.01256 0.9646	0.50852 0.0529	0.51835 0.0478	0.10116 0.7198	-0.06004 0.8317	-0.22004 0.4307	0.18996 0.4977	0.46016 0.0844	0.13966 0.6196	1.00000 0.0000	-0.10206 0.7174
IBI3PCT	0.34436 0.2088	-0.37634 0.1668	-0.09946 0.7243	0.21020 0.4521	0.64311 0.0097	0.29991 0.2775	0.53262 0.0409	0.37780 0.1650	-0.35242 0.1976	0.11986 0.6705	-0.10206 0.7174	1.00000 0.0000

Fig. 19a(iii) Group 1 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho=0$ / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 14	0.85114 0.0004 12	0.24009 0.4084 14	0.13861 0.6365 14	0.32231 0.2828 13	0.01213 0.9672 14	0.81608 0.0004 14	0.72167 0.0036 14	0.49119 0.0745 14	-0.25991 0.3695 14	0.56167 0.0366 14	0.09031 0.7588 14
APA2PCT	0.85114 0.0004 12	1.00000 0.0000 13	0.10744 0.7268 13	-0.12380 0.6870 13	0.27510 0.3630 13	-0.32276 0.2821 13	0.70248 0.0074 13	0.75929 0.0026 13	0.41681 0.1777 12	-0.24518 0.4424 12	0.24380 0.4222 13	-0.07989 0.7953 13
APA3PCT	0.24009 0.4084 14	0.10744 0.7268 13	1.00000 0.0000 15	-0.18945 0.4989 15	0.17841 0.5417 14	0.36079 0.1865 15	0.18962 0.4985 15	0.28597 0.3015 15	0.57269 0.0323 14	-0.39758 0.1592 14	-0.00894 0.9748 15	0.43470 0.1054 15
ADA1PCT	0.13861 0.6365 14	-0.12380 0.6870 13	-0.18945 0.4989 15	1.00000 0.0000 15	0.23762 0.4133 14	0.37925 0.1633 15	0.30206 0.2739 15	-0.00357 0.9899 15	-0.00660 0.9821 14	0.16282 0.5781 14	0.28597 0.3015 15	0.26631 0.3374 15
ADA2PCT	0.32231 0.2828 13	0.27510 0.3630 13	0.17841 0.5417 14	0.23762 0.4133 14	1.00000 0.0000 14	0.35391 0.2144 14	0.24229 0.4039 14	0.10781 0.7137 14	-0.25069 0.4087 13	0.27961 0.3548 13	0.45705 0.1004 14	0.15639 0.5934 14
ADA3PCT	0.01213 0.9672 14	-0.32276 0.2821 13	0.36079 0.1865 15	0.37925 0.1633 15	0.35391 0.2144 14	1.00000 0.0000 15	0.14951 0.5949 15	-0.04293 0.8792 15	0.40353 0.1525 14	0.44983 0.1066 14	-0.17099 0.5423 15	0.29006 0.2943 15
ATA1PCT	0.81608 0.0004 14	0.70248 0.0074 13	0.18962 0.4985 15	0.30206 0.2739 15	0.24229 0.4039 14	0.14951 0.5949 15	1.00000 0.0000 15	0.61662 0.0144 15	0.51982 0.0567 14	-0.15418 0.5987 14	0.37388 0.1698 15	-0.09839 0.7272 15
ATA2PCT	0.72167 0.0036 14	0.75929 0.0026 13	0.28597 0.3015 15	-0.00357 0.9899 15	0.10781 0.7137 14	-0.04293 0.8792 15	0.61662 0.0144 15	1.00000 0.0000 15	0.58526 0.0279 14	-0.42244 0.1324 14	0.12869 0.6476 15	-0.10724 0.7036 15
ATA3PCT	0.49119 0.0745 14	0.41681 0.1777 12	0.57269 0.0323 14	-0.00660 0.9821 14	-0.25069 0.4087 13	0.40353 0.1525 14	0.51982 0.0567 14	0.58526 0.0279 14	1.00000 0.0000 14	-0.40969 0.1457 14	-0.17291 0.5544 14	0.23018 0.4286 14
IDI1PCT	-0.25991 0.3695 14	-0.24518 0.4424 12	-0.39758 0.1592 14	0.16282 0.5781 14	0.27961 0.3548 13	0.44983 0.1066 14	-0.15418 0.5987 14	-0.42244 0.1324 14	-0.40969 0.1457 14	1.00000 0.0000 14	-0.12445 0.6716 14	0.04185 0.8870 14
IDI2PCT	0.56167 0.0366 14	0.24380 0.4222 13	-0.00894 0.9748 15	0.28597 0.3015 15	0.45705 0.1004 14	-0.17099 0.5423 15	0.37388 0.1698 15	0.12869 0.6476 15	-0.17291 0.5544 14	-0.12445 0.6716 14	1.00000 0.0000 15	0.26476 0.3403 15
IDI3PCT	0.09031 0.7588 14	-0.07989 0.7953 13	0.43470 0.1054 15	0.26631 0.3374 15	0.15639 0.5934 14	0.29006 0.2943 15	-0.09839 0.7272 15	-0.10724 0.7036 15	0.23018 0.4286 14	0.04185 0.8870 14	0.26476 0.3403 15	1.00000 0.0000 15
PCT	0.76128 0.0016 14	0.71252 0.0063 13	-0.02324 0.9345 15	0.05357 0.8496 15	0.11221 0.7025 14	0.05009 0.8593 15	0.55943 0.0301 15	0.70357 0.0034 15	0.40044 0.1560 14	0.09021 0.7591 14	0.25916 0.3510 15	0.01966 0.9446 15

Fig. 19b(i) Results of the Spearman's correlations for experiment three in Group 2.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IP12PCT	0.53965 0.0464 14	0.63085 0.0208 13	0.42576 0.1136 15	-0.24129 0.3863 15	0.24670 0.3952 14	0.38675 0.1544 15	0.45438 0.0888 15	0.52368 0.0451 15	0.76101 0.0016 14	-0.12996 0.6579 14	-0.10555 0.7081 15	0.11002 0.6963 15
IP13PCT	0.04683 0.8792 13	0.11228 0.7283 12	0.51101 0.0618 14	-0.07481 0.7994 14	0.34711 0.2452 13	0.50827 0.0635 14	0.02863 0.9226 14	0.32123 0.2628 14	0.26997 0.3724 13	0.34435 0.2493 13	-0.22687 0.4354 14	0.27643 0.3387 14
ABA1PCT	-0.21562 0.4591 14	0.16506 0.5900 13	-0.25380 0.3614 15	0.33571 0.2212 15	0.52145 0.0558 14	0.26655 0.3369 15	-0.07685 0.7854 15	0.10000 0.7229 15	-0.27503 0.3413 14	0.47525 0.0859 14	-0.04290 0.8794 15	0.00357 0.9899 15
ABA2PCT	0.61826 0.0184 14	0.56946 0.0422 13	0.13762 0.6248 15	0.55000 0.0337 15	0.47965 0.0826 14	0.17174 0.5405 15	0.57730 0.0242 15	0.57500 0.0249 15	0.30583 0.2876 14	-0.13201 0.6528 14	0.32708 0.2341 15	0.14120 0.6157 15
ABA3PCT	-0.07701 0.7936 14	-0.13755 0.6541 13	0.49866 0.0585 15	0.25000 0.3688 15	0.32783 0.2525 14	0.76387 0.0009 15	-0.13047 0.6430 15	-0.07857 0.7808 15	0.33003 0.2492 14	0.30143 0.2950 14	-0.16622 0.5538 15	0.58803 0.0211 15
ITI1PCT	0.64097 0.0135 14	0.66942 0.0123 13	0.01431 0.9596 15	-0.04111 0.8843 15	0.00551 0.9851 14	-0.02238 0.9369 15	0.52236 0.0458 15	0.76318 0.0009 15	0.39427 0.1630 14	-0.07599 0.7963 14	-0.00805 0.9773 15	-0.28086 0.3106 15
ITI2PCT	0.77093 0.0012 14	0.73906 0.0060 12	0.41189 0.1434 14	0.00220 0.9940 14	0.02204 0.9430 13	0.20948 0.4723 14	0.54185 0.0453 14	0.73047 0.0030 14	0.76652 0.0014 14	-0.29075 0.3132 14	0.18722 0.5216 14	0.27093 0.3488 14
ITI3PCT	-0.03315 0.9104 14	-0.20937 0.4924 13	0.71570 0.0027 15	-0.18638 0.5060 15	0.14537 0.6200 14	0.49910 0.0582 15	-0.24574 0.3773 15	0.03226 0.9091 15	0.32707 0.2537 14	-0.00884 0.9761 14	-0.22063 0.4294 15	0.48610 0.0662 15
IBI1PCT	0.43784 0.1174 14	0.44056 0.1517 12	0.08361 0.7763 14	-0.02857 0.9228 14	0.51719 0.0703 13	0.03304 0.9107 14	0.55006 0.0416 14	0.49451 0.0722 14	0.23322 0.4223 14	-0.15182 0.6044 14	0.42244 0.1324 14	-0.01980 0.9464 14
IBI2PCT	0.15639 0.5934 14	0.25069 0.4087 13	0.36136 0.1857 15	0.09473 0.7370 15	0.22687 0.4354 14	0.40107 0.1384 15	0.27549 0.3203 15	0.13762 0.6248 15	0.45925 0.0985 14	0.11013 0.7078 14	0.04472 0.8743 15	0.53578 0.0395 15
IBI3PCT	-0.16667 0.6047 12	-0.22374 0.5084 11	0.15565 0.6116 13	-0.31362 0.2967 13	0.46667 0.1262 12	0.21931 0.4716 13	-0.36501 0.2201 13	-0.03026 0.9218 13	-0.15789 0.6241 12	0.29474 0.3524 12	0.06336 0.8371 13	0.33563 0.2622 13
	IP11PCT	IP12PCT	IP13PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.76128 0.0016 14	0.53965 0.0464 14	0.04683 0.8792 13	-0.21562 0.4591 14	0.61826 0.0184 14	-0.07701 0.7936 14	0.64097 0.0135 14	0.77093 0.0012 14	-0.03315 0.9104 14	0.43784 0.1174 14	0.15639 0.5934 14	-0.16667 0.6047 12

Fig. 19b(ii) Group 2 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	0.71252 0.0063 13	0.63085 0.0208 13	0.11228 0.7283 12	0.16506 0.5900 13	0.56946 0.0422 13	-0.13755 0.6541 13	0.66942 0.0123 13	0.73906 0.0060 12	-0.20937 0.4924 13	0.44056 0.1517 12	0.25069 0.4087 13	-0.22374 0.5084 11
APA3PCT	-0.02324 0.9345 15	0.42576 0.1136 15	0.51101 0.0618 14	-0.25380 0.3614 15	0.13762 0.6248 15	0.49866 0.0585 15	0.01431 0.9596 15	0.41189 0.1434 14	0.71570 0.0027 15	0.08361 0.7763 14	0.36136 0.1857 15	0.15565 0.6116 13
ADA1PCT	0.05357 0.8496 15	-0.24129 0.3863 15	-0.07481 0.7994 14	0.33571 0.2212 15	0.55000 0.0337 15	0.25000 0.3688 15	-0.04111 0.8843 15	0.00220 0.9940 14	-0.18638 0.5060 15	-0.02857 0.9228 14	0.09473 0.7370 15	-0.31362 0.2967 13
ADA2PCT	0.11221 0.7025 14	0.24670 0.3952 14	0.34711 0.2452 13	0.52145 0.0558 14	0.47965 0.0826 14	0.32783 0.2525 14	0.00551 0.9851 14	0.02204 0.9430 13	0.14537 0.6200 14	0.51719 0.0703 13	0.22687 0.4354 14	0.46667 0.1262 12
ADA3PCT	0.05009 0.8593 15	0.38675 0.1544 15	0.50827 0.0635 14	0.26655 0.3369 15	0.17174 0.5405 15	0.76387 0.0009 15	-0.02238 0.9369 15	0.20948 0.4723 14	0.49910 0.0582 15	0.03304 0.9107 14	0.40107 0.1384 15	0.21931 0.4716 13
ATA1PCT	0.55943 0.0301 15	0.45438 0.0888 15	0.02863 0.9226 14	-0.07685 0.7854 15	0.57730 0.0242 15	-0.13047 0.6430 15	0.52236 0.0458 15	0.54185 0.0453 14	-0.24574 0.3773 15	0.55006 0.0416 14	0.27549 0.3203 15	-0.36501 0.2201 13
ATA2PCT	0.70357 0.0034 15	0.52368 0.0451 15	0.32123 0.2628 14	0.10000 0.7229 15	0.57500 0.0249 15	-0.07857 0.7808 15	0.76318 0.0009 15	0.73047 0.0030 14	0.03226 0.9091 15	0.49451 0.0722 14	0.13762 0.6248 15	-0.03026 0.9218 13
ATA3PCT	0.40044 0.1560 14	0.76101 0.0016 14	0.26997 0.3724 13	-0.27503 0.3413 14	0.30583 0.2876 14	0.33003 0.2492 14	0.39427 0.1630 14	0.76652 0.0014 14	0.32707 0.2537 14	0.23322 0.4223 14	0.45925 0.0985 14	-0.15789 0.6241 12
ID11PCT	0.09021 0.7591 14	-0.12996 0.6579 14	0.34435 0.2493 13	0.47525 0.0859 14	-0.13201 0.6528 14	0.30143 0.2950 14	-0.07599 0.7963 14	-0.29075 0.3132 14	-0.00884 0.9761 14	-0.15182 0.6044 14	0.11013 0.7078 14	0.29474 0.3524 12
ID12PCT	0.25916 0.3510 15	-0.10555 0.7081 15	-0.22687 0.4354 14	-0.04290 0.8794 15	0.32708 0.2341 15	-0.16622 0.5538 15	-0.00805 0.9773 15	0.18722 0.5216 14	-0.22063 0.4294 15	0.42244 0.1324 14	0.04472 0.8743 15	0.06336 0.8371 13
ID13PCT	0.01966 0.9446 15	0.11002 0.6963 15	0.27643 0.3387 14	0.00357 0.9899 15	0.14120 0.6157 15	0.58803 0.0211 15	-0.28086 0.3106 15	0.27093 0.3488 14	0.48610 0.0662 15	-0.01980 0.9464 14	0.53578 0.0395 15	0.33563 0.2622 13
IP11PCT	1.00000 0.0000 15	0.50581 0.0544 15	0.27503 0.3413 14	0.12143 0.6664 15	0.53929 0.0380 15	-0.02143 0.9396 15	0.84540 0.0001 15	0.78988 0.0008 14	-0.06093 0.8292 15	0.18681 0.5225 14	0.14120 0.6157 15	0.00275 0.9929 13
IP12PCT	0.50581 0.0544 15	1.00000 0.0000 15	0.27283 0.3453 14	0.01609 0.9546 15	0.37712 0.1658 15	0.28597 0.3015 15	0.45796 0.0860 15	0.70815 0.0046 14	0.26009 0.3492 15	0.45765 0.0999 14	0.54204 0.0369 15	0.18432 0.5466 13

Fig. 19 b(iii) Group 2 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.27503 0.3413 14	0.27283 0.3453 14	1.00000 0.0000 14	0.24202 0.4045 14	-0.02200 0.9405 14	0.72827 0.0031 14	0.14758 0.6146 14	0.11554 0.7070 13	0.76686 0.0014 14	0.11279 0.7137 13	0.05941 0.8401 14	0.51719 0.0703 13
ABA1PCT	0.12143 0.6664 15	0.01609 0.9546 15	0.24202 0.4045 14	1.00000 0.0000 15	0.36786 0.1773 15	0.31071 0.2597 15	0.13584 0.6293 15	-0.14741 0.6150 14	-0.07527 0.7898 15	0.12967 0.6586 14	0.26631 0.3374 15	0.03026 0.9218 13
ABA2PCT	0.53929 0.0380 15	0.37712 0.1658 15	0.02200 0.9405 14	0.36786 0.1773 15	1.00000 0.0000 15	0.10000 0.7229 15	0.56479 0.0283 15	0.57206 0.0326 14	-0.18280 0.5143 15	0.29231 0.3105 14	0.31635 0.2507 15	-0.37414 0.2079 13
ABA3PCT	-0.02143 0.9396 15	0.28597 0.3015 15	0.72827 0.0031 14	0.31071 0.2597 15	0.10000 0.7229 15	1.00000 0.0000 15	-0.24307 0.3827 15	0.13641 0.6419 14	0.80287 0.0003 15	-0.12967 0.6586 14	0.30742 0.2650 15	0.37414 0.2079 13
ITI1PCT	0.84540 0.0001 15	0.45796 0.0860 15	0.14758 0.6146 14	0.13584 0.6293 15	0.56479 0.0283 15	-0.24307 0.3827 15	1.00000 0.0000 15	0.74780 0.0021 14	-0.19372 0.4891 15	0.11661 0.6914 14	0.07156 0.7999 15	-0.17355 0.5707 13
ITI2PCT	0.78988 0.0008 14	0.70815 0.0046 14	0.11554 0.7070 13	-0.14741 0.6150 14	0.57206 0.0326 14	0.13641 0.6419 14	0.74780 0.0021 14	1.00000 0.0000 14	0.17901 0.5403 14	0.20242 0.4877 14	0.44383 0.1119 14	-0.17163 0.5938 12
ITI3PCT	-0.06093 0.8292 15	0.26009 0.3492 15	0.76686 0.0014 14	-0.07527 0.7898 15	-0.18280 0.5143 15	0.80287 0.0003 15	-0.19372 0.4891 15	0.17901 0.5403 14	1.00000 0.0000 15	-0.19205 0.5107 14	0.07713 0.7847 15	0.49793 0.0833 13
IBI1PCT	0.18681 0.5225 14	0.45765 0.0999 14	0.11279 0.7137 13	0.12967 0.6586 14	0.29231 0.3105 14	-0.12967 0.6586 14	0.11661 0.6914 14	0.20242 0.4877 14	-0.19205 0.5107 14	1.00000 0.0000 14	0.40484 0.1510 14	0.24518 0.4424 12
IBI2PCT	0.14120 0.6157 15	0.54204 0.0369 15	0.05941 0.8401 14	0.26631 0.3374 15	0.31635 0.2507 15	0.30742 0.2650 15	0.07156 0.7999 15	0.44383 0.1119 14	0.07713 0.7847 15	0.40484 0.1510 14	1.00000 0.0000 15	-0.06878 0.8233 13
IBI3PCT	0.00275 0.9929 13	0.18432 0.5466 13	0.51719 0.0703 13	0.03026 0.9218 13	-0.37414 0.2079 13	0.37414 0.2079 13	-0.17355 0.5707 13	-0.17163 0.5938 12	0.49793 0.0833 13	0.24518 0.4424 12	-0.06878 0.8233 13	1.00000 0.0000 13

Fig. 19b(iv) Group 2 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 14	0.31567 0.2716 14	0.22456 0.4829 12	-0.06354 0.8366 13	0.14459 0.6219 14	-0.10193 0.7404 13	0.36825 0.1951 14	0.09655 0.7537 13	-0.54821 0.0524 13	-0.05234 0.8652 13	-0.03453 0.9108 13	-0.65264 0.0214 12
APA2PCT	0.31567 0.2716 14	1.00000 0.0000 15	-0.17332 0.5712 13	0.08811 0.7646 14	0.48969 0.0639 15	0.16722 0.5677 14	0.43432 0.1057 15	0.78548 0.0009 14	0.31463 0.2732 14	0.16062 0.5833 14	0.29736 0.3019 14	0.06593 0.8305 13
APA3PCT	0.22456 0.4829 12	-0.17332 0.5712 13	1.00000 0.0000 13	-0.21716 0.4978 12	-0.19337 0.5267 13	-0.01648 0.9574 13	-0.44505 0.1275 13	-0.58741 0.0446 12	-0.47802 0.0985 13	0.15385 0.6331 12	-0.03853 0.9054 12	-0.09091 0.7904 11
ADA1PCT	-0.06354 0.8366 13	0.08811 0.7646 14	-0.21716 0.4978 12	1.00000 0.0000 14	0.22542 0.4384 14	0.59422 0.0322 13	0.20242 0.4877 14	0.55846 0.0473 13	0.05777 0.8513 13	0.47868 0.0980 13	-0.34711 0.2452 13	-0.07356 0.8203 12
ADA2PCT	0.14459 0.6219 14	0.48969 0.0639 15	-0.19337 0.5267 13	0.22542 0.4384 14	1.00000 0.0000 15	0.40839 0.1471 14	0.12186 0.6653 15	0.72827 0.0031 14	0.32009 0.2646 14	0.28919 0.3160 14	0.58785 0.0270 14	-0.07735 0.8017 13
ADA3PCT	-0.10193 0.7404 13	0.16722 0.5677 14	-0.01648 0.9574 13	0.59422 0.0322 13	0.40839 0.1471 14	1.00000 0.0000 14	-0.14286 0.6261 14	0.46703 0.1076 13	0.26593 0.3581 14	0.28571 0.3440 13	0.37139 0.2115 13	0.39860 0.1993 12
ATA1PCT	0.36825 0.1951 14	0.43432 0.1057 15	-0.44505 0.1275 13	0.20242 0.4877 14	0.12186 0.6653 15	-0.14286 0.6261 14	1.00000 0.0000 15	0.41978 0.1351 14	-0.05495 0.8520 14	-0.00659 0.9822 14	-0.13201 0.6528 14	-0.17033 0.5780 13
ATA2PCT	0.09655 0.7537 13	0.78548 0.0009 14	-0.58741 0.0446 12	0.55846 0.0473 13	0.72827 0.0031 14	0.46703 0.1076 13	0.41978 0.1351 14	1.00000 0.0000 14	0.37912 0.2014 13	0.25824 0.3943 13	0.23626 0.4371 13	-0.04196 0.8970 12
ATA3PCT	-0.54821 0.0524 13	0.31463 0.2732 14	-0.47802 0.0985 13	0.05777 0.8513 13	0.32009 0.2646 14	0.26593 0.3581 14	-0.05495 0.8520 14	0.37912 0.2014 13	1.00000 0.0000 14	-0.09890 0.7479 13	0.54746 0.0528 13	0.49650 0.1006 12
IDI1PCT	-0.05234 0.8652 13	0.16062 0.5833 14	0.15385 0.6331 12	0.47868 0.0980 13	0.28919 0.3160 14	0.28571 0.3440 13	-0.00659 0.9822 14	0.25824 0.3943 13	-0.09890 0.7479 13	1.00000 0.0000 14	0.10454 0.7339 13	0.24476 0.4433 12
IDI2PCT	-0.03453 0.9108 13	0.29736 0.3019 14	-0.03853 0.9054 12	-0.34711 0.2452 13	0.58785 0.0270 14	0.37139 0.2115 13	-0.13201 0.6528 14	0.23626 0.4371 13	0.54746 0.0528 13	0.10454 0.7339 13	1.00000 0.0000 14	0.57793 0.0490 12
IDI3PCT	-0.65264 0.0214 12	0.06593 0.8305 13	-0.09091 0.7904 11	-0.07356 0.8203 12	-0.07735 0.8017 13	0.39860 0.1993 12	-0.17033 0.5780 13	-0.04196 0.8970 12	0.49650 0.1006 12	0.24476 0.4433 12	0.57793 0.0490 12	1.00000 0.0000 13
IDI1PCT	-0.07854 0.7896 14	0.43190 0.1079 15	-0.34207 0.2526 13	-0.15673 0.5926 14	0.41869 0.1204 15	-0.03308 0.9106 14	0.05551 0.8442 15	0.43440 0.1206 14	0.40574 0.1500 14	0.24449 0.3996 14	0.28225 0.3282 14	0.12397 0.6866 13

Fig. 19c(i) Results of the Spearman's correlations for experiment three in Group 3.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IP12PCT	0.26409 0.3616 14	0.69024 0.0044 15	-0.20633 0.4988 13	0.08159 0.7816 14	0.19569 0.4846 15	0.02423 0.9345 14	0.52415 0.0449 15	0.57206 0.0326 14	-0.05947 0.8400 14	0.25330 0.3822 14	-0.08490 0.7729 14	-0.07438 0.8092 13
IP13PCT	-0.02636 0.9352 12	0.42011 0.1529 13	-0.22767 0.4767 12	0.12121 0.6932 13	0.35408 0.2352 13	-0.00275 0.9929 13	0.27785 0.3580 13	0.49387 0.1027 12	0.05777 0.8513 13	-0.00701 0.9828 12	-0.18947 0.5553 12	-0.03645 0.9153 11
ABA1PCT	0.22075 0.4482 14	0.29428 0.2870 15	-0.08803 0.7749 13	0.53194 0.0502 14	0.45381 0.0893 15	0.26843 0.3535 14	0.00715 0.9798 15	0.47305 0.0876 14	0.18702 0.5220 14	0.34763 0.2233 14	-0.03524 0.9048 14	-0.42857 0.1440 13
ABA2PCT	0.15894 0.5873 14	0.47986 0.0703 15	-0.07989 0.7953 13	-0.34141 0.2322 14	-0.25673 0.3557 15	-0.50661 0.0645 14	0.48837 0.0647 15	0.01982 0.9464 14	0.14978 0.6093 14	-0.20705 0.4776 14	0.02315 0.9374 14	0.05777 0.8513 13
ABA3PCT	-0.10276 0.7267 14	0.39212 0.1483 15	-0.37964 0.2007 13	0.43109 0.1238 14	0.22801 0.4138 15	0.58966 0.0265 14	0.29159 0.2917 15	0.59031 0.0263 14	0.21562 0.4591 14	0.04185 0.8870 14	0.15656 0.5930 14	0.30854 0.3050 13
II11PCT	-0.43213 0.1403 13	0.15453 0.5979 14	-0.40071 0.1968 12	0.21793 0.4744 13	0.25249 0.3838 14	0.26759 0.3768 13	0.22051 0.4487 14	0.34711 0.2452 13	0.29242 0.3323 13	0.07714 0.8022 13	0.16575 0.5884 13	0.42456 0.1689 12
II12PCT	0.24033 0.4290 13	0.25771 0.3737 14	-0.21429 0.4821 13	-0.12397 0.6866 13	0.42873 0.1261 14	-0.06044 0.8445 13	0.53685 0.0478 14	0.23659 0.4364 13	0.11538 0.7074 13	0.12088 0.6940 13	0.31680 0.2916 13	-0.02802 0.9311 12
II13PCT	-0.25828 0.3726 14	0.18722 0.5216 14	-0.66200 0.0190 12	-0.00689 0.9822 13	0.31938 0.2657 14	0.12105 0.6936 13	0.23982 0.4089 14	0.51444 0.0721 13	0.20083 0.5106 13	0.11554 0.7070 13	0.22558 0.4587 13	0.37828 0.2253 12
IB11PCT	-0.00882 0.9761 14	0.11260 0.6895 15	-0.07143 0.8166 13	-0.55226 0.0406 14	0.31900 0.2465 15	-0.08132 0.7823 14	-0.34643 0.2059 15	0.02857 0.9228 14	0.39341 0.1640 14	-0.32747 0.2531 14	0.69307 0.0060 14	0.11538 0.7074 13
IB12PCT	0.20250 0.5070 13	0.28950 0.3154 14	-0.26620 0.4030 12	0.34025 0.2553 13	0.30276 0.2927 14	0.13480 0.6606 13	0.27594 0.3396 14	0.47020 0.0898 14	-0.01926 0.9502 13	0.34938 0.2420 13	0.19337 0.5267 13	-0.15493 0.6307 12
IB13PCT	0.40089 0.1554 14	0.39103 0.1495 15	-0.21547 0.4796 13	0.15969 0.5855 14	0.37050 0.1740 15	0.09051 0.7583 14	0.17563 0.5313 15	0.42164 0.1332 14	-0.01104 0.9701 14	0.24945 0.3898 14	0.17459 0.5505 14	-0.06327 0.8373 13
IPI1PCT		IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	-0.07854 0.7896 14	0.26409 0.3616 14	-0.02636 0.9352 12	0.22075 0.4482 14	0.15894 0.5873 14	-0.10276 0.7267 14	-0.43213 0.1403 13	0.24033 0.4290 13	-0.25828 0.3726 14	-0.00882 0.9761 14	0.20250 0.5070 13	0.40089 0.1554 14

Fig. 19c(ii) Group 3 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	0.43190 0.1079 15	0.69024 0.0044 15	0.42011 0.1529 13	0.29428 0.2870 15	0.47986 0.0703 15	0.39212 0.1483 15	0.15453 0.5979 14	0.25771 0.3737 14	0.18722 0.5216 14	0.11260 0.6895 15	0.28950 0.3154 14	0.39103 0.1495 15
APA3PCT	-0.34207 0.2526 13	-0.20633 0.4988 13	-0.22767 0.4767 12	-0.08803 0.7749 13	-0.07989 0.7953 13	-0.37964 0.2007 13	-0.40071 0.1968 12	-0.21429 0.4821 13	-0.66200 0.0190 12	-0.07143 0.8166 13	-0.26620 0.4030 12	-0.21547 0.4796 13
ADA1PCT	-0.15673 0.5926 14	0.08159 0.7816 14	0.12121 0.6932 13	0.53194 0.0502 14	-0.34141 0.2322 14	0.43109 0.1238 14	0.21793 0.4744 13	-0.12397 0.6866 13	-0.00689 0.9822 13	-0.55226 0.0406 14	0.34025 0.2553 13	0.15969 0.5855 14
ADA2PCT	0.41869 0.1204 15	0.19569 0.4846 15	0.35408 0.2352 13	0.45381 0.0893 15	-0.25673 0.3557 15	0.22801 0.4138 15	0.25249 0.3838 14	0.42873 0.1261 14	0.31938 0.2657 14	0.31900 0.2465 15	0.30276 0.2927 14	0.37050 0.1740 15
ADA3PCT	-0.03308 0.9106 14	0.02423 0.9345 14	-0.00275 0.9929 13	0.26843 0.3535 14	-0.50661 0.0645 14	0.58966 0.0265 14	0.26759 0.3768 13	-0.06044 0.8445 13	0.12105 0.6936 13	-0.08132 0.7823 14	0.13480 0.6606 13	0.09051 0.7583 14
ATA1PCT	0.05551 0.8442 15	0.52415 0.0449 15	0.27785 0.3580 13	0.00715 0.9798 15	0.48837 0.0647 15	0.29159 0.2917 15	0.22051 0.4487 14	0.53685 0.0478 14	0.23982 0.4089 14	-0.34643 0.2059 15	0.27594 0.3396 14	0.17563 0.5313 15
ATA2PCT	0.43440 0.1206 14	0.57206 0.0326 14	0.49387 0.1027 12	0.47305 0.0876 14	0.01982 0.9464 14	0.59031 0.0263 14	0.34711 0.2452 13	0.23659 0.4364 13	0.51444 0.0721 13	0.02857 0.9228 14	0.47020 0.0898 14	0.42164 0.1332 14
ATA3PCT	0.40574 0.1500 14	-0.05947 0.8400 14	0.05777 0.8513 13	0.18702 0.5220 14	0.14978 0.6093 14	0.21562 0.4591 14	0.29242 0.3323 13	0.11538 0.7074 13	0.20083 0.5106 13	0.39341 0.1640 14	-0.01926 0.9502 13	-0.01104 0.9701 14
ID11PCT	0.24449 0.3996 14	0.25330 0.3822 14	-0.00701 0.9828 12	0.34763 0.2233 14	-0.20705 0.4776 14	0.04185 0.8870 14	0.07714 0.8022 13	0.12088 0.6940 13	0.11554 0.7070 13	-0.32747 0.2531 14	0.34938 0.2420 13	0.24945 0.3898 14
ID12PCT	0.28225 0.3282 14	-0.08490 0.7729 14	-0.18947 0.5553 12	-0.03524 0.9048 14	0.02315 0.9374 14	0.15656 0.5930 14	0.16575 0.5884 13	0.31680 0.2916 13	0.22558 0.4587 13	0.69307 0.0060 14	0.19337 0.5267 13	0.17459 0.5505 14
ID13PCT	0.12397 0.6866 13	-0.07438 0.8092 13	-0.03645 0.9153 11	-0.42857 0.1440 13	0.05777 0.8513 13	0.30854 0.3050 13	0.42456 0.1689 12	-0.02802 0.9311 12	0.37828 0.2253 12	0.11538 0.7074 13	-0.15493 0.6307 12	-0.06327 0.8373 13
IP11PCT	1.00000 0.0000 15	0.21525 0.4410 15	0.34531 0.2479 13	0.46505 0.0807 15	-0.08520 0.7627 15	0.00179 0.9949 15	0.55028 0.0415 14	0.32782 0.2525 14	0.10155 0.7298 14	0.08594 0.7607 15	0.08638 0.7691 14	0.69003 0.0044 15
IP12PCT	0.21525 0.4410 15	1.00000 0.0000 15	0.68966 0.0091 13	0.02328 0.9344 15	0.42115 0.1180 15	0.62993 0.0118 15	0.05414 0.8541 14	0.18943 0.5166 14	0.52260 0.0552 14	-0.13417 0.6336 15	0.46630 0.0928 14	0.26212 0.3453 15

Fig. 19c(iii) Group 3 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.34531 0.2479 13	0.68966 0.0091 13	1.00000 0.0000 13	0.15978 0.6021 13	-0.07713 0.8022 13	0.62397 0.0227 13	0.34507 0.2720 12	0.14361 0.6561 12	0.55789 0.0594 12	-0.03301 0.9147 13	0.29123 0.3584 12	0.29477 0.3282 13
ABA1PCT	0.46505 0.0807 15	0.02328 0.9344 15	0.15978 0.6021 13	1.00000 0.0000 15	-0.38138 0.1607 15	0.05461 0.8467 15	-0.03308 0.9106 14	-0.02863 0.9226 14	-0.26322 0.3632 14	-0.06971 0.8050 15	0.37127 0.1912 14	0.49148 0.0628 15
ABA2PCT	-0.08520 0.7627 15	0.42115 0.1180 15	-0.07713 0.8022 13	-0.38138 0.1607 15	1.00000 0.0000 15	-0.06093 0.8292 15	-0.13702 0.6404 14	0.22271 0.4441 14	0.08150 0.7818 14	0.09839 0.7272 15	-0.04867 0.8688 14	-0.10054 0.7215 15
ABA3PCT	0.00179 0.9949 15	0.62993 0.0118 15	0.62397 0.0227 13	0.05461 0.8467 15	-0.06093 0.8292 15	1.00000 0.0000 15	0.27042 0.3498 14	-0.06725 0.8193 14	0.61632 0.0189 14	-0.08766 0.7561 15	0.51991 0.0567 14	0.12567 0.6554 15
ITI1PCT	0.55028 0.0415 14	0.05414 0.8541 14	0.34507 0.2720 12	-0.03308 0.9106 14	-0.13702 0.6404 14	0.27042 0.3498 14	1.00000 0.0000 14	0.53177 0.0614 13	0.22621 0.4574 13	-0.33738 0.2381 14	-0.25208 0.4061 13	0.45183 0.1048 14
ITI2PCT	0.32782 0.2525 14	0.18943 0.5166 14	0.14361 0.6561 12	-0.02863 0.9226 14	0.22271 0.4441 14	-0.06725 0.8193 14	0.53177 0.0614 13	1.00000 0.0000 14	0.22314 0.4637 13	-0.10341 0.7250 14	-0.22130 0.4675 13	0.34696 0.2242 14
ITI3PCT	0.10155 0.7298 14	0.52260 0.0552 14	0.55789 0.0594 12	-0.26322 0.3632 14	0.08150 0.7818 14	0.61632 0.0189 14	0.22621 0.4574 13	0.22314 0.4637 13	1.00000 0.0000 14	0.31243 0.2768 14	0.35408 0.2352 13	0.07072 0.8101 14
IBI1PCT	0.08594 0.7607 15	-0.13417 0.6336 15	-0.03301 0.9147 13	-0.06971 0.8050 15	0.09839 0.7272 15	-0.08766 0.7561 15	-0.33738 0.2381 14	-0.10341 0.7250 14	0.31243 0.2768 14	1.00000 0.0000 15	0.12583 0.6682 14	-0.01434 0.9596 15
IBI2PCT	0.08638 0.7691 14	0.46630 0.0928 14	0.29123 0.3584 12	0.37127 0.1912 14	-0.04867 0.8688 14	0.51991 0.0567 14	-0.25208 0.4061 13	-0.22130 0.4675 13	0.35408 0.2352 13	0.12583 0.6682 14	1.00000 0.0000 14	0.34368 0.2289 14
IBI3PCT	0.69003 0.0044 15	0.26212 0.3453 15	0.29477 0.3282 13	0.49148 0.0628 15	-0.10054 0.7215 15	0.12567 0.6554 15	0.45183 0.1048 14	0.34696 0.2242 14	0.07072 0.8101 14	-0.01434 0.9596 15	0.34368 0.2289 14	1.00000 0.0000 15

Fig. 19c(iv) Group 3 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H₀:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 14	0.59121 0.0260 14	0.70879 0.0067 13	0.31429 0.2738 14	0.10454 0.7339 13	0.46189 0.0964 14	0.67912 0.0076 14	0.58966 0.0265 14	0.52527 0.0537 14	0.49244 0.0873 13	0.12088 0.6806 14	-0.11648 0.6917 14
APA2PCT	0.59121 0.0260 14	1.00000 0.0000 15	0.59121 0.0260 14	0.25357 0.3618 15	0.16502 0.5729 14	0.06278 0.8241 15	0.35714 0.1913 15	0.26452 0.3407 15	0.60000 0.0181 15	0.64246 0.0132 14	0.36071 0.1866 15	0.03571 0.8994 15
APA3PCT	0.70879 0.0067 13	0.59121 0.0260 14	1.00000 0.0000 14	0.53407 0.0492 14	0.19231 0.5291 13	0.47294 0.0877 14	0.69231 0.0061 14	0.66887 0.0089 14	0.53407 0.0492 14	0.55571 0.0486 13	-0.01538 0.9584 14	0.03297 0.9109 14
ADA1PCT	0.31429 0.2738 14	0.25357 0.3618 15	0.53407 0.0492 14	1.00000 0.0000 15	0.43124 0.1237 14	0.48790 0.0650 15	0.40714 0.1320 15	0.62198 0.0133 15	0.49643 0.0598 15	0.25303 0.3828 14	0.03929 0.8894 15	-0.05000 0.8595 15
ADA2PCT	0.10454 0.7339 13	0.16502 0.5729 14	0.19231 0.5291 13	0.43124 0.1237 14	1.00000 0.0000 14	0.29646 0.3034 14	0.19362 0.5072 14	0.37996 0.1802 14	0.17602 0.5472 14	0.27273 0.3673 13	0.58086 0.0294 14	0.43344 0.1216 14
ADA3PCT	0.46189 0.0964 14	0.06278 0.8241 15	0.47294 0.0877 14	0.48790 0.0650 15	0.29646 0.3034 14	1.00000 0.0000 15	0.49687 0.0595 15	0.68223 0.0051 15	0.40897 0.1301 15	0.26549 0.3589 14	-0.05022 0.8589 15	0.04126 0.8839 15
ATA1PCT	0.67912 0.0076 14	0.35714 0.1913 15	0.69231 0.0061 14	0.40714 0.1320 15	0.19362 0.5072 14	0.49687 0.0595 15	1.00000 0.0000 15	0.46828 0.0783 15	0.53929 0.0380 15	0.48845 0.0764 14	0.09643 0.7325 15	-0.15714 0.5760 15
ATA2PCT	0.58966 0.0265 14	0.26452 0.3407 15	0.66887 0.0089 14	0.62198 0.0133 15	0.37996 0.1802 14	0.68223 0.0051 15	0.46828 0.0783 15	1.00000 0.0000 15	0.44861 0.0935 15	0.37665 0.1844 14	0.21984 0.4311 15	0.15192 0.5889 15
ATA3PCT	0.52527 0.0537 14	0.60000 0.0181 15	0.53407 0.0492 14	0.49643 0.0598 15	0.17602 0.5472 14	0.40897 0.1301 15	0.53929 0.0380 15	0.44861 0.0935 15	1.00000 0.0000 15	0.75028 0.0020 14	0.32500 0.2372 15	0.09643 0.7325 15
IDI1PCT	0.49244 0.0873 13	0.64246 0.0132 14	0.55571 0.0486 13	0.25303 0.3828 14	0.27273 0.3673 13	0.26549 0.3589 14	0.48845 0.0764 14	0.37665 0.1844 14	0.75028 0.0020 14	1.00000 0.0000 14	0.51045 0.0622 14	0.24642 0.3957 14
IDI2PCT	0.12088 0.6806 14	0.36071 0.1866 15	-0.01538 0.9584 14	0.03929 0.8894 15	0.58086 0.0294 14	-0.05022 0.8589 15	0.09643 0.7325 15	0.21984 0.4311 15	0.32500 0.2372 15	0.51045 0.0622 14	1.00000 0.0000 15	0.62143 0.0134 15
IDI3PCT	-0.11648 0.6917 14	0.03571 0.8994 15	0.03297 0.9109 14	-0.05000 0.8595 15	0.43344 0.1216 14	0.04126 0.8839 15	-0.15714 0.5760 15	0.15192 0.5889 15	0.09643 0.7325 15	0.24642 0.3957 14	0.62143 0.0134 15	1.00000 0.0000 15
IDI1PCT	0.43736 0.1178 14	0.65000 0.0087 15	0.63077 0.0156 14	0.17143 0.5413 15	0.10561 0.7194 14	0.15964 0.5698 15	0.39643 0.1435 15	0.35389 0.1956 15	0.46071 0.0839 15	0.40484 0.1510 14	0.17857 0.5243 15	0.28929 0.2957 15

Fig. 19d(i) Results of the Spearman's correlations for experiment three in Group 4.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IP12PCT	0.49945 0.0690 14	0.21805 0.4350 15	0.29263 0.3100 14	0.11439 0.6848 15	0.06388 0.8283 14	0.21365 0.4445 15	0.05541 0.8445 15	0.33095 0.2282 15	0.12869 0.6476 15	0.29515 0.3056 14	0.13762 0.6248 15	0.33959 0.2156 15
IP13PCT	0.60440 0.0221 14	0.51429 0.0498 15	0.78022 0.0010 14	0.45357 0.0895 15	-0.03960 0.8931 14	0.19014 0.4973 15	0.56429 0.0284 15	0.33601 0.2208 15	0.51786 0.0480 15	0.32563 0.2559 14	-0.21429 0.4431 15	-0.28214 0.3083 15
ABA1PCT	0.26872 0.3529 14	-0.00358 0.9899 15	0.27283 0.3453 14	0.13596 0.6290 15	0.74421 0.0023 14	0.24708 0.3746 15	0.27370 0.3236 15	0.44584 0.0958 15	-0.06082 0.8295 15	0.23899 0.4106 14	0.37209 0.1720 15	0.40072 0.1388 15
ABA2PCT	0.41364 0.1415 14	0.15907 0.5712 15	0.10561 0.7194 14	-0.11975 0.6708 15	0.08811 0.7646 14	0.22262 0.4252 15	0.69348 0.0041 15	0.08945 0.7512 15	0.12690 0.6522 15	0.04626 0.8752 14	0.22163 0.4273 15	-0.21269 0.4466 15
ABA3PCT	0.06608 0.8224 14	0.19141 0.4944 15	0.35242 0.2165 14	0.13059 0.6427 15	0.48732 0.0771 14	0.55616 0.0313 15	0.38283 0.1590 15	0.37511 0.1683 15	0.11986 0.6705 15	0.44212 0.1134 14	0.13059 0.6427 15	0.11449 0.6845 15
ITI1PCT	0.70847 0.0046 14	0.72922 0.0020 15	0.84268 0.0002 14	0.60590 0.0167 15	0.32123 0.2628 14	0.38600 0.1553 15	0.63628 0.0108 15	0.61717 0.0142 15	0.61126 0.0155 15	0.73568 0.0027 14	0.38070 0.1615 15	0.18231 0.5155 15
ITI2PCT	0.48571 0.0783 14	0.59643 0.0189 15	0.74066 0.0024 14	0.24286 0.3831 15	0.11441 0.6969 14	-0.10224 0.7169 15	0.33571 0.2212 15	0.30384 0.2709 15	0.23571 0.3977 15	0.62266 0.0174 14	0.25000 0.3688 15	0.20000 0.4748 15
ITI3PCT	0.64099 0.0182 13	0.76128 0.0016 14	0.83907 0.0003 13	0.45325 0.1036 14	0.51982 0.0567 14	0.28761 0.3187 14	0.45325 0.1036 14	0.61564 0.0191 14	0.63586 0.0145 14	0.75758 0.0027 13	0.51485 0.0596 14	0.46865 0.0910 14
IBI1PCT	0.65787 0.0105 14	-0.08043 0.7757 15	0.23516 0.4183 14	0.13047 0.6430 15	0.30286 0.2926 14	0.59067 0.0204 15	0.40393 0.1354 15	0.49016 0.0636 15	0.16622 0.5538 15	0.16960 0.5621 14	0.34853 0.2030 15	0.16265 0.5625 15
IBI2PCT	0.70702 0.0069 13	0.36524 0.1991 14	0.37689 0.2043 13	0.08581 0.7705 14	0.60248 0.0293 13	0.40930 0.1462 14	0.40264 0.1535 14	0.40924 0.1462 14	0.36084 0.2050 14	0.57576 0.0395 13	0.68867 0.0065 14	0.33883 0.2360 14
IBI3PCT	0.33663 0.2392 14	0.61305 0.0151 15	0.03960 0.8931 14	0.22341 0.4235 15	0.16740 0.5673 14	0.23878 0.3914 15	0.30563 0.2680 15	-0.01073 0.9697 15	0.52904 0.0426 15	0.45374 0.1032 14	0.49330 0.0617 15	0.23950 0.3899 15
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.43736 0.1178 14	0.49945 0.0690 14	0.60440 0.0221 14	0.26872 0.3529 14	0.41364 0.1415 14	0.06608 0.8224 14	0.70847 0.0046 14	0.48571 0.0783 14	0.64099 0.0182 13	0.65787 0.0105 14	0.70702 0.0069 13	0.33663 0.2392 14

Fig. 19d(ii) Group 4 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H₀:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	0.65000 0.0087 15	0.21805 0.4350 15	0.51429 0.0498 15	-0.00358 0.9899 15	0.15907 0.5712 15	0.19141 0.4944 15	0.72922 0.0020 15	0.59643 0.0189 15	0.76128 0.0016 14	-0.08043 0.7757 15	0.36524 0.1991 14	0.61305 0.0151 15
APA3PCT	0.63077 0.0156 14	0.29263 0.3100 14	0.78022 0.0010 14	0.27283 0.3453 14	0.10561 0.7194 14	0.35242 0.2165 14	0.84268 0.0002 14	0.74066 0.0024 14	0.83907 0.0003 13	0.23516 0.4183 14	0.37689 0.2043 13	0.03960 0.8931 14
ADA1PCT	0.17143 0.5413 15	0.11439 0.6848 15	0.45357 0.0895 15	0.13596 0.6290 15	-0.11975 0.6708 15	0.13059 0.6427 15	0.60590 0.0167 15	0.24286 0.3831 15	0.45325 0.1036 14	0.13047 0.6430 15	0.08581 0.7705 14	0.22341 0.4235 15
ADA2PCT	0.10561 0.7194 14	0.06388 0.8283 14	-0.03960 0.8931 14	0.74421 0.0023 14	0.08811 0.7646 14	0.48732 0.0771 14	0.32123 0.2628 14	0.11441 0.6969 14	0.51982 0.0567 14	0.30286 0.2926 14	0.60248 0.0293 13	0.16740 0.5673 14
ADA3PCT	0.15964 0.5698 15	0.21365 0.4445 15	0.19014 0.4973 15	0.24708 0.3746 15	0.22262 0.4252 15	0.55616 0.0313 15	0.38600 0.1553 15	-0.10224 0.7169 15	0.28761 0.3187 14	0.59067 0.0204 15	0.40930 0.1462 14	0.23878 0.3914 15
ATA1PCT	0.39643 0.1435 15	0.05541 0.8445 15	0.56429 0.0284 15	0.27370 0.3236 15	0.69348 0.0041 15	0.38283 0.1590 15	0.63628 0.0108 15	0.33571 0.2212 15	0.45325 0.1036 14	0.40393 0.1354 15	0.40264 0.1535 14	0.30563 0.2680 15
ATA2PCT	0.35389 0.1956 15	0.33095 0.2282 15	0.33601 0.2208 15	0.44584 0.0958 15	0.08945 0.7512 15	0.37511 0.1683 15	0.61717 0.0142 15	0.30384 0.2709 15	0.61564 0.0191 14	0.49016 0.0636 15	0.40924 0.1462 14	-0.01073 0.9697 15
ATA3PCT	0.46071 0.0839 15	0.12869 0.6476 15	0.51786 0.0480 15	-0.06082 0.8295 15	0.12690 0.6522 15	0.11986 0.6705 15	0.61126 0.0155 15	0.23571 0.3977 15	0.63586 0.0145 14	0.16622 0.5538 15	0.36084 0.2050 14	0.52904 0.0426 15
ID11PCT	0.40484 0.1510 14	0.29515 0.3056 14	0.32563 0.2559 14	0.23899 0.4106 14	0.04626 0.8752 14	0.44212 0.1134 14	0.73568 0.0027 14	0.62266 0.0174 14	0.75758 0.0027 13	0.16960 0.5621 14	0.57576 0.0395 13	0.45374 0.1032 14
ID12PCT	0.17857 0.5243 15	0.13762 0.6248 15	-0.21429 0.4431 15	0.37209 0.1720 15	0.22163 0.4273 15	0.13059 0.6427 15	0.38070 0.1615 15	0.25000 0.3688 15	0.51485 0.0596 14	0.34853 0.2030 15	0.68867 0.0065 14	0.49330 0.0617 15
ID13PCT	0.28929 0.2957 15	0.33959 0.2156 15	-0.28214 0.3083 15	0.40072 0.1388 15	-0.21269 0.4466 15	0.11449 0.6845 15	0.18231 0.5155 15	0.20000 0.4748 15	0.46865 0.0910 14	0.16265 0.5625 15	0.33883 0.2360 14	0.23950 0.3899 15
IP11PCT	1.00000 0.0000 15	0.48436 0.0673 15	0.55000 0.0337 15	0.09123 0.7464 15	0.15550 0.5800 15	0.25760 0.3540 15	0.60769 0.0163 15	0.63571 0.0109 15	0.77008 0.0013 14	-0.10188 0.7179 15	0.14962 0.6097 14	0.32350 0.2395 15
IP12PCT	0.48436 0.0673 15	1.00000 0.0000 15	0.03932 0.8893 15	0.29543 0.2851 15	-0.15921 0.5709 15	0.12534 0.6563 15	0.43292 0.1070 15	0.49151 0.0628 15	0.54405 0.0443 14	0.20751 0.4580 15	0.34251 0.2306 14	0.12880 0.6473 15

Fig. 19d(iii) Group 4 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.55000 0.0337 15	0.03932 0.8893 15	1.00000 0.0000 15	-0.11628 0.6798 15	0.09115 0.7466 15	-0.06798 0.8098 15	0.59875 0.0184 15	0.54643 0.0351 15	0.51485 0.0596 14	0.04111 0.8843 15	0.14301 0.6257 14	0.05362 0.8495 15
ABA1PCT	0.09123 0.7464 15	0.29543 0.2851 15	-0.11628 0.6798 15	1.00000 0.0000 15	0.17189 0.5402 15	0.57885 0.0238 15	0.31871 0.2470 15	0.29159 0.2917 15	0.44873 0.1075 14	0.33662 0.2199 15	0.52370 0.0546 14	-0.12981 0.6447 15
ABA2PCT	0.15550 0.5800 15	-0.15921 0.5709 15	0.09115 0.7466 15	0.17189 0.5402 15	1.00000 0.0000 15	0.25962 0.3501 15	0.16190 0.5643 15	-0.08758 0.7563 15	-0.01542 0.9583 14	0.44186 0.0991 15	0.31498 0.2727 14	0.35242 0.1976 15
ABA3PCT	0.25760 0.3540 15	0.12534 0.6563 15	-0.06798 0.8098 15	0.57885 0.0238 15	0.25962 0.3501 15	1.00000 0.0000 15	0.30260 0.2730 15	0.16637 0.5535 15	0.35281 0.2160 14	0.09400 0.7390 15	0.23925 0.4101 14	0.11817 0.6749 15
ITI1PCT	0.60769 0.0163 15	0.43292 0.1070 15	0.59875 0.0184 15	0.31871 0.2470 15	0.16190 0.5643 15	0.30260 0.2730 15	1.00000 0.0000 15	0.77927 0.0006 15	0.85369 0.0001 14	0.27013 0.3302 15	0.55286 0.0403 14	0.47764 0.0718 15
ITI2PCT	0.63571 0.0109 15	0.49151 0.0628 15	0.54643 0.0351 15	0.29159 0.2917 15	-0.08758 0.7563 15	0.16637 0.5535 15	0.77927 0.0006 15	1.00000 0.0000 15	0.73487 0.0028 14	-0.07149 0.8001 15	0.29703 0.3024 14	0.08400 0.7660 15
ITI3PCT	0.77008 0.0013 14	0.54405 0.0443 14	0.51485 0.0596 14	0.44873 0.1075 14	-0.01542 0.9583 14	0.35281 0.2160 14	0.85369 0.0001 14	0.73487 0.0028 14	1.00000 0.0000 14	0.13106 0.6552 14	0.59366 0.0324 13	0.31828 0.2674 14
IBI1PCT	-0.10188 0.7179 15	0.20751 0.4580 15	0.04111 0.8843 15	0.33662 0.2199 15	0.44186 0.0991 15	0.09400 0.7390 15	0.27013 0.3302 15	-0.07149 0.8001 15	0.13106 0.6552 14	1.00000 0.0000 15	0.85352 0.0001 14	0.16369 0.5600 15
IBI2PCT	0.14962 0.6097 14	0.34251 0.2306 14	0.14301 0.6257 14	0.52370 0.0546 14	0.31498 0.2727 14	0.23925 0.4101 14	0.55286 0.0403 14	0.29703 0.3024 14	0.59366 0.0324 13	0.85352 0.0001 14	1.00000 0.0000 14	0.35573 0.2119 14
IBI3PCT	0.32350 0.2395 15	0.12880 0.6473 15	0.05362 0.8495 15	-0.12981 0.6447 15	0.35242 0.1976 15	0.11817 0.6749 15	0.47764 0.0718 15	0.08400 0.7660 15	0.31828 0.2674 14	0.16369 0.5600 15	0.35573 0.2119 14	1.00000 0.0000 15

Fig. 19d(iv) Group 4 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER $H_0: \rho = 0$ / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 13	-0.22847 0.4751 12	0.34463 0.3295 10	0.31129 0.3005 13	0.39448 0.1822 13	-0.05023 0.8834 11	0.52982 0.0764 12	0.34737 0.2686 12	0.27854 0.4069 11	0.57991 0.0615 11	0.42382 0.1698 12	0.11872 0.7281 11
APA2PCT	-0.22847 0.4751 12	1.00000 0.0000 14	0.59448 0.0537 11	0.67034 0.0087 14	0.36825 0.1951 14	0.69947 0.0113 12	0.45793 0.1156 13	0.62897 0.0213 13	0.48155 0.1129 12	0.34798 0.2677 12	0.25344 0.4034 13	0.23902 0.4544 12
APA3PCT	0.34463 0.3295 10	0.59448 0.0537 11	1.00000 0.0000 12	0.82894 0.0009 12	0.71379 0.0091 12	0.62435 0.0300 12	0.64384 0.0325 11	0.94064 0.0001 11	0.87126 0.0002 12	0.60791 0.0623 10	0.30524 0.3614 11	0.27514 0.3868 12
ADA1PCT	0.31129 0.3005 13	0.67034 0.0087 14	0.82894 0.0009 12	1.00000 0.0000 15	0.66070 0.0073 15	0.80716 0.0009 13	0.78855 0.0008 14	0.75330 0.0019 14	0.70248 0.0074 13	0.60882 0.0272 13	0.45765 0.0999 14	0.27824 0.3573 13
ADA2PCT	0.39448 0.1822 13	0.36825 0.1951 14	0.71379 0.0091 12	0.66070 0.0073 15	1.00000 0.0000 15	0.54345 0.0549 13	0.56388 0.0357 14	0.78060 0.0010 14	0.44966 0.1232 13	0.61983 0.0238 13	0.53524 0.0486 14	0.19448 0.5243 13
ADA3PCT	-0.05023 0.8834 11	0.69947 0.0113 12	0.62435 0.0300 12	0.80716 0.0009 13	0.54345 0.0549 13	1.00000 0.0000 13	0.42456 0.1689 12	0.66316 0.0187 12	0.65289 0.0155 13	0.33333 0.3165 11	0.36077 0.2493 12	0.02204 0.9430 13
ATA1PCT	0.52982 0.0764 12	0.45793 0.1156 13	0.64384 0.0325 11	0.78855 0.0008 14	0.56388 0.0357 14	0.42456 0.1689 12	1.00000 0.0000 14	0.69146 0.0088 13	0.64912 0.0224 12	0.54821 0.0524 13	0.51444 0.0721 13	0.58494 0.0457 12
ATA2PCT	0.34737 0.2686 12	0.62897 0.0213 13	0.94064 0.0001 11	0.75330 0.0019 14	0.78060 0.0010 14	0.66316 0.0187 12	0.69146 0.0088 13	1.00000 0.0000 14	0.78246 0.0026 12	0.68044 0.0105 13	0.60286 0.0225 14	0.49387 0.1027 12
ATA3PCT	0.27854 0.4069 11	0.48155 0.1129 12	0.87126 0.0002 12	0.70248 0.0074 13	0.44966 0.1232 13	0.65289 0.0155 13	0.64912 0.0224 12	0.78246 0.0026 12	1.00000 0.0000 13	0.37900 0.2504 11	0.57793 0.0490 12	0.22590 0.4580 13
IDI1PCT	0.57991 0.0615 11	0.34798 0.2677 12	0.60791 0.0623 10	0.60882 0.0272 13	0.61983 0.0238 13	0.33333 0.3165 11	0.54821 0.0524 13	0.68044 0.0105 13	0.37900 0.2504 11	1.00000 0.0000 13	0.72902 0.0047 13	0.55125 0.0788 11
IDI2PCT	0.42382 0.1698 12	0.25344 0.4034 13	0.30524 0.3614 11	0.45765 0.0999 14	0.53524 0.0486 14	0.36077 0.2493 12	0.51444 0.0721 13	0.60286 0.0225 14	0.57793 0.0490 12	0.72902 0.0047 13	1.00000 0.0000 14	0.57343 0.0513 12
IDI3PCT	0.11872 0.7281 11	0.23902 0.4544 12	0.27514 0.3868 12	0.27824 0.3573 13	0.19448 0.5243 13	0.02204 0.9430 13	0.58494 0.0457 12	0.49387 0.1027 12	0.22590 0.4580 13	0.55125 0.0788 11	0.57343 0.0513 12	1.00000 0.0000 13
IDI1PCT	0.32337 0.3052 12	0.01243 0.9678 13	0.23503 0.4866 11	0.20507 0.4819 14	0.26269 0.3642 14	-0.13708 0.6710 12	0.75035 0.0031 13	0.37190 0.2108 13	0.54833 0.0649 12	0.01754 0.9568 12	0.28886 0.3385 13	0.29701 0.3485 12

Fig. 19e(i) Results of the Spearman's correlations for experiment three in Group 5.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IPI2PCT	0.03862 0.9003 13	0.24945 0.3898 14	0.20812 0.5163 12	0.25604 0.3570 15	0.08244 0.7702 15	-0.01928 0.9501 13	0.65711 0.0107 14	0.54245 0.0451 14	0.43251 0.1399 13	0.28690 0.3419 13	0.42071 0.1342 14	0.62810 0.0215 13
IPI3PCT	-0.09205 0.8138 9	0.67073 0.0338 10	0.75610 0.0114 10	0.63326 0.0365 11	0.31963 0.3380 11	0.47836 0.1367 11	0.57751 0.0804 10	0.73804 0.0095 11	0.76993 0.0056 11	0.02432 0.9468 10	0.20046 0.5545 11	0.32346 0.3319 11
ABA1PCT	0.43191 0.1405 13	0.39691 0.1600 14	0.71959 0.0083 12	0.79428 0.0004 15	0.68129 0.0052 15	0.57851 0.0383 13	0.81188 0.0004 14	0.77974 0.0010 14	0.56198 0.0456 13	0.61623 0.0249 13	0.63806 0.0141 14	0.43939 0.1330 13
ABA2PCT	-0.18078 0.5948 11	0.52762 0.0639 13	0.68103 0.0302 10	0.41793 0.1553 13	0.45379 0.1193 13	0.44749 0.1676 11	0.35677 0.2550 12	0.67663 0.0157 12	0.43379 0.1825 11	0.58810 0.0570 11	0.50527 0.0938 12	0.75799 0.0069 11
ABA3PCT	0.20501 0.5454 11	0.61053 0.0350 12	0.79579 0.0020 12	0.67400 0.0115 13	0.57300 0.0407 13	0.74553 0.0034 13	0.64098 0.0247 12	0.83713 0.0007 12	0.76204 0.0025 13	0.60592 0.0482 11	0.50350 0.0952 12	0.08803 0.7749 13
ITI1PCT	0.41047 0.1636 13	0.39845 0.1582 14	0.83039 0.0008 12	0.74127 0.0016 15	0.72581 0.0022 15	0.72552 0.0050 13	0.79824 0.0006 14	0.75413 0.0018 14	0.92690 0.0001 13	0.36690 0.2175 13	0.51762 0.0580 14	0.32552 0.2778 13
ITI2PCT	0.20672 0.4980 13	0.56127 0.0368 14	0.81560 0.0012 12	0.83397 0.0001 15	0.57725 0.0242 15	0.76157 0.0025 13	0.70160 0.0052 14	0.73278 0.0029 14	0.88710 0.0001 13	0.22628 0.4573 13	0.45387 0.1031 14	0.25107 0.4080 13
ITI3PCT	0.19512 0.5891 10	0.87414 0.0004 11	0.77626 0.0050 11	0.85263 0.0004 12	0.67135 0.0168 12	0.55088 0.0634 12	0.74429 0.0086 11	0.88070 0.0002 12	0.64912 0.0224 12	0.43379 0.1825 11	0.33976 0.2799 12	0.48687 0.1084 12
IBI1PCT	0.44719 0.1450 12	0.67265 0.0118 13	0.82151 0.0019 11	0.83665 0.0002 14	0.84548 0.0001 14	0.59051 0.0432 12	0.79250 0.0007 14	0.89779 0.0001 13	0.66081 0.0193 12	0.61602 0.0250 13	0.62069 0.0236 13	0.55790 0.0594 12
IBI2PCT	0.56392 0.0562 12	0.44077 0.1317 13	0.71233 0.0139 11	0.72907 0.0031 14	0.83462 0.0002 14	0.62105 0.0311 12	0.70248 0.0074 13	0.72467 0.0034 14	0.72281 0.0079 12	0.57576 0.0395 13	0.67107 0.0086 14	0.61296 0.0341 12
IBI3PCT	-0.20091 0.5536 11	0.67838 0.0153 12	0.52558 0.0793 12	0.58953 0.0340 13	0.11586 0.7062 13	0.61433 0.0255 13	0.57544 0.0503 12	0.71930 0.0084 12	0.63912 0.0187 13	0.45662 0.1580 11	0.51489 0.0867 12	0.52893 0.0631 13
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.32337 0.3052 12	0.03862 0.9003 13	-0.09205 0.8138 9	0.43191 0.1405 13	-0.18078 0.5948 11	0.20501 0.5454 11	0.41047 0.1636 13	0.20672 0.4980 13	0.19512 0.5891 10	0.44719 0.1450 12	0.56392 0.0562 12	-0.20091 0.5536 11

Fig. 19e(ii) Group 5 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	0.01243 0.9678 13	0.24945 0.3898 14	0.67073 0.0338 10	0.39691 0.1600 14	0.52762 0.0639 13	0.61053 0.0350 12	0.39845 0.1582 14	0.56127 0.0368 14	0.87414 0.0004 11	0.67265 0.0118 13	0.44077 0.1317 13	0.67838 0.0153 12
APA3PCT	0.23503 0.4866 11	0.20812 0.5163 12	0.75610 0.0114 10	0.71959 0.0083 12	0.68103 0.0302 10	0.79579 0.0020 12	0.83039 0.0008 12	0.81560 0.0012 12	0.77626 0.0050 11	0.82151 0.0019 11	0.71233 0.0139 11	0.52558 0.0793 12
ADA1PCT	0.20507 0.4819 14	0.25604 0.3570 15	0.63326 0.0365 11	0.79428 0.0004 15	0.41793 0.1553 13	0.67400 0.0115 13	0.74127 0.0016 15	0.83397 0.0001 15	0.85263 0.0004 12	0.83665 0.0002 14	0.72907 0.0031 14	0.58953 0.0340 13
ADA2PCT	0.26269 0.3642 14	0.08244 0.7702 15	0.31963 0.3380 11	0.68129 0.0052 15	0.45379 0.1193 13	0.57300 0.0407 13	0.72581 0.0022 15	0.57725 0.0242 15	0.67135 0.0168 12	0.84548 0.0001 14	0.83462 0.0002 14	0.11586 0.7062 13
ADA3PCT	-0.13708 0.6710 12	-0.01928 0.9501 13	0.47836 0.1367 11	0.57851 0.0383 13	0.44749 0.1676 11	0.74553 0.0034 13	0.72552 0.0050 13	0.76157 0.0025 13	0.55088 0.0634 12	0.59051 0.0432 12	0.62105 0.0311 12	0.61433 0.0255 13
ATA1PCT	0.75035 0.0031 13	0.65711 0.0107 14	0.57751 0.0804 10	0.81188 0.0004 14	0.35677 0.2550 12	0.64098 0.0247 12	0.79824 0.0006 14	0.70160 0.0052 14	0.74429 0.0086 11	0.79250 0.0007 14	0.70248 0.0074 13	0.57544 0.0503 12
ATA2PCT	0.37190 0.2108 13	0.54245 0.0451 14	0.73804 0.0095 11	0.77974 0.0010 14	0.67663 0.0157 12	0.83713 0.0007 12	0.75413 0.0018 14	0.73278 0.0029 14	0.88070 0.0002 12	0.89779 0.0001 13	0.72467 0.0034 14	0.71930 0.0084 12
ATA3PCT	0.54833 0.0649 12	0.43251 0.1399 13	0.76993 0.0056 11	0.56198 0.0456 13	0.43379 0.1825 11	0.76204 0.0025 13	0.92690 0.0001 13	0.88710 0.0001 13	0.64912 0.0224 12	0.66081 0.0193 12	0.72281 0.0079 12	0.63912 0.0187 13
ID11PCT	0.01754 0.9568 12	0.28690 0.3419 13	0.02432 0.9468 10	0.61623 0.0249 13	0.58810 0.0570 11	0.60592 0.0482 11	0.36690 0.2175 13	0.22628 0.4573 13	0.43379 0.1825 11	0.61602 0.0250 13	0.57576 0.0395 13	0.45662 0.1580 11
ID12PCT	0.28886 0.3385 13	0.42071 0.1342 14	0.20046 0.5545 11	0.63806 0.0141 14	0.50527 0.0938 12	0.50350 0.0952 12	0.51762 0.0580 14	0.45387 0.1031 14	0.33976 0.2799 12	0.62069 0.0236 13	0.67107 0.0086 14	0.51489 0.0867 12
ID13PCT	0.29701 0.3485 12	0.62810 0.0215 13	0.32346 0.3319 11	0.43939 0.1330 13	0.75799 0.0069 11	0.08803 0.7749 13	0.32552 0.2778 13	0.25107 0.4080 13	0.48687 0.1084 12	0.55790 0.0594 12	0.61296 0.0341 12	0.52893 0.0631 13
IPI1PCT	1.00000 0.0000 14	0.61810 0.0185 14	0.65654 0.0392 10	0.43660 0.1186 14	0.22535 0.4813 12	0.28421 0.3706 12	0.65894 0.0104 14	0.49170 0.0741 14	0.39726 0.2263 11	0.48271 0.0948 13	0.47383 0.1019 13	0.24912 0.4349 12
IPI2PCT	0.61810 0.0185 14	1.00000 0.0000 15	0.81549 0.0022 11	0.31692 0.2498 15	0.23586 0.4379 13	0.09629 0.7543 13	0.49283 0.0620 15	0.51312 0.0505 15	0.66316 0.0187 12	0.57459 0.0316 14	0.46527 0.0936 14	0.61433 0.0255 13

Fig. 19e(iii) Group 5 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
1PI3PCT	0.65654 0.0392 10	0.81549 0.0022 11	1.00000 0.0000 11	0.47945 0.1356 11	0.36975 0.3274 9	0.55125 0.0788 11	0.79452 0.0035 11	0.89198 0.0002 11	0.84738 0.0010 11	0.70122 0.0239 10	0.56164 0.0722 11	0.73059 0.0107 11
ABA1PCT	0.43660 0.1186 14	0.31692 0.2498 15	0.47945 0.1356 11	1.00000 0.0000 15	0.53517 0.0595 13	0.65200 0.0157 13	0.72247 0.0023 15	0.67151 0.0061 15	0.71579 0.0088 12	0.75193 0.0019 14	0.67952 0.0075 14	0.47107 0.1042 13
ABA2PCT	0.22535 0.4813 12	0.23586 0.4379 13	0.36975 0.3274 9	0.53517 0.0595 13	1.00000 0.0000 13	0.55581 0.0758 11	0.36464 0.2206 13	0.31008 0.3025 13	0.62805 0.0518 10	0.55106 0.0633 12	0.40000 0.1976 12	0.46925 0.1454 11
ABA3PCT	0.28421 0.3706 12	0.09629 0.7543 13	0.55125 0.0788 11	0.65200 0.0157 13	0.55581 0.0758 11	1.00000 0.0000 13	0.79890 0.0011 13	0.69366 0.0085 13	0.56392 0.0562 12	0.62106 0.0311 12	0.59194 0.0426 12	0.60798 0.0275 13
ITI1PCT	0.65894 0.0104 14	0.49283 0.0620 15	0.79452 0.0035 11	0.72247 0.0023 15	0.36464 0.2206 13	0.79890 0.0011 13	1.00000 0.0000 15	0.87808 0.0001 15	0.78735 0.0024 12	0.80774 0.0005 14	0.90077 0.0001 14	0.64552 0.0172 13
ITI2PCT	0.49170 0.0741 14	0.51312 0.0505 15	0.89198 0.0002 11	0.67151 0.0061 15	0.31008 0.3025 13	0.69366 0.0085 13	0.87808 0.0001 15	1.00000 0.0000 15	0.78441 0.0025 12	0.75673 0.0017 14	0.74504 0.0022 14	0.68764 0.0094 13
ITI3PCT	0.39726 0.2263 11	0.66316 0.0187 12	0.84738 0.0010 11	0.71579 0.0088 12	0.62805 0.0518 10	0.56392 0.0562 12	0.78735 0.0024 12	0.78441 0.0025 12	1.00000 0.0000 12	0.95195 0.0001 11	0.72982 0.0071 12	0.60000 0.0392 12
IBI1PCT	0.48271 0.0948 13	0.57459 0.0316 14	0.70122 0.0239 10	0.75193 0.0019 14	0.55106 0.0633 12	0.62106 0.0311 12	0.80774 0.0005 14	0.75673 0.0017 14	0.95195 0.0001 11	1.00000 0.0000 14	0.84393 0.0003 13	0.47100 0.1222 12
IBI2PCT	0.47383 0.1019 13	0.46527 0.0936 14	0.56164 0.0722 11	0.67952 0.0075 14	0.40000 0.1976 12	0.59194 0.0426 12	0.90077 0.0001 14	0.74504 0.0022 14	0.72982 0.0071 12	0.84393 0.0003 13	1.00000 0.0000 14	0.61404 0.0337 12
IBI3PCT	0.24912 0.4349 12	0.61433 0.0255 13	0.73059 0.0107 11	0.47107 0.1042 13	0.46925 0.1454 11	0.60798 0.0275 13	0.64552 0.0172 13	0.68764 0.0094 13	0.60000 0.0392 12	0.47100 0.1222 12	0.61404 0.0337 12	1.00000 0.0000 13

Fig. 19e(iv) Group 5 continued.

exp4
GROUP=6

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 13	0.12727 0.7092 11	0.07692 0.8028 13	0.09890 0.7479 13	0.54396 0.0546 13	-0.20358 0.5047 13	0.23636 0.5109 10	0.21429 0.4821 13	0.20315 0.5266 12	0.31818 0.3403 11	0.76754 0.0022 13	0.28022 0.3538 13
APA2PCT	0.12727 0.7092 11	1.00000 0.0000 12	0.34545 0.2981 11	-0.08182 0.8110 11	0.19264 0.5486 12	0.63748 0.0258 12	0.54394 0.1301 9	0.72504 0.0076 12	0.46809 0.1725 12	0.21667 0.5755 9	0.32982 0.2951 12	0.62727 0.0388 11
APA3PCT	0.07692 0.8028 13	0.34545 0.2981 11	1.00000 0.0000 14	0.20440 0.4833 14	0.05055 0.8637 14	0.29263 0.3100 14	-0.09091 0.7904 11	-0.00659 0.9822 14	0.68501 0.0098 13	0.55455 0.0767 11	0.10561 0.7194 14	0.47802 0.0985 13
ADA1PCT	0.09890 0.7479 13	-0.08182 0.8110 11	0.20440 0.4833 14	1.00000 0.0000 14	0.56044 0.0371 14	0.38504 0.1740 14	0.60909 0.0467 11	0.20000 0.4930 14	0.29161 0.3337 13	0.36364 0.2716 11	0.05281 0.8577 14	0.18681 0.5411 13
ADA2PCT	0.54396 0.0546 13	0.19264 0.5486 12	0.05055 0.8637 14	0.56044 0.0371 14	1.00000 0.0000 15	0.30027 0.2769 15	0.80420 0.0016 12	0.64286 0.0097 15	0.47593 0.1002 13	0.64545 0.0320 11	0.65058 0.0086 15	0.53846 0.0576 13
ADA3PCT	-0.20358 0.5047 13	0.63748 0.0258 12	0.29263 0.3100 14	0.38504 0.1740 14	0.30027 0.2769 15	1.00000 0.0000 15	0.47986 0.1144 12	0.23771 0.3936 15	0.55372 0.0496 13	0.30980 0.3539 11	0.09750 0.7296 15	0.14030 0.6475 13
ATA1PCT	0.23636 0.5109 10	0.54394 0.1301 9	-0.09091 0.7904 11	0.60909 0.0467 11	0.80420 0.0016 12	0.47986 0.1144 12	1.00000 0.0000 12	0.82517 0.0010 12	0.40909 0.2115 11	0.64848 0.0425 10	0.64448 0.0237 12	0.60000 0.0667 10
ATA2PCT	0.21429 0.4821 13	0.72504 0.0076 12	-0.00659 0.9822 14	0.20000 0.4930 14	0.64286 0.0097 15	0.23771 0.3936 15	0.82517 0.0010 12	1.00000 0.0000 15	0.47593 0.1002 13	0.70000 0.0165 11	0.70241 0.0035 15	0.80769 0.0008 13
ATA3PCT	0.20315 0.5266 12	0.46809 0.1725 10	0.68501 0.0098 13	0.29161 0.3337 13	0.47593 0.1002 13	0.55372 0.0496 13	0.40909 0.2115 11	0.47593 0.1002 13	1.00000 0.0000 13	0.77905 0.0047 11	0.57576 0.0395 13	0.73906 0.0060 12
IDI1PCT	0.31818 0.3403 11	0.21667 0.5755 9	0.55455 0.0767 11	0.36364 0.2716 11	0.64545 0.0320 11	0.30980 0.3539 11	0.64848 0.0425 10	0.70000 0.0165 11	0.77905 0.0047 11	1.00000 0.0000 11	0.85194 0.0009 11	0.80909 0.0026 11
IDI2PCT	0.76754 0.0022 13	0.32982 0.2951 12	0.10561 0.7194 14	0.05281 0.8577 14	0.65058 0.0086 15	0.09750 0.7296 15	0.64448 0.0237 12	0.70241 0.0035 15	0.57576 0.0395 13	0.85194 0.0009 11	1.00000 0.0000 15	0.66575 0.0130 13
IDI3PCT	0.28022 0.3538 13	0.62727 0.0388 11	0.47802 0.0985 13	0.18681 0.5411 13	0.53846 0.0576 13	0.14030 0.6475 13	0.60000 0.0667 10	0.80769 0.0008 13	0.73906 0.0060 12	0.80909 0.0026 11	0.66575 0.0130 13	1.00000 0.0000 13
IDI1PCT	0.12380 0.6870 13	0.63326 0.0365 11	0.17382 0.5523 14	-0.29703 0.3024 14	0.09461 0.7477 14	-0.08811 0.7646 14	0.11390 0.7388 11	0.56106 0.0369 14	0.15840 0.6053 13	0.46925 0.1454 11	0.45154 0.1051 14	0.59147 0.0332 13

Fig. 19f(i) Results of the Spearman's correlations for experiment three in Group 6.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
1PI2PCT	0.22590 0.4580 13	0.61053 0.0350 12	0.04185 0.8870 14	-0.01542 0.9583 14	0.28980 0.2948 15	0.11817 0.6749 15	0.11208 0.7287 12	0.47943 0.0706 15	0.12672 0.6799 13	0.09112 0.7899 11	0.31871 0.2470 15	0.49862 0.0828 13
1PI3PCT	0.18982 0.5345 13	0.35274 0.2607 12	-0.16960 0.5621 14	-0.11894 0.6855 14	0.38027 0.1620 15	-0.05566 0.8438 15	0.32983 0.2951 12	0.57579 0.0247 15	0.15427 0.6148 13	0.50909 0.1097 11	0.45961 0.0848 15	0.58322 0.0364 13
ABA1PCT	0.08791 0.7752 13	0.71103 0.0095 12	0.33626 0.2398 14	0.26154 0.3664 14	0.20357 0.4668 15	0.35746 0.1908 15	0.30769 0.3306 12	0.46429 0.0813 15	0.31912 0.2879 13	0.28182 0.4011 11	0.21448 0.4427 15	0.34066 0.2547 13
ABA2PCT	0.37570 0.2058 13	0.33684 0.2843 12	-0.10817 0.7128 14	-0.04194 0.8868 14	0.53764 0.0387 15	-0.15247 0.5875 15	0.57044 0.0528 12	0.80287 0.0003 15	0.16598 0.5879 13	0.40369 0.2182 11	0.65471 0.0081 15	0.55802 0.0475 13
ABA3PCT	-0.22767 0.4767 12	0.66133 0.0267 11	0.05502 0.8583 13	0.03026 0.9218 13	0.08370 0.7760 14	0.17089 0.5591 14	0.45455 0.1601 11	0.48899 0.0760 14	0.27544 0.3862 12	0.26140 0.4657 10	0.12459 0.6713 14	0.35026 0.2643 12
1111PCT	-0.37082 0.2915 10	0.05858 0.8810 9	-0.25532 0.4765 10	-0.46201 0.1789 10	-0.10334 0.7763 10	-0.08841 0.8081 10	-0.16767 0.6915 8	0.03647 0.9203 10	-0.26050 0.4984 9	0.20921 0.5890 9	0.02744 0.9400 10	0.11550 0.7507 10
1TI2PCT	0.28485 0.4250 10	-0.29412 0.4424 9	0.29697 0.4047 10	-0.20000 0.5796 10	0.02278 0.9470 11	-0.49203 0.1242 11	-0.32636 0.3914 9	-0.15945 0.6396 11	0.10042 0.7971 9	0.36667 0.3317 9	0.13212 0.6986 11	0.50303 0.1383 10
1TI3PCT	0.40606 0.2443 10	0.80952 0.0149 8	-0.17273 0.6115 11	-0.02727 0.9366 11	0.52727 0.0956 11	-0.11818 0.7293 11	0.50000 0.1705 9	0.57273 0.0655 11	-0.07295 0.8413 10	0.33333 0.3807 9	0.46364 0.1509 11	0.61212 0.0600 10
1BI1PCT	-0.13636 0.6893 11	0.48333 0.1875 9	0.20000 0.5554 11	-0.60909 0.0467 11	-0.35455 0.2847 11	0.13212 0.6986 11	-0.38333 0.3085 9	-0.02727 0.9366 11	-0.07903 0.8282 10	0.07879 0.8287 10	0.18223 0.5918 11	0.07273 0.8317 11
1BI2PCT	0.16084 0.6175 12	0.50303 0.1383 10	0.15934 0.6031 13	0.18132 0.5533 13	0.50000 0.0819 13	0.07153 0.8164 13	0.55455 0.0767 11	0.78571 0.0015 13	0.28371 0.3715 12	0.41818 0.2006 11	0.42091 0.1521 13	0.54545 0.0666 12
1BI3PCT	0.60000 0.0510 11	0.52392 0.0981 11	0.02797 0.9312 12	-0.32168 0.3079 12	0.29121 0.3344 13	0.03297 0.9149 13	0.39091 0.2345 11	0.63736 0.0191 13	0.12301 0.7186 11	0.16364 0.6515 10	0.60523 0.0284 13	0.43636 0.1797 11
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.12380 0.6870 13	0.22590 0.4580 13	0.18982 0.5345 13	0.08791 0.7752 13	0.37570 0.2058 13	-0.22767 0.4767 12	-0.37082 0.2915 10	0.28485 0.4250 10	0.40606 0.2443 10	-0.13636 0.6893 11	0.16084 0.6175 12	0.60000 0.0510 11

Fig. 19f(ii) Group 6 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	0.63326 0.0365 11	0.61053 0.0350 12	0.35274 0.2607 12	0.71103 0.0095 12	0.33684 0.2843 12	0.66133 0.0267 11	0.05858 0.8810 9	-0.29412 0.4424 9	0.80952 0.0149 8	0.48333 0.1875 9	0.50303 0.1383 10	0.52392 0.0981 11
APA3PCT	0.17382 0.5523 14	0.04185 0.8870 14	-0.16960 0.5621 14	0.33626 0.2398 14	-0.10817 0.7128 14	0.05502 0.8583 13	-0.25532 0.4765 10	0.29697 0.4047 10	-0.17273 0.6115 11	0.20000 0.5554 11	0.15934 0.6031 13	0.02797 0.9312 12
ADA1PCT	-0.29703 0.3024 14	-0.01542 0.9583 14	-0.11894 0.6855 14	0.26154 0.3664 14	-0.04194 0.8868 14	0.03026 0.9218 13	-0.46201 0.1789 10	-0.20000 0.5796 10	-0.02727 0.9366 11	-0.60909 0.0467 11	0.18132 0.5533 13	-0.32168 0.3079 12
ADA2PCT	0.09461 0.7477 14	0.28980 0.2948 15	0.38027 0.1620 15	0.20357 0.4668 15	0.53764 0.0387 15	0.08370 0.7760 14	-0.10334 0.7763 10	0.02278 0.9470 11	0.52727 0.0956 11	-0.35455 0.2847 11	0.50000 0.0819 13	0.29121 0.3344 13
ADA3PCT	-0.08811 0.7646 14	0.11817 0.6749 15	-0.05566 0.8438 15	0.35746 0.1908 15	-0.15247 0.5875 15	0.17089 0.5591 14	-0.08841 0.8081 10	-0.49203 0.1242 11	-0.11818 0.7293 11	0.13212 0.6986 11	0.07153 0.8164 13	0.03297 0.9149 13
ATA1PCT	0.11390 0.7388 11	0.11208 0.7287 12	0.32983 0.2951 12	0.30769 0.3306 12	0.57044 0.0528 12	0.45455 0.1601 11	-0.16767 0.6915 8	-0.32636 0.3914 9	0.50000 0.1705 9	-0.38333 0.3085 9	0.55455 0.0767 11	0.39091 0.2345 11
ATA2PCT	0.56106 0.0369 14	0.47943 0.0706 15	0.57579 0.0247 15	0.46429 0.0813 15	0.80287 0.0003 15	0.48899 0.0760 14	0.03647 0.9203 10	-0.15945 0.6396 11	0.57273 0.0655 11	-0.02727 0.9366 11	0.78571 0.0015 13	0.63736 0.0191 13
ATA3PCT	0.15840 0.6053 13	0.12672 0.6799 13	0.15427 0.6148 13	0.31912 0.2879 13	0.16598 0.5879 13	0.27544 0.3862 12	-0.26050 0.4984 9	0.10042 0.7971 9	-0.07295 0.8413 10	-0.07903 0.8282 10	0.28371 0.3715 12	0.12301 0.7186 11
ID11PCT	0.46925 0.1454 11	0.09112 0.7899 11	0.50909 0.1097 11	0.28182 0.4011 11	0.40369 0.2182 11	0.26140 0.4657 10	0.20921 0.5890 9	0.36667 0.3317 9	0.33333 0.3807 9	0.07879 0.8287 10	0.41818 0.2006 11	0.16364 0.6515 10
ID12PCT	0.45154 0.1051 14	0.31871 0.2470 15	0.45961 0.0848 15	0.21448 0.4427 15	0.65471 0.0081 15	0.12459 0.6713 14	0.02744 0.9400 10	0.13212 0.6986 11	0.46364 0.1509 11	0.18223 0.5918 11	0.42091 0.1521 13	0.60523 0.0284 13
ID13PCT	0.59147 0.0332 13	0.49862 0.0828 13	0.58322 0.0364 13	0.34066 0.2547 13	0.55802 0.0475 13	0.35026 0.2643 12	0.11550 0.7507 10	0.50303 0.1383 10	0.61212 0.0600 10	0.07273 0.8317 11	0.54545 0.0666 12	0.43636 0.1797 11
IP11PCT	1.00000 0.0000 14	0.57773 0.0305 14	0.72216 0.0035 14	0.55446 0.0396 14	0.60553 0.0217 14	0.52893 0.0631 13	0.60366 0.0646 10	0.24316 0.4984 10	0.50000 0.1173 11	0.70909 0.0146 11	0.49794 0.0833 13	0.53590 0.0725 12
IP12PCT	0.57773 0.0305 14	1.00000 0.0000 15	0.51123 0.0514 15	0.56887 0.0269 15	0.52065 0.0466 15	0.47351 0.0872 14	0.26524 0.4589 10	0.05479 0.8729 11	0.77170 0.0054 11	0.14612 0.6681 11	0.44077 0.1317 13	0.44628 0.1264 13

Fig. 19f(iii) Group 6 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.72216 0.0035 14	0.51123 0.0514 15	1.00000 0.0000 15	0.44126 0.0997 15	0.57066 0.0263 15	0.69768 0.0055 14	0.69512 0.0257 10	0.41380 0.2058 11	0.61504 0.0440 11	0.32727 0.3259 11	0.57851 0.0383 13	0.22407 0.4618 13
ABA1PCT	0.55446 0.0396 14	0.56887 0.0269 15	0.44126 0.0997 15	1.00000 0.0000 15	0.36918 0.1757 15	0.71806 0.0038 14	0.03647 0.9203 10	-0.25968 0.4406 11	0.36364 0.2716 11	0.37273 0.2589 11	0.63187 0.0205 13	0.35714 0.2309 13
ABA2PCT	0.60553 0.0217 14	0.52065 0.0466 15	0.57066 0.0263 15	0.36918 0.1757 15	1.00000 0.0000 15	0.32965 0.2497 14	0.27964 0.4339 10	-0.17472 0.6074 11	0.47708 0.1379 11	0.12845 0.7066 11	0.84532 0.0003 13	0.78454 0.0015 13
ABA3PCT	0.52893 0.0631 13	0.47351 0.0872 14	0.69768 0.0055 14	0.71806 0.0038 14	0.32965 0.2497 14	1.00000 0.0000 14	0.31513 0.4088 9	0.05793 0.8737 10	0.51515 0.1276 10	0.27356 0.4444 10	0.60946 0.0354 12	0.32983 0.2951 12
ITI1PCT	0.60366 0.0646 10	0.26524 0.4589 10	0.69512 0.0257 10	0.03647 0.9203 10	0.27964 0.4339 10	0.31513 0.4088 9	1.00000 0.0000 10	0.33333 0.4198 8	0.38095 0.3518 8	0.74478 0.0213 9	0.01216 0.9734 10	-0.01674 0.9659 9
ITI2PCT	0.24316 0.4984 10	0.05479 0.8729 11	0.41380 0.2058 11	-0.25968 0.4406 11	-0.17472 0.6074 11	0.05793 0.8737 10	0.33333 0.4198 8	1.00000 0.0000 11	0.66667 0.0499 9	0.03333 0.9322 9	0.15152 0.6761 10	-0.12158 0.7379 10
ITI3PCT	0.50000 0.1173 11	0.77170 0.0054 11	0.61504 0.0440 11	0.36364 0.2716 11	0.47708 0.1379 11	0.51515 0.1276 10	0.38095 0.3518 8	0.66667 0.0499 9	1.00000 0.0000 11	0.13939 0.7009 10	0.70000 0.0165 11	0.80606 0.0049 10
IBI1PCT	0.70909 0.0146 11	0.14612 0.6681 11	0.32727 0.3259 11	0.37273 0.2589 11	0.12845 0.7066 11	0.27356 0.4444 10	0.74478 0.0213 9	0.03333 0.9322 9	0.13939 0.7009 10	1.00000 0.0000 11	0.16364 0.6307 11	0.36970 0.2931 10
IBI2PCT	0.49794 0.0833 13	0.44077 0.1317 13	0.57851 0.0383 13	0.63187 0.0205 13	0.84532 0.0003 13	0.60946 0.0354 12	0.01216 0.9734 10	0.15152 0.6761 10	0.70000 0.0165 11	0.16364 0.6307 11	1.00000 0.0000 13	0.77622 0.0030 12
IBI3PCT	0.53590 0.0725 12	0.44628 0.1264 13	0.22407 0.4618 13	0.35714 0.2309 13	0.78454 0.0015 13	0.32983 0.2951 12	-0.01674 0.9659 9	-0.12158 0.7379 10	0.80606 0.0049 10	0.36970 0.2931 10	0.77622 0.0030 12	1.00000 0.0000 13

Fig. 19f(iv) Group 6 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 13	0.17273 0.6115 11	0.25513 0.4490 11	0.31319 0.2974 13	0.19780 0.5171 13	0.29121 0.3344 13	0.48411 0.0937 13	0.18759 0.5394 13	0.61959 0.0420 11	0.58314 0.0597 11	0.44483 0.1473 12	-0.03026 0.9218 13
APA2PCT	0.17273 0.6115 11	1.00000 0.0000 13	0.32632 0.3006 12	0.15385 0.6331 12	0.09091 0.7787 12	0.46703 0.1076 13	0.65611 0.0205 12	0.65965 0.0196 12	0.14085 0.6624 12	0.26424 0.4324 11	0.67582 0.0112 13	-0.03026 0.9218 13
APA3PCT	0.25513 0.4490 11	0.32632 0.3006 12	1.00000 0.0000 13	-0.15790 0.6241 12	0.42106 0.1729 12	-0.03306 0.9146 13	0.10797 0.7384 12	0.41197 0.1833 12	0.24735 0.4383 12	-0.30106 0.3417 12	0.34386 0.2738 12	0.10483 0.7332 13
ADA1PCT	0.31319 0.2974 13	0.15385 0.6331 12	-0.15790 0.6241 12	1.00000 0.0000 14	0.29231 0.3105 14	0.25275 0.3833 14	0.36686 0.1970 14	0.37793 0.2029 13	0.64790 0.0227 12	0.68421 0.0141 12	0.00275 0.9929 13	0.20462 0.4829 14
ADA2PCT	0.19780 0.5171 13	0.09091 0.7787 12	0.42106 0.1729 12	0.29231 0.3105 14	1.00000 0.0000 14	-0.32747 0.2531 14	-0.03536 0.9045 14	0.36414 0.2213 13	0.43663 0.1558 12	0.20351 0.5258 12	0.26135 0.3884 13	-0.07041 0.8110 14
ADA3PCT	0.29121 0.3344 13	0.46703 0.1076 13	-0.03306 0.9146 13	0.25275 0.3833 14	-0.32747 0.2531 14	1.00000 0.0000 15	0.71603 0.0040 14	-0.00662 0.9821 14	0.07735 0.8017 13	0.17355 0.5707 13	0.24422 0.4001 14	0.36315 0.1834 15
ATA1PCT	0.48411 0.0937 13	0.65611 0.0205 12	0.10797 0.7384 12	0.36686 0.1970 14	-0.03536 0.9045 14	0.71603 0.0040 14	1.00000 0.0000 14	0.35139 0.2391 13	0.40142 0.1959 12	0.32218 0.3071 12	0.33242 0.2671 13	0.14823 0.6130 14
ATA2PCT	0.18759 0.5394 13	0.65965 0.0196 12	0.41197 0.1833 12	0.37793 0.2029 13	0.36414 0.2213 13	-0.00662 0.9821 14	0.35139 0.2391 13	1.00000 0.0000 14	0.43761 0.1548 12	0.20914 0.5142 12	0.47586 0.1002 13	0.25856 0.3721 14
ATA3PCT	0.61959 0.0420 11	0.14085 0.6624 12	0.24735 0.4383 12	0.64790 0.0227 12	0.43663 0.1558 12	0.07735 0.8017 13	0.40142 0.1959 12	0.43761 0.1548 12	1.00000 0.0000 13	0.77602 0.0030 12	0.51453 0.0720 13	0.49585 0.0848 13
IDI1PCT	0.58314 0.0597 11	0.26424 0.4324 11	-0.30106 0.3417 12	0.68421 0.0141 12	0.20351 0.5258 12	0.17355 0.5707 13	0.32218 0.3071 12	0.20914 0.5142 12	0.77602 0.0030 12	1.00000 0.0000 13	0.47368 0.1198 12	0.16436 0.5916 13
IDI2PCT	0.44483 0.1473 12	0.67582 0.0112 13	0.34386 0.2738 12	0.00275 0.9929 13	0.26135 0.3884 13	0.24422 0.4001 14	0.33242 0.2671 13	0.47586 0.1002 13	0.51453 0.0720 13	0.47368 0.1198 12	1.00000 0.0000 14	0.17089 0.5591 14
IDI3PCT	-0.03026 0.9218 13	-0.03026 0.9218 13	0.10483 0.7332 13	0.20462 0.4829 14	-0.07041 0.8110 14	0.36315 0.1834 15	0.14823 0.6130 14	0.25856 0.3721 14	0.49585 0.0848 13	0.16436 0.5916 13	0.17089 0.5591 14	1.00000 0.0000 15
IDI1PCT	0.45604 0.1173 13	-0.01099 0.9716 13	0.33609 0.2615 13	0.73187 0.0029 14	0.64396 0.0129 14	0.03929 0.8894 15	0.24089 0.4068 14	0.40133 0.1550 14	0.69614 0.0082 13	0.41047 0.1636 13	-0.00660 0.9821 14	0.16995 0.5448 15

Fig. 19g(i) Results of the Spearman's correlations for experiment three in Group 7.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IP12PCT	0.50000 0.0819 13	0.48352 0.0941 13	0.27273 0.3673 13	0.26154 0.3664 14	0.34945 0.2207 14	0.03571 0.8994 15	0.24089 0.4068 14	0.67035 0.0087 14	0.64089 0.0183 13	0.57025 0.0419 13	0.70627 0.0048 14	0.43113 0.1086 15
IP13PCT	0.37139 0.2115 13	0.46962 0.1054 13	0.40720 0.1673 13	0.24504 0.3985 14	0.15673 0.5926 14	0.21147 0.4493 15	0.57714 0.0307 14	0.76490 0.0014 14	0.35556 0.2332 13	-0.00414 0.9893 13	0.27845 0.3350 14	0.16697 0.5520 15
ABA1PCT	0.34965 0.2652 12	0.20909 0.5372 11	0.37900 0.2504 11	0.42308 0.1497 13	0.45055 0.1223 13	-0.06044 0.8445 13	0.08540 0.7815 13	0.26011 0.4142 12	0.51378 0.1060 11	0.42923 0.1877 11	0.19615 0.5412 12	0.09904 0.7475 13
ABA2PCT	0.31524 0.3182 12	0.42369 0.1941 11	0.47597 0.1389 11	-0.09904 0.7475 13	0.15956 0.6026 13	0.20633 0.4988 13	0.49241 0.0874 13	0.19190 0.5502 12	-0.01839 0.9572 11	-0.36156 0.2746 11	0.23333 0.4655 12	-0.22039 0.4694 13
ABA3PCT	0.23636 0.5109 10	0.85000 0.0037 9	0.51883 0.1524 9	0.32121 0.3655 10	0.00606 0.9867 10	0.35455 0.2847 11	0.74545 0.0133 10	0.54464 0.0832 11	0.51667 0.1544 9	0.00837 0.9830 9	0.59575 0.0692 10	0.27335 0.4160 11
ITI1PCT	0.26135 0.3884 13	0.21458 0.4814 13	-0.05379 0.8614 13	0.42684 0.1280 14	0.17602 0.5472 14	0.41644 0.1226 15	0.42478 0.1300 14	0.36534 0.1990 14	0.44814 0.1246 13	0.30345 0.3135 13	0.13877 0.6361 14	0.54432 0.0359 15
ITI2PCT	0.37762 0.2262 12	0.57343 0.0513 12	0.29072 0.3593 12	0.41209 0.1618 13	0.18132 0.5533 13	0.00220 0.9941 14	0.26833 0.3754 13	0.51791 0.0698 13	0.65495 0.0208 12	0.62106 0.0311 12	0.64649 0.0170 13	0.31057 0.2798 14
ITI3PCT	0.69248 0.0182 11	0.50438 0.0945 12	0.58483 0.0358 13	0.33625 0.2852 12	0.31524 0.3182 12	0.12930 0.6738 13	0.56185 0.0573 12	0.73240 0.0068 12	0.63846 0.0255 12	0.31986 0.3108 12	0.35727 0.2542 12	0.22039 0.4694 13
IBI1PCT	0.51489 0.0867 12	0.50088 0.0972 12	0.36380 0.2450 12	0.37689 0.2043 13	0.16506 0.5900 13	0.13861 0.6365 14	0.68838 0.0093 13	0.64966 0.0162 13	0.56667 0.0547 12	0.22982 0.4724 12	0.32737 0.2749 13	0.28115 0.3302 14
IBI2PCT	0.04959 0.8722 13	0.55692 0.0600 12	0.48070 0.1137 12	0.17181 0.5570 14	0.30176 0.2944 14	0.25771 0.3737 14	0.35327 0.2153 14	0.72061 0.0055 13	0.10229 0.7517 12	-0.33040 0.2942 12	0.40138 0.1740 13	0.11136 0.7047 14
IBI3PCT	0.30070 0.3423 12	0.02797 0.9312 12	-0.17544 0.5855 12	0.41758 0.1557 13	0.29670 0.3249 13	-0.09890 0.7366 14	0.20661 0.4982 13	0.52414 0.0660 13	0.22536 0.4813 12	0.15439 0.6319 12	-0.13480 0.6606 13	0.00441 0.9881 14
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.45604 0.1173 13	0.50000 0.0819 13	0.37139 0.2115 13	0.34965 0.2652 12	0.31524 0.3182 12	0.23636 0.5109 10	0.26135 0.3884 13	0.37762 0.2262 12	0.69248 0.0182 11	0.51489 0.0867 12	0.04959 0.8722 13	0.30070 0.3423 12

Fig. 19g(ii) Group 7 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	-0.01099 0.9716 13	0.48352 0.0941 13	0.46962 0.1054 13	0.20909 0.5372 11	0.42369 0.1941 11	0.85000 0.0037 9	0.21458 0.4814 13	0.57343 0.0513 12	0.50438 0.0945 12	0.50088 0.0972 12	0.55692 0.0600 12	0.02797 0.9312 12
APA3PCT	0.33609 0.2615 13	0.27273 0.3673 13	0.40720 0.1673 13	0.37900 0.2504 11	0.47597 0.1389 11	0.51883 0.1524 9	-0.05379 0.8614 13	0.29072 0.3593 12	0.58483 0.0358 13	0.36380 0.2450 12	0.48070 0.1137 12	-0.17544 0.5855 12
ADA1PCT	0.73187 0.0029 14	0.26154 0.3664 14	0.24504 0.3985 14	0.42308 0.1497 13	-0.09904 0.7475 13	0.32121 0.3655 10	0.42684 0.1280 14	0.41209 0.1618 13	0.33625 0.2852 12	0.37689 0.2043 13	0.17181 0.5570 14	0.41758 0.1557 13
ADA2PCT	0.64396 0.0129 14	0.34945 0.2207 14	0.15673 0.5926 14	0.45055 0.1223 13	0.15956 0.6026 13	0.00606 0.9867 10	0.17602 0.5472 14	0.18132 0.5533 13	0.31524 0.3182 12	0.16506 0.5900 13	0.30176 0.2944 14	0.29670 0.3249 13
ADA3PCT	0.03929 0.8894 15	0.03571 0.8994 15	0.21147 0.4493 15	-0.06044 0.8445 13	0.20633 0.4988 13	0.35455 0.2847 11	0.41644 0.1226 15	0.00220 0.9941 14	0.12930 0.6738 13	0.13861 0.6365 14	0.25771 0.3737 14	-0.09890 0.7366 14
ATA1PCT	0.24089 0.4068 14	0.24089 0.4068 14	0.57714 0.0307 14	0.08540 0.7815 13	0.49241 0.0874 13	0.74545 0.0133 10	0.42478 0.1300 14	0.26833 0.3754 13	0.56185 0.0573 12	0.68838 0.0093 13	0.35327 0.2153 14	0.20661 0.4982 13
ATA2PCT	0.40133 0.1550 14	0.67035 0.0087 14	0.76490 0.0014 14	0.26011 0.4142 12	0.19190 0.5502 12	0.54464 0.0832 11	0.36534 0.1990 14	0.51791 0.0698 13	0.73240 0.0068 12	0.64966 0.0162 13	0.72061 0.0055 13	0.52414 0.0660 13
ATA3PCT	0.69614 0.0082 13	0.64089 0.0183 13	0.35556 0.2332 13	0.51378 0.1060 11	-0.01839 0.9572 11	0.51667 0.1544 9	0.44814 0.1246 13	0.65495 0.0208 12	0.63846 0.0255 12	0.56667 0.0547 12	0.10229 0.7517 12	0.22536 0.4813 12
ID11PCT	0.41047 0.1636 13	0.57025 0.0419 13	-0.00414 0.9893 13	0.42923 0.1877 11	-0.36156 0.2746 11	0.00837 0.9830 9	0.30345 0.3135 13	0.62106 0.0311 12	0.31986 0.3108 12	0.22982 0.4724 12	-0.33040 0.2942 12	0.15439 0.6319 12
ID12PCT	-0.00660 0.9821 14	0.70627 0.0048 14	0.27845 0.3350 14	0.19615 0.5412 12	0.23333 0.4655 12	0.59575 0.0692 10	0.13877 0.6361 14	0.64649 0.0170 13	0.35727 0.2542 12	0.32737 0.2749 13	0.40138 0.1740 13	-0.13480 0.6606 13
ID13PCT	0.16995 0.5448 15	0.43113 0.1086 15	0.16697 0.5520 15	0.09904 0.7475 13	-0.22039 0.4694 13	0.27335 0.4160 11	0.54432 0.0359 15	0.31057 0.2798 14	0.22039 0.4694 13	0.28115 0.3302 14	0.11136 0.7047 14	0.00441 0.9881 14
IP11PCT	1.00000 0.0000 15	0.25714 0.3549 15	0.37993 0.1625 15	0.35165 0.2387 13	-0.04127 0.8935 13	0.41818 0.2006 11	0.47900 0.0708 15	0.20440 0.4833 14	0.50069 0.0814 13	0.38064 0.1794 14	0.28414 0.3249 14	0.49451 0.0722 14
IP12PCT	0.25714 0.3549 15	1.00000 0.0000 15	0.32258 0.2409 15	0.50549 0.0780 13	-0.00825 0.9787 13	0.43636 0.1797 11	0.51475 0.0496 15	0.89451 0.0001 14	0.62724 0.0218 13	0.53245 0.0500 14	0.19163 0.5116 14	0.22637 0.4364 14

Fig. 19g(iii) Group 7 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.37993 0.1625 15	0.32258 0.2409 15	1.00000 0.0000 15	-0.09945 0.7465 13	0.21854 0.4732 13	0.56037 0.0730 11	0.12377 0.6603 15	0.13466 0.6463 14	0.78562 0.0015 13	0.63205 0.0153 14	0.54867 0.0422 14	0.38632 0.1724 14
ABA1PCT	0.35165 0.2387 13	0.50549 0.0780 13	-0.09945 0.7465 13	1.00000 0.0000 13	0.10158 0.7534 12	0.05455 0.8810 10	0.35488 0.2341 13	0.60839 0.0358 12	0.50114 0.1163 11	0.03503 0.9139 12	-0.12930 0.6738 13	0.10490 0.7456 12
ABA2PCT	-0.04127 0.8935 13	-0.00825 0.9787 13	0.21854 0.4732 13	0.10158 0.7534 12	1.00000 0.0000 13	0.57576 0.0816 10	0.00825 0.9787 13	-0.04904 0.8797 12	0.36073 0.2758 11	0.64448 0.0237 12	0.53517 0.0595 13	0.09354 0.7612 13
ABA3PCT	0.41818 0.2006 11	0.43636 0.1797 11	0.56037 0.0730 11	0.05455 0.8810 10	0.57576 0.0816 10	1.00000 0.0000 11	0.38182 0.2466 11	0.51515 0.1276 10	0.69457 0.0379 9	0.62424 0.0537 10	0.56535 0.0885 10	0.42727 0.1899 11
ITI1PCT	0.47900 0.0708 15	0.51475 0.0496 15	0.12377 0.6603 15	0.35488 0.2341 13	0.00825 0.9787 13	0.38182 0.2466 11	1.00000 0.0000 15	0.40264 0.1535 14	0.33609 0.2615 13	0.31388 0.2745 14	0.26461 0.3606 14	0.56044 0.0371 14
ITI2PCT	0.20440 0.4833 14	0.89451 0.0001 14	0.13466 0.6463 14	0.60839 0.0358 12	-0.04904 0.8797 12	0.51515 0.1276 10	0.40264 0.1535 14	1.00000 0.0000 14	0.53240 0.0748 12	0.52820 0.0635 13	0.08264 0.7884 13	0.02198 0.9432 13
ITI3PCT	0.50069 0.0814 13	0.62724 0.0218 13	0.78562 0.0015 13	0.50114 0.1163 11	0.36073 0.2758 11	0.69457 0.0379 9	0.33609 0.2615 13	0.53240 0.0748 12	1.00000 0.0000 13	0.74386 0.0055 12	0.32574 0.3015 12	0.43082 0.1621 12
IBI1PCT	0.38064 0.1794 14	0.53245 0.0500 14	0.63205 0.0153 14	0.03503 0.9139 12	0.64448 0.0237 12	0.62424 0.0537 10	0.31388 0.2745 14	0.52820 0.0635 13	0.74386 0.0055 12	1.00000 0.0000 14	0.69517 0.0083 13	0.42091 0.1521 13
IBI2PCT	0.28414 0.3249 14	0.19163 0.5116 14	0.54867 0.0422 14	-0.12930 0.6738 13	0.53517 0.0595 13	0.56535 0.0885 10	0.26461 0.3606 14	0.08264 0.7884 13	0.32574 0.3015 12	0.69517 0.0083 13	1.00000 0.0000 14	0.28926 0.3378 13
IBI3PCT	0.49451 0.0722 14	0.22637 0.4364 14	0.38632 0.1724 14	0.10490 0.7456 12	0.09354 0.7612 13	0.42727 0.1899 11	0.56044 0.0371 14	0.02198 0.9432 13	0.43082 0.1621 12	0.42091 0.1521 13	0.28926 0.3378 13	1.00000 0.0000 14

Fig. 19g(iv) Group 7 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H₀:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
APA1PCT	1.00000 0.0000 14	0.05975 0.8536 12	0.27356 0.4444 10	0.42480 0.1687 12	0.54696 0.0531 13	0.46556 0.1751 10	0.22183 0.4884 12	0.50343 0.1144 11	0.81379 0.0007 13	0.19512 0.5891 10	0.56491 0.0556 12	0.04281 0.9065 10
APA2PCT	0.05975 0.8536 12	1.00000 0.0000 13	0.21212 0.5563 10	-0.08898 0.7833 12	0.06621 0.8299 13	-0.21400 0.5527 10	0.01757 0.9568 12	0.14155 0.6780 11	0.21404 0.5041 12	-0.14634 0.6866 10	0.08676 0.7998 11	-0.01220 0.9733 10
APA3PCT	0.27356 0.4444 10	0.21212 0.5563 10	1.00000 0.0000 11	0.20122 0.5772 10	-0.03645 0.9153 11	-0.01695 0.9655 9	-0.01818 0.9602 10	0.49091 0.1497 10	0.56364 0.0710 11	-0.09524 0.8225 8	-0.06667 0.8548 10	0.01667 0.9661 9
ADA1PCT	0.42480 0.1687 12	-0.08898 0.7833 12	0.20122 0.5772 10	1.00000 0.0000 13	0.70715 0.0069 13	0.31971 0.3678 10	0.23582 0.4606 12	0.35485 0.2842 11	0.59471 0.0414 12	0.55658 0.0947 10	0.53919 0.0870 11	0.31804 0.3705 10
ADA2PCT	0.54696 0.0531 13	0.06621 0.8299 13	-0.03645 0.9153 11	0.70715 0.0069 13	1.00000 0.0000 14	0.48737 0.1284 11	-0.02624 0.9322 13	0.29174 0.3575 12	0.54069 0.0564 13	0.27854 0.4069 11	0.64323 0.0240 12	0.56164 0.0722 11
ADA3PCT	0.46556 0.1751 10	-0.21400 0.5527 10	-0.01695 0.9655 9	0.31971 0.3678 10	0.48737 0.1284 11	1.00000 0.0000 11	0.81229 0.0024 11	-0.01254 0.9726 10	0.31536 0.3448 11	0.89152 0.0012 9	-0.12321 0.7345 10	0.48295 0.1574 10
ATA1PCT	0.22183 0.4884 12	0.01757 0.9568 12	-0.01818 0.9602 10	0.23582 0.4606 12	-0.02624 0.9322 13	0.81229 0.0024 11	1.00000 0.0000 13	-0.07763 0.8205 11	0.32632 0.3006 12	0.68037 0.0212 11	-0.06849 0.8414 11	0.43379 0.1825 11
ATA2PCT	0.50343 0.1144 11	0.14155 0.6780 11	0.49091 0.1497 10	0.35485 0.2842 11	0.29174 0.3575 12	-0.01254 0.9726 10	-0.07763 0.8205 11	1.00000 0.0000 12	0.34035 0.2790 12	0.12605 0.7466 9	0.33333 0.3165 11	-0.54878 0.1004 10
ATA3PCT	0.81379 0.0007 13	0.21404 0.5041 12	0.56364 0.0710 11	0.59471 0.0414 12	0.54069 0.0564 13	0.31536 0.3448 11	0.32632 0.3006 12	0.34035 0.2790 12	1.00000 0.0000 14	0.50000 0.1411 10	0.55923 0.0469 13	0.26027 0.4395 11
IDI1PCT	0.19512 0.5891 10	-0.14634 0.6866 10	-0.09524 0.8225 8	0.55658 0.0947 10	0.27854 0.4069 11	0.89152 0.0012 9	0.68037 0.0212 11	0.12605 0.7466 9	0.50000 0.1411 10	1.00000 0.0000 11	0.28049 0.4325 10	0.26829 0.4536 10
IDI2PCT	0.56491 0.0556 12	0.08676 0.7998 11	-0.06667 0.8548 10	0.53919 0.0870 11	0.64323 0.0240 12	-0.12321 0.7345 10	-0.06849 0.8414 11	0.33333 0.3165 11	0.55923 0.0469 13	0.28049 0.4325 10	1.00000 0.0000 13	0.15854 0.6618 10
IDI3PCT	0.04281 0.9065 10	-0.01220 0.9733 10	0.01667 0.9661 9	0.31804 0.3705 10	0.56164 0.0722 11	0.48295 0.1574 10	0.43379 0.1825 11	-0.54878 0.1004 10	0.26027 0.4395 11	0.26829 0.4536 10	0.15854 0.6618 10	1.00000 0.0000 11
11PCT	0.66667 0.0353 10	-0.30488 0.3917 10	-0.06667 0.8647 9	-0.06135 0.8663 10	0.26027 0.4395 11	0.26758 0.4263 11	0.18721 0.5815 11	0.15854 0.6618 10	0.51598 0.1042 11	0.21008 0.5875 9	0.53659 0.1098 10	0.28049 0.4325 10

Fig. 19h(i). Results of the Spearman's correlations for experiment three in Group 8.

PEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	APA1PCT	APA2PCT	APA3PCT	ADA1PCT	ADA2PCT	ADA3PCT	ATA1PCT	ATA2PCT	ATA3PCT	IDI1PCT	IDI2PCT	IDI3PCT
IP12PCT	0.80822 0.0026 11	0.39726 0.2263 11	0.06667 0.8548 10	0.38232 0.2200 12	0.53427 0.0735 12	0.08430 0.8169 10	0.24201 0.4734 11	0.40639 0.2149 11	0.77544 0.0030 12	-0.24370 0.5275 9	0.74429 0.0086 11	0.18293 0.6130 10
IP13PCT	0.16169 0.6156 12	0.63470 0.0359 11	0.10303 0.7770 10	0.18434 0.5874 11	0.47100 0.1222 12	-0.25716 0.4732 10	-0.11416 0.7382 11	-0.02456 0.9396 12	0.60882 0.0272 13	0.04202 0.9145 9	0.50175 0.0965 12	0.37805 0.2814 10
ABA1PCT	-0.18207 0.5516 13	0.47658 0.0997 13	0.16364 0.6307 11	-0.20057 0.5112 13	0.16097 0.5825 14	0.26758 0.4263 11	0.11862 0.6995 13	-0.14386 0.6556 12	0.00275 0.9929 13	-0.15068 0.6583 11	-0.57193 0.0520 12	0.10502 0.7586 11
ABA2PCT	-0.34626 0.2465 13	-0.07192 0.8154 13	0.36364 0.2716 11	0.24057 0.4285 13	-0.10398 0.7235 14	-0.06736 0.8440 11	-0.01662 0.9570 13	-0.21870 0.4947 12	-0.01660 0.9571 13	0.41380 0.2058 11	-0.11288 0.7269 12	-0.09196 0.7880 11
ABA3PCT	0.74105 0.0038 13	-0.19965 0.5339 12	0.28182 0.4011 11	0.55834 0.0592 12	0.36915 0.2145 13	0.28604 0.3938 11	0.12960 0.6881 12	0.51489 0.0867 12	0.51045 0.0622 14	0.07295 0.8413 10	0.52545 0.0652 13	0.08656 0.8002 11
II11PCT	-0.47945 0.1356 11	0.54338 0.0841 11	-0.63333 0.0671 9	-0.02294 0.9466 11	0.06327 0.8451 12	-0.26588 0.4578 10	-0.25308 0.4274 12	-0.35366 0.3161 10	-0.47945 0.1356 11	0.23288 0.4908 11	0.23288 0.4908 11	0.07317 0.8408 10
II12PCT	-0.07763 0.8205 11	-0.00457 0.9894 11	0.00000 1.0000 9	-0.27258 0.3914 12	0.07381 0.8197 12	-0.59011 0.0725 10	-0.87171 0.0002 12	-0.15854 0.6618 10	-0.17808 0.6004 11	-0.64634 0.0435 10	0.14634 0.6866 10	0.19512 0.5891 10
II13PCT	0.42010 0.1983 11	-0.19590 0.5637 11	0.20000 0.6059 9	0.44313 0.1996 10	0.39636 0.2275 11	0.34816 0.3585 9	0.43769 0.2059 10	-0.43769 0.2059 10	0.43783 0.1546 12	0.00837 0.9830 9	0.50570 0.1125 11	0.71733 0.0195 10
IB11PCT	-0.07780 0.8201 11	0.27731 0.4700 9	0.23424 0.6132 7	-0.20744 0.5653 10	0.26911 0.4521 10	-0.37743 0.4039 7	-0.75950 0.0176 9	-0.14546 0.7311 8	0.18349 0.6119 10	-0.34940 0.3962 8	0.36134 0.3393 9	-0.08485 0.8417 8
IB12PCT	0.43515 0.2418 9	0.04255 0.9071 10	-0.08333 0.8312 9	0.38397 0.3076 9	0.24390 0.4971 10	-0.55594 0.1950 7	-0.51681 0.1543 9	-0.23810 0.5702 8	0.18333 0.6368 9	0.17964 0.6703 8	0.63333 0.0671 9	0.14286 0.7599 7
IB13PCT	0.44312 0.2715 8	0.71429 0.0713 7	0.47619 0.2329 8	0.16217 0.7283 7	0.40476 0.3199 8	-0.32434 0.4779 7	-0.39286 0.3833 7	0.28571 0.5345 7	0.54762 0.1600 8	-0.40000 0.5046 5	0.92857 0.0025 7	0.60000 0.2080 6
	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA1PCT	0.66667 0.0353 10	0.80822 0.0026 11	0.16169 0.6156 12	-0.18207 0.5516 13	-0.34626 0.2465 13	0.74105 0.0038 13	-0.47945 0.1356 11	-0.07763 0.8205 11	0.42010 0.1983 11	-0.07780 0.8201 11	0.43515 0.2418 9	0.44312 0.2715 8

Fig. 19h(ii) Group 8 continued.

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
APA2PCT	-0.30488 0.3917 10	0.39726 0.2263 11	0.63470 0.0359 11	0.47658 0.0997 13	-0.07192 0.8154 13	-0.19965 0.5339 12	0.54338 0.0841 11	-0.00457 0.9894 11	-0.19590 0.5637 11	0.27731 0.4700 9	0.04255 0.9071 10	0.71429 0.0713 7
APA3PCT	-0.06667 0.8647 9	0.06667 0.8548 10	0.10303 0.7770 10	0.16364 0.6307 11	0.36364 0.2716 11	0.28182 0.4011 11	-0.63333 0.0671 9	0.00000 1.0000 9	0.20000 0.6059 9	0.23424 0.6132 7	-0.08333 0.8312 9	0.47619 0.2329 8
ADA1PCT	-0.06135 0.8663 10	0.38232 0.2200 12	0.18434 0.5874 11	-0.20057 0.5112 13	0.24057 0.4285 13	0.55834 0.0592 12	-0.02294 0.9466 11	-0.27258 0.3914 12	0.44313 0.1996 10	-0.20744 0.5653 10	0.38397 0.3076 9	0.16217 0.7283 7
ADA2PCT	0.26027 0.4395 11	0.53427 0.0735 12	0.47100 0.1222 12	0.16097 0.5825 14	-0.10398 0.7235 14	0.36915 0.2145 13	0.06327 0.8451 12	0.07381 0.8197 12	0.39636 0.2275 11	0.26911 0.4521 10	0.24390 0.4971 10	0.40476 0.3199 8
ADA3PCT	0.26758 0.4263 11	0.08430 0.8169 10	-0.25716 0.4732 10	0.26758 0.4263 11	-0.06736 0.8440 11	0.28604 0.3938 11	-0.26588 0.4578 10	-0.59011 0.0725 10	0.34816 0.3585 9	-0.37743 0.4039 7	-0.55594 0.1950 7	-0.32434 0.4779 7
ATA1PCT	0.18721 0.5815 11	0.24201 0.4734 11	-0.11416 0.7382 11	0.11862 0.6995 13	-0.01662 0.9570 13	0.12960 0.6881 12	-0.25308 0.4274 12	-0.87171 0.0002 12	0.43769 0.2059 10	-0.75950 0.0176 9	-0.51681 0.1543 9	-0.39286 0.3833 7
ATA2PCT	0.15854 0.6618 10	0.40639 0.2149 11	-0.02456 0.9396 12	-0.14386 0.6556 12	-0.21870 0.4947 12	0.51489 0.0867 12	-0.35366 0.3161 10	-0.15854 0.6618 10	-0.43769 0.2059 10	-0.14546 0.7311 8	-0.23810 0.5702 8	0.28571 0.5345 7
ATA3PCT	0.51598 0.1042 11	0.77544 0.0030 12	0.60882 0.0272 13	0.00275 0.9929 13	-0.01660 0.9571 13	0.51045 0.0622 14	-0.47945 0.1356 11	-0.17808 0.6004 11	0.43783 0.1546 12	0.18349 0.6119 10	0.18333 0.6368 9	0.54762 0.1600 8
ID11PCT	0.21008 0.5875 9	-0.24370 0.5275 9	0.04202 0.9145 9	-0.15068 0.6583 11	0.41380 0.2058 11	0.07295 0.8413 10	0.23288 0.4908 11	-0.64634 0.0435 10	0.00837 0.9830 9	-0.34940 0.3962 8	0.17964 0.6703 8	-0.40000 0.5046 5
ID12PCT	0.53659 0.1098 10	0.74429 0.0086 11	0.50175 0.0965 12	-0.57193 0.0520 12	-0.11288 0.7269 12	0.52545 0.0652 13	0.23288 0.4908 11	0.14634 0.6866 10	0.50570 0.1125 11	0.36134 0.3393 9	0.63333 0.0671 9	0.92857 0.0025 7
ID13PCT	0.28049 0.4325 10	0.18293 0.6130 10	0.37805 0.2814 10	0.10502 0.7586 11	-0.09196 0.7880 11	0.08656 0.8002 11	0.07317 0.8408 10	0.19512 0.5891 10	0.71733 0.0195 10	-0.08485 0.8417 8	0.14286 0.7599 7	0.60000 0.2080 6
IP11PCT	1.00000 0.0000 11	0.62195 0.0549 10	0.12195 0.7372 10	-0.48858 0.1273 11	-0.60691 0.0477 11	0.55125 0.0788 11	-0.18293 0.6130 10	0.32927 0.3529 10	0.56067 0.1163 9	-0.07340 0.8757 7	0.50000 0.2532 7	0.67857 0.0938 7
IP12PCT	0.62195 0.0549 10	1.00000 0.0000 12	0.50685 0.1116 11	-0.17193 0.5931 12	-0.40918 0.1866 12	0.54991 0.0640 12	-0.29268 0.4118 10	-0.12329 0.7180 11	0.53496 0.1111 10	-0.11814 0.7621 9	0.14286 0.7358 8	0.92857 0.0025 7

Fig. 19h(iii) Group 8 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	IPI1PCT	IPI2PCT	IPI3PCT	ABA1PCT	ABA2PCT	ABA3PCT	ITI1PCT	ITI2PCT	ITI3PCT	IBI1PCT	IBI2PCT	IBI3PCT
IPI3PCT	0.12195 0.7372 10	0.50685 0.1116 11	1.00000 0.0000 13	0.31930 0.3117 12	0.08466 0.7936 12	0.01926 0.9502 13	0.48780 0.1526 10	0.14634 0.6866 10	0.00456 0.9894 11	0.69199 0.0389 9	0.16667 0.6932 8	0.75000 0.0522 7
ABA1PCT	-0.48858 0.1273 11	-0.17193 0.5931 12	0.31930 0.3117 12	1.00000 0.0000 14	0.14807 0.6134 14	-0.64099 0.0182 13	0.05965 0.8539 12	-0.13684 0.6715 12	-0.35080 0.2902 11	0.54435 0.1038 10	-0.77204 0.0089 10	-0.52381 0.1827 8
ABA2PCT	-0.60691 0.0477 11	-0.40918 0.1866 12	0.08466 0.7936 12	0.14807 0.6134 14	1.00000 0.0000 14	-0.04420 0.8860 13	0.04233 0.8961 12	-0.16931 0.5988 12	-0.09175 0.7885 11	0.43425 0.2098 10	0.15198 0.6751 10	-0.33333 0.4198 8
ABA3PCT	0.55125 0.0788 11	0.54991 0.0640 12	0.01926 0.9502 13	-0.64099 0.0182 13	-0.04420 0.8860 13	1.00000 0.0000 14	-0.41458 0.2049 11	0.02278 0.9470 11	0.41958 0.1745 12	-0.17073 0.6372 10	0.56667 0.1116 9	0.35714 0.3851 8
ITI1PCT	-0.18293 0.6130 10	-0.29268 0.4118 10	0.48780 0.1526 10	0.05965 0.8539 12	0.04233 0.8961 12	-0.41458 0.2049 11	1.00000 0.0000 12	0.21461 0.5263 11	-0.46026 0.2125 9	0.42169 0.2981 8	0.45189 0.2220 9	0.65714 0.1562 6
ITI2PCT	0.32927 0.3529 10	-0.12329 0.7180 11	0.14634 0.6866 10	-0.13684 0.6715 12	-0.16931 0.5988 12	0.02278 0.9470 11	0.21461 0.5263 11	1.00000 0.0000 12	0.09205 0.8138 9	0.91984 0.0004 9	0.68265 0.0621 8	0.94286 0.0048 6
ITI3PCT	0.56067 0.1163 9	0.53496 0.1111 10	0.00456 0.9894 11	-0.35080 0.2902 11	-0.09175 0.7885 11	0.41958 0.1745 12	-0.46026 0.2125 9	0.09205 0.8138 9	1.00000 0.0000 12	-0.19247 0.6198 9	0.71429 0.0465 8	0.88571 0.0188 6
IBI1PCT	-0.07340 0.8757 7	-0.11814 0.7621 9	0.69199 0.0389 9	0.54435 0.1038 10	0.43425 0.2098 10	-0.17073 0.6372 10	0.42169 0.2981 8	0.91984 0.0004 9	-0.19247 0.6198 9	1.00000 0.0000 11	0.65714 0.1562 6	0.87208 0.0539 5
IBI2PCT	0.50000 0.2532 7	0.14286 0.7358 8	0.16667 0.6932 8	-0.77204 0.0089 10	0.15198 0.6751 10	0.56667 0.1116 9	0.45189 0.2220 9	0.68265 0.0621 8	0.71429 0.0465 8	0.65714 0.1562 6	1.00000 0.0000 10	0.94286 0.0048 6
IBI3PCT	0.67857 0.0938 7	0.92857 0.0025 7	0.75000 0.0522 7	-0.52381 0.1827 8	-0.33333 0.4198 8	0.35714 0.3851 8	0.65714 0.1562 6	0.94286 0.0048 6	0.88571 0.0188 6	0.87208 0.0539 5	0.94286 0.0048 6	1.00000 0.0000 8

Fig. 19h(iv) Group 8 continued.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 14	0.15842 0.5886 14	0.39384 0.1635 14	0.46865 0.0910 14	0.64246 0.0132 14	0.56766 0.0342 14	-0.14521 0.6204 14	-0.51265 0.0609 14	0.15402 0.5991 14	0.46916 0.0906 14	-0.31938 0.2657 14	-0.02643 0.9285 14
SIS2PCT	0.15842 0.5886 14	1.00000 0.0000 15	0.37500 0.1684 15	0.58571 0.0218 15	0.19643 0.4829 15	0.60000 0.0181 15	0.23571 0.3977 15	-0.18929 0.4993 15	0.38022 0.1799 14	0.34316 0.2105 15	0.17516 0.5324 15	-0.30742 0.2650 15
SIS3PCT	0.39384 0.1635 14	0.37500 0.1684 15	1.00000 0.0000 15	0.10714 0.7039 15	0.56071 0.0297 15	0.47143 0.0761 15	0.10000 0.7229 15	-0.00714 0.9798 15	0.22198 0.4456 14	0.59517 0.0192 15	0.02324 0.9345 15	-0.13226 0.6384 15
ZIZ1PCT	0.46865 0.0910 14	0.58571 0.0218 15	0.10714 0.7039 15	1.00000 0.0000 15	0.16071 0.5672 15	0.40000 0.1396 15	-0.11786 0.6757 15	-0.36429 0.1819 15	0.53407 0.0492 14	0.40214 0.1373 15	-0.10903 0.6989 15	0.36819 0.1769 15
ZIZ2PCT	0.64246 0.0132 14	0.19643 0.4829 15	0.56071 0.0297 15	0.16071 0.5672 15	1.00000 0.0000 15	0.47857 0.0711 15	-0.12143 0.6664 15	-0.46071 0.0839 15	0.16923 0.5630 14	0.80608 0.0003 15	0.03932 0.8893 15	-0.09830 0.7274 15
ZIZ3PCT	0.56766 0.0342 14	0.60000 0.0181 15	0.47143 0.0761 15	0.40000 0.1396 15	0.47857 0.0711 15	1.00000 0.0000 15	-0.25714 0.3549 15	-0.71786 0.0026 15	-0.07253 0.8054 14	0.52726 0.0434 15	0.18409 0.5113 15	-0.27703 0.3175 15
SAS1PCT	-0.14521 0.6204 14	0.23571 0.3977 15	0.10000 0.7229 15	-0.11786 0.6757 15	-0.12143 0.6664 15	-0.25714 0.3549 15	1.00000 0.0000 15	0.62143 0.0134 15	0.24835 0.3919 14	-0.28954 0.2952 15	0.20375 0.4664 15	-0.37534 0.1680 15
SAS2PCT	-0.51265 0.0609 14	-0.18929 0.4993 15	-0.00714 0.9798 15	-0.36429 0.1819 15	-0.46071 0.0839 15	-0.71786 0.0026 15	0.62143 0.0134 15	1.00000 0.0000 15	0.32308 0.2599 14	-0.48257 0.0685 15	-0.16443 0.5581 15	-0.09294 0.7418 15
SAS3PCT	0.15402 0.5991 14	0.38022 0.1799 14	0.22198 0.4456 14	0.53407 0.0492 14	0.16923 0.5630 14	-0.07253 0.8054 14	0.24835 0.3919 14	0.32308 0.2599 14	1.00000 0.0000 14	0.53025 0.0511 14	-0.53465 0.0489 14	0.19802 0.4974 14
ZAZ1PCT	0.46916 0.0906 14	0.34316 0.2105 15	0.59517 0.0192 15	0.40214 0.1373 15	0.80608 0.0003 15	0.52726 0.0434 15	-0.28954 0.2952 15	-0.48257 0.0685 15	0.53025 0.0511 14	1.00000 0.0000 15	-0.07871 0.7804 15	0.23077 0.4080 15
ZAZ2PCT	-0.31938 0.2657 14	0.17516 0.5324 15	0.02324 0.9345 15	-0.10903 0.6989 15	0.03932 0.8893 15	0.18409 0.5113 15	0.20375 0.4664 15	-0.16443 0.5581 15	-0.53465 0.0489 14	-0.07871 0.7804 15	1.00000 0.0000 15	0.06887 0.8073 15
ZAZ3PCT	-0.02643 0.9285 14	-0.30742 0.2650 15	-0.13226 0.6384 15	0.36819 0.1769 15	-0.09830 0.7274 15	-0.27703 0.3175 15	-0.37534 0.1680 15	-0.09294 0.7418 15	0.19802 0.4974 14	0.23077 0.4080 15	0.06887 0.8073 15	1.00000 0.0000 15

Fig. 35a Results of the Spearman's correlations for experiment four in Group 1.

SPEARMAN CORRELATION COEFFICIENTS / PROB * |R| UNDER $H_0: \rho=0$ / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 14	0.23102 0.4268 14	0.34989 0.2201 14	0.14876 0.6277 13	0.03509 0.9138 12	0.38790 0.1903 13	0.19625 0.5013 14	0.12555 0.6689 14	0.24035 0.4078 14	0.17428 0.5691 13	0.26843 0.3535 14	-0.41804 0.1369 14
SIS2PCT	0.23102 0.4268 14	1.00000 0.0000 15	0.63563 0.0109 15	0.26183 0.3659 14	0.31912 0.2879 13	0.09011 0.7593 14	0.57424 0.0252 15	0.45975 0.0847 15	0.40608 0.1331 15	0.69096 0.0062 14	0.35000 0.2009 15	0.13571 0.6296 15
SIS3PCT	0.34989 0.2201 14	0.63563 0.0109 15	1.00000 0.0000 15	0.34216 0.2311 14	0.82597 0.0005 13	0.31498 0.2727 14	0.27085 0.3289 15	0.39910 0.1406 15	0.33901 0.2164 15	0.80177 0.0006 14	0.47807 0.0715 15	0.01611 0.9545 15
ZIZ1PCT	0.14876 0.6277 13	0.26183 0.3659 14	0.34216 0.2311 14	1.00000 0.0000 14	0.77895 0.0028 12	0.70330 0.0073 13	0.26461 0.3606 14	0.06836 0.8164 14	-0.13782 0.6385 14	0.20194 0.5082 13	0.60946 0.0207 14	0.15622 0.5938 14
ZIZ2PCT	0.03509 0.9138 12	0.31912 0.2879 13	0.82597 0.0005 13	0.77895 0.0028 12	1.00000 0.0000 13	0.54291 0.0682 12	0.12828 0.6762 13	0.16552 0.5889 13	0.13103 0.6696 13	0.51176 0.0738 13	0.56396 0.0447 13	0.16231 0.5963 13
ZIZ3PCT	0.38790 0.1903 13	0.09011 0.7593 14	0.31498 0.2727 14	0.70330 0.0073 13	0.54291 0.0682 12	1.00000 0.0000 14	0.25991 0.3695 14	0.24229 0.4039 14	0.10341 0.7250 14	0.40332 0.1718 13	0.49890 0.0694 14	-0.02857 0.9228 14
SAS1PCT	0.19625 0.5013 14	0.57424 0.0252 15	0.27085 0.3289 15	0.26461 0.3606 14	0.12828 0.6762 13	0.25991 0.3695 14	1.00000 0.0000 15	0.56183 0.0293 15	0.33781 0.2182 15	0.72124 0.0036 14	0.62075 0.0135 15	0.50984 0.0522 15
SAS2PCT	0.12555 0.6689 14	0.45975 0.0847 15	0.39910 0.1406 15	0.06836 0.8164 14	0.16552 0.5889 13	0.24229 0.4039 14	0.56183 0.0293 15	1.00000 0.0000 15	0.57168 0.0260 15	0.65487 0.0110 14	0.54920 0.0340 15	0.24329 0.3823 15
SAS3PCT	0.24035 0.4078 14	0.40608 0.1331 15	0.33901 0.2164 15	-0.13782 0.6385 14	0.13103 0.6696 13	0.10341 0.7250 14	0.33781 0.2182 15	0.57168 0.0260 15	1.00000 0.0000 15	0.42478 0.1300 14	0.06440 0.8196 15	0.00358 0.9899 15
ZAZ1PCT	0.17428 0.5691 13	0.69096 0.0062 14	0.80177 0.0006 14	0.20194 0.5082 13	0.51176 0.0738 13	0.40332 0.1718 13	0.72124 0.0036 14	0.65487 0.0110 14	0.42478 0.1300 14	1.00000 0.0000 14	0.62473 0.0169 14	0.52760 0.0525 14
ZAZ2PCT	0.26843 0.3535 14	0.35000 0.2009 15	0.47807 0.0715 15	0.60946 0.0207 14	0.56396 0.0447 13	0.49890 0.0694 14	0.62075 0.0135 15	0.54920 0.0340 15	0.06440 0.8196 15	0.62473 0.0169 14	1.00000 0.0000 15	0.47143 0.0761 15
ZAZ3PCT	-0.41804 0.1369 14	0.13571 0.6296 15	0.01611 0.9545 15	0.15622 0.5938 14	0.16231 0.5963 13	-0.02857 0.9228 14	0.50984 0.0522 15	0.24329 0.3823 15	0.00358 0.9899 15	0.52760 0.0525 14	0.47143 0.0761 15	1.00000 0.0000 15

Fig. 35b Results of the Spearman's correlations for experiment four in Group 2.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 14	0.56292 0.0361 14	0.27153 0.3477 14	0.37143 0.1910 14	0.28352 0.3260 14	0.55021 0.0514 13	0.34103 0.2328 14	0.80220 0.0010 13	0.17428 0.5691 13	0.12088 0.6940 13	0.26403 0.3617 14	0.51099 0.0743 13
SIS2PCT	0.56292 0.0361 14	1.00000 0.0000 15	0.55396 0.0321 15	0.13979 0.6193 15	0.26523 0.3394 15	0.27845 0.3350 14	0.14170 0.6144 15	0.69096 0.0062 14	0.35960 0.2067 14	-0.10387 0.7238 14	0.17040 0.5437 15	0.36866 0.1946 14
SIS3PCT	0.27153 0.3477 14	0.55396 0.0321 15	1.00000 0.0000 15	0.37276 0.1712 15	0.48746 0.0653 15	0.43757 0.1176 14	0.10224 0.7169 15	0.43930 0.1160 14	0.23973 0.4091 14	0.51271 0.0608 14	0.41614 0.1229 15	0.35983 0.2063 14
ZIZ1PCT	0.37143 0.1910 14	0.13979 0.6193 15	0.37276 0.1712 15	1.00000 0.0000 15	0.52143 0.0462 15	0.38944 0.1687 14	0.00357 0.9899 15	0.20000 0.4930 14	0.18785 0.5202 14	0.53245 0.0500 14	0.76676 0.0009 15	0.58242 0.0289 14
ZIZ2PCT	0.28352 0.3260 14	0.26523 0.3394 15	0.48746 0.0653 15	0.52143 0.0462 15	1.00000 0.0000 15	0.86029 0.0001 14	0.27703 0.3175 15	0.56044 0.0371 14	0.45305 0.1038 14	0.52365 0.0546 14	0.51832 0.0478 15	0.62637 0.0165 14
ZIZ3PCT	0.55021 0.0514 13	0.27845 0.3350 14	0.43757 0.1176 14	0.38944 0.1687 14	0.86029 0.0001 14	1.00000 0.0000 14	0.57930 0.0299 14	0.57426 0.0317 14	0.53540 0.0485 14	0.45374 0.1032 14	0.31057 0.2798 14	0.57206 0.0326 14
SAS1PCT	0.34103 0.2328 14	0.14170 0.6144 15	0.10224 0.7169 15	0.00357 0.9899 15	0.27703 0.3175 15	0.57930 0.0299 14	1.00000 0.0000 15	0.32123 0.2628 14	0.60841 0.0210 14	0.22026 0.4492 14	-0.33363 0.2243 15	0.35644 0.2110 14
SAS2PCT	0.80220 0.0010 13	0.69096 0.0062 14	0.43930 0.1160 14	0.20000 0.4930 14	0.56044 0.0371 14	0.57426 0.0317 14	0.32123 0.2628 14	1.00000 0.0000 14	0.49062 0.0749 14	0.30803 0.2840 14	0.26403 0.3617 14	0.67912 0.0076 14
SAS3PCT	0.17428 0.5691 13	0.35960 0.2067 14	0.23973 0.4091 14	0.18785 0.5202 14	0.45305 0.1038 14	0.53540 0.0485 14	0.60841 0.0210 14	0.49062 0.0749 14	1.00000 0.0000 14	0.39602 0.1610 14	0.01106 0.9701 14	0.75360 0.0019 14
ZAZ1PCT	0.12088 0.6940 13	-0.10387 0.7238 14	0.51271 0.0608 14	0.53245 0.0500 14	0.52365 0.0546 14	0.45374 0.1032 14	0.22026 0.4492 14	0.30803 0.2840 14	0.39602 0.1610 14	1.00000 0.0000 14	0.61564 0.0191 14	0.65567 0.0109 14
ZAZ2PCT	0.26403 0.3617 14	0.17040 0.5437 15	0.41614 0.1229 15	0.76676 0.0009 15	0.51832 0.0478 15	0.31057 0.2798 14	-0.33363 0.2243 15	0.26403 0.3617 14	0.01106 0.9701 14	0.61564 0.0191 14	1.00000 0.0000 15	0.46865 0.0910 14
ZAZ3PCT	0.51099 0.0743 13	0.36866 0.1946 14	0.35983 0.2063 14	0.58242 0.0289 14	0.62637 0.0165 14	0.57206 0.0326 14	0.35644 0.2110 14	0.67912 0.0076 14	0.75360 0.0019 14	0.65567 0.0109 14	0.46865 0.0910 14	1.00000 0.0000 14

Fig. 35c Results of the Spearman's correlations for experiment four in Group 3.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 13	0.17580 0.6051 11	0.26833 0.3754 13	-0.18070 0.5741 12	0.21016 0.5121 12	0.29103 0.3347 13	0.49383 0.1027 12	0.18342 0.5683 12	0.43526 0.1371 13	0.10759 0.7265 13	0.21183 0.4872 13	0.20908 0.4930 13
SIS2PCT	0.17580 0.6051 11	1.00000 0.0000 12	0.50794 0.0918 12	-0.31279 0.3490 11	-0.51064 0.1315 10	0.04386 0.8923 12	0.11993 0.7104 12	-0.22928 0.4735 12	0.38584 0.2412 11	0.04912 0.8795 12	0.09457 0.7700 12	-0.14711 0.6482 12
SIS3PCT	0.26833 0.3754 13	0.50794 0.0918 12	1.00000 0.0000 14	-0.25620 0.3982 13	0.41331 0.1817 12	0.33186 0.2464 14	0.15000 0.6248 13	0.30556 0.3100 13	0.42047 0.1525 13	0.02434 0.9342 14	-0.12141 0.6793 14	0.26270 0.3642 14
ZIZ1PCT	-0.18070 0.5741 12	-0.31279 0.3490 11	-0.25620 0.3982 13	1.00000 0.0000 14	0.47318 0.1024 13	0.38759 0.1907 13	0.13831 0.6523 13	0.32365 0.2807 13	0.20937 0.4924 13	0.43172 0.1232 14	0.05502 0.8583 13	0.61073 0.0266 13
ZIZ2PCT	0.21016 0.5121 12	-0.51064 0.1315 10	0.41331 0.1817 12	0.47318 0.1024 13	1.00000 0.0000 13	0.64211 0.0244 12	0.39438 0.2046 12	0.42959 0.1634 12	0.25585 0.3988 13	0.34938 0.2420 13	0.19580 0.5419 12	0.44056 0.1517 12
ZIZ3PCT	0.29103 0.3347 13	0.04386 0.8923 12	0.33186 0.2464 14	0.38759 0.1907 13	0.64211 0.0244 12	1.00000 0.0000 14	0.09141 0.7665 13	0.56233 0.0455 13	0.59310 0.0326 13	0.46247 0.0959 14	0.40529 0.1505 14	0.56168 0.0366 14
SAS1PCT	0.49383 0.1027 12	0.11993 0.7104 12	0.15000 0.6248 13	0.13831 0.6523 13	0.39438 0.2046 12	0.09141 0.7665 13	1.00000 0.0000 14	0.23725 0.4141 14	-0.01667 0.9569 13	0.66962 0.0088 14	0.32597 0.2771 13	0.14365 0.6397 13
SAS2PCT	0.18342 0.5683 12	-0.22928 0.4735 12	0.30556 0.3100 13	0.32365 0.2807 13	0.42959 0.1634 12	0.56233 0.0455 13	0.23725 0.4141 14	1.00000 0.0000 14	0.61667 0.0248 13	0.50608 0.0648 14	-0.04972 0.8718 13	0.64642 0.0170 13
SAS3PCT	0.43526 0.1371 13	0.38584 0.2412 11	0.42047 0.1525 13	0.20937 0.4924 13	0.25585 0.3988 13	0.59310 0.0326 13	-0.01667 0.9569 13	0.61667 0.0248 13	1.00000 0.0000 14	0.26327 0.3631 14	0.05227 0.8653 13	0.72352 0.0052 13
ZAZ1PCT	0.10759 0.7265 13	0.04912 0.8795 12	0.02434 0.9342 14	0.43172 0.1232 14	0.34938 0.2420 13	0.46247 0.0959 14	0.66962 0.0088 14	0.50608 0.0648 14	0.26327 0.3631 14	1.00000 0.0000 15	0.63436 0.0148 14	0.47137 0.0889 14
ZAZ2PCT	0.21183 0.4872 13	0.09457 0.7700 12	-0.12141 0.6793 14	0.05502 0.8583 13	0.19580 0.5419 12	0.40529 0.1505 14	0.32597 0.2771 13	-0.04972 0.8718 13	0.05227 0.8653 13	0.63436 0.0148 14	1.00000 0.0000 14	0.08571 0.7708 14
ZAZ3PCT	0.20908 0.4930 13	-0.14711 0.6482 12	0.26270 0.3642 14	0.61073 0.0266 13	0.44056 0.1517 12	0.56168 0.0366 14	0.14365 0.6397 13	0.64642 0.0170 13	0.72352 0.0052 13	0.47137 0.0889 14	0.08571 0.7708 14	1.00000 0.0000 14

Fig. 35 d Results of the Spearman's correlations for experiment four in Group 4.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 15	0.47143 0.0761 15	0.20879 0.4936 13	0.43571 0.1045 15	0.23956 0.4094 14	0.43956 0.1329 13	0.68929 0.0045 15	0.15385 0.6158 13	0.08791 0.7752 13	0.40220 0.1540 14	0.42117 0.1337 14	0.22417 0.4837 12
SIS2PCT	0.47143 0.0761 15	1.00000 0.0000 15	0.54945 0.0518 13	0.36786 0.1773 15	0.16923 0.5630 14	0.43407 0.1383 13	0.33214 0.2265 15	0.49451 0.0858 13	0.37363 0.2086 13	0.45055 0.1059 14	0.29548 0.3051 14	0.36778 0.2395 12
SIS3PCT	0.20879 0.4936 13	0.54945 0.0518 13	1.00000 0.0000 13	0.64835 0.0165 13	0.53846 0.0709 12	0.57343 0.0513 12	-0.02747 0.9290 13	0.07273 0.8317 11	0.62937 0.0283 12	0.42657 0.1667 12	0.36141 0.2484 12	0.06834 0.8418 11
ZIZ1PCT	0.43571 0.1045 15	0.36786 0.1773 15	0.64835 0.0165 13	1.00000 0.0000 15	0.55604 0.0389 14	0.59341 0.0325 13	0.11429 0.6851 15	-0.08242 0.7890 13	0.30769 0.3064 13	0.12527 0.6696 14	0.33738 0.2381 14	-0.28021 0.3777 12
ZIZ2PCT	0.23956 0.4094 14	0.16923 0.5630 14	0.53846 0.0709 12	0.55604 0.0389 14	1.00000 0.0000 14	0.34965 0.2652 12	0.12967 0.6586 14	-0.06294 0.8459 12	0.28671 0.3663 12	0.06044 0.8445 13	0.31405 0.2960 13	0.32925 0.2960 12
ZIZ3PCT	0.43956 0.1329 13	0.43407 0.1383 13	0.57343 0.0513 12	0.59341 0.0325 13	0.34965 0.2652 12	1.00000 0.0000 13	0.12637 0.6808 13	0.01818 0.9577 11	0.23626 0.4371 13	0.34615 0.2466 13	-0.26316 0.4086 12	-0.26270 0.4094 12
SAS1PCT	0.68929 0.0045 15	0.33214 0.2265 15	-0.02747 0.9290 13	0.11429 0.6851 15	0.12967 0.6586 14	0.12637 0.6808 13	1.00000 0.0000 15	0.46703 0.1076 13	0.36264 0.2233 13	0.38022 0.1799 14	0.24476 0.3990 14	0.49737 0.0999 12
SAS2PCT	0.15385 0.6158 13	0.49451 0.0858 13	0.07273 0.8317 11	-0.08242 0.7890 13	-0.06294 0.8459 12	0.01818 0.9577 11	0.46703 0.1076 13	1.00000 0.0000 13	0.50000 0.1173 11	0.32867 0.2969 12	-0.10207 0.7400 13	0.20000 0.5796 10
SAS3PCT	0.08791 0.7752 13	0.37363 0.2086 13	0.62937 0.0283 12	0.30769 0.3064 13	0.28671 0.3663 12	0.23626 0.4371 13	0.36264 0.2233 13	0.50000 0.1173 11	1.00000 0.0000 13	0.36264 0.2233 13	0.17544 0.5855 12	0.35377 0.2593 12
ZAZ1PCT	0.40220 0.1540 14	0.45055 0.1059 14	0.42657 0.1667 12	0.12527 0.6696 14	0.06044 0.8445 13	0.34615 0.2466 13	0.38022 0.1799 14	0.32867 0.2969 12	0.36264 0.2233 13	1.00000 0.0000 14	0.34160 0.2533 13	0.47636 0.1174 12
ZAZ2PCT	0.42117 0.1337 14	0.29548 0.3051 14	0.36141 0.2484 12	0.33738 0.2381 14	0.31405 0.2960 13	-0.26316 0.4086 12	0.24476 0.3990 14	-0.10207 0.7400 13	0.17544 0.5855 12	0.34160 0.2533 13	1.00000 0.0000 14	0.65675 0.0281 11
ZAZ3PCT	0.22417 0.4837 12	0.36778 0.2395 12	0.06834 0.8418 11	-0.28021 0.3777 12	0.32925 0.2960 12	-0.26270 0.4094 12	0.49737 0.0999 12	0.20000 0.5796 10	0.35377 0.2593 12	0.47636 0.1174 12	0.65675 0.0281 11	1.00000 0.0000 12

Fig. 35e Results of the Spearman's correlations for experiment four in Group 5.

SPERMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 12	0.35080 0.2902 11	0.38947 0.2108 12	0.55789 0.0594 12	0.65455 0.0289 11	0.07706 0.8119 12	0.52189 0.0818 12	0.76357 0.0039 12	0.35026 0.2643 12	0.85814 0.0004 12	0.54214 0.0849 11	0.83012 0.0008 12
SIS2PCT	0.35080 0.2902 11	1.00000 0.0000 13	0.39780 0.1783 13	0.27273 0.3911 12	0.18881 0.5567 12	0.26374 0.3839 13	-0.09341 0.7615 13	0.66484 0.0132 13	0.19780 0.5171 13	0.38462 0.2170 12	0.44755 0.1446 12	0.15934 0.6031 13
SIS3PCT	0.38947 0.2108 12	0.39780 0.1783 13	1.00000 0.0000 14	-0.03596 0.9072 13	0.48067 0.0964 13	0.04194 0.8868 14	0.16115 0.5821 14	0.22738 0.4344 14	0.25387 0.3811 14	0.40885 0.1654 13	0.17680 0.5634 13	0.19647 0.5008 14
ZIZ1PCT	0.55789 0.0594 12	0.27273 0.3911 12	-0.03596 0.9072 13	1.00000 0.0000 14	0.39890 0.1770 13	0.21183 0.4872 13	0.14317 0.6253 14	0.52270 0.0668 13	0.00660 0.9821 14	0.37844 0.1821 14	0.42916 0.1434 13	0.17822 0.5421 14
ZIZ2PCT	0.65455 0.0289 11	0.18881 0.5567 12	0.48067 0.0964 13	0.39890 0.1770 13	1.00000 0.0000 14	0.31319 0.2974 13	0.44176 0.1138 14	0.15934 0.6031 13	-0.14725 0.6154 14	0.54945 0.0518 13	0.71429 0.0061 13	0.56044 0.0371 14
ZIZ3PCT	0.07706 0.8119 12	0.26374 0.3839 13	0.04194 0.8868 14	0.21183 0.4872 13	0.31319 0.2974 13	1.00000 0.0000 14	0.28352 0.3260 14	0.48571 0.0783 14	-0.16923 0.5630 14	0.29670 0.3249 13	0.75275 0.0030 13	0.31868 0.2668 14
SAS1PCT	0.52189 0.0818 12	-0.09341 0.7615 13	0.16115 0.5821 14	0.14317 0.6253 14	0.44176 0.1138 14	0.28352 0.3260 14	1.00000 0.0000 15	0.14286 0.6261 14	0.19124 0.4948 15	0.37184 0.1905 14	0.66447 0.0095 14	0.34853 0.2030 15
SAS2PCT	0.76357 0.0039 12	0.66484 0.0132 13	0.22738 0.4344 14	0.52270 0.0668 13	0.15934 0.6031 13	0.48571 0.0783 14	0.14286 0.6261 14	1.00000 0.0000 14	0.13407 0.6477 14	0.64286 0.0178 13	0.43956 0.1329 13	0.52967 0.0514 14
SAS3PCT	0.35026 0.2643 12	0.19780 0.5171 13	0.25387 0.3811 14	0.00660 0.9821 14	-0.14725 0.6154 14	-0.16923 0.5630 14	0.19124 0.4948 15	0.13407 0.6477 14	1.00000 0.0000 15	0.50330 0.0666 14	-0.03736 0.8991 14	0.32857 0.2318 15
ZAZ1PCT	0.85814 0.0004 12	0.38462 0.2170 12	0.40885 0.1654 13	0.37844 0.1821 14	0.54945 0.0518 13	0.29670 0.3249 13	0.37184 0.1905 14	0.64286 0.0178 13	0.50330 0.0666 14	1.00000 0.0000 14	0.35714 0.2309 13	0.78901 0.0008 14
ZAZ2PCT	0.54214 0.0849 11	0.44755 0.1446 12	0.17680 0.5634 13	0.42916 0.1434 13	0.71429 0.0061 13	0.75275 0.0030 13	0.66447 0.0095 14	0.43956 0.1329 13	-0.03736 0.8991 14	0.35714 0.2309 13	1.00000 0.0000 14	0.44615 0.1098 14
ZAZ3PCT	0.83012 0.0008 12	0.15934 0.6031 13	0.19647 0.5008 14	0.17822 0.5421 14	0.56044 0.0371 14	0.31868 0.2668 14	0.34853 0.2030 15	0.52967 0.0514 14	0.32857 0.2318 15	0.78901 0.0008 14	0.44615 0.1098 14	1.00000 0.0000 15

Fig. 35f Results of the Spearman's correlations for experiment four in Group 6.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 13	0.41301 0.1821 12	0.54214 0.0849 11	0.66942 0.0123 13	0.55152 0.0984 10	0.71053 0.0096 12	0.62105 0.0311 12	0.70753 0.0101 12	0.23235 0.4918 11	0.72154 0.0081 12	0.41667 0.2646 9	0.53939 0.1076 10
SIS2PCT	0.41301 0.1821 12	1.00000 0.0000 14	0.49315 0.1232 11	0.58483 0.0358 13	0.54214 0.0849 11	0.50439 0.0945 12	0.19559 0.5219 13	0.39649 0.2019 12	0.36491 0.2435 12	0.44493 0.1109 14	0.66059 0.0269 11	0.26970 0.3966 12
SIS3PCT	0.54214 0.0849 11	0.49315 0.1232 11	1.00000 0.0000 12	0.79825 0.0019 12	0.82675 0.0032 10	0.73973 0.0093 11	0.61048 0.0461 11	0.55581 0.0758 11	0.51481 0.1051 11	0.51481 0.1051 11	0.83683 0.0049 9	0.39636 0.2275 11
ZIZ1PCT	0.66942 0.0123 13	0.58483 0.0358 13	0.79825 0.0019 12	1.00000 0.0000 14	0.78360 0.0043 11	0.64463 0.0174 13	0.70799 0.0068 13	0.66850 0.0125 13	0.46235 0.1302 12	0.81706 0.0007 13	0.65654 0.0392 10	0.25968 0.4406 11
ZIZ2PCT	0.55152 0.0984 10	0.54214 0.0849 11	0.82675 0.0032 10	0.78360 0.0043 11	1.00000 0.0000 12	0.66364 0.0260 11	0.63326 0.0365 11	0.71818 0.0128 11	0.78182 0.0045 11	0.54545 0.0827 11	0.74545 0.0085 11	0.18788 0.6032 10
ZIZ3PCT	0.71053 0.0096 12	0.50439 0.0945 12	0.73973 0.0093 11	0.64463 0.0174 13	0.66364 0.0260 11	1.00000 0.0000 13	0.74737 0.0052 12	0.61623 0.0249 13	0.33976 0.2799 12	0.74256 0.0057 12	0.76970 0.0092 10	0.78420 0.0072 10
SAS1PCT	0.62105 0.0311 12	0.19559 0.5219 13	0.61048 0.0461 11	0.70799 0.0068 13	0.63326 0.0365 11	0.74737 0.0052 12	1.00000 0.0000 14	0.89317 0.0001 12	0.63047 0.0280 12	0.80220 0.0010 13	0.36970 0.2931 10	0.06364 0.8525 11
SAS2PCT	0.70753 0.0101 12	0.39649 0.2019 12	0.55581 0.0758 11	0.66850 0.0125 13	0.71818 0.0128 11	0.61623 0.0249 13	0.89317 0.0001 12	1.00000 0.0000 13	0.64336 0.0240 12	0.72028 0.0082 12	0.44242 0.2004 10	0.29697 0.4047 10
SAS3PCT	0.23235 0.4918 11	0.36491 0.2435 12	0.51481 0.1051 11	0.46235 0.1302 12	0.78182 0.0045 11	0.33976 0.2799 12	0.63047 0.0280 12	0.64336 0.0240 12	1.00000 0.0000 13	0.26573 0.4038 12	0.58788 0.0739 10	0.11818 0.7293 11
ZAZ1PCT	0.72154 0.0081 12	0.44493 0.1109 14	0.51481 0.1051 11	0.81706 0.0007 13	0.54545 0.0827 11	0.74256 0.0057 12	0.80220 0.0010 13	0.72028 0.0082 12	0.26573 0.4038 12	1.00000 0.0000 14	0.38182 0.2466 11	0.32168 0.3079 12
ZAZ2PCT	0.41667 0.2646 9	0.66059 0.0269 11	0.83683 0.0049 9	0.65654 0.0392 10	0.74545 0.0085 11	0.76970 0.0092 10	0.36970 0.2931 10	0.44242 0.2004 10	0.58788 0.0739 10	0.38182 0.2466 11	1.00000 0.0000 11	0.34545 0.3282 10
ZAZ3PCT	0.53939 0.1076 10	0.26970 0.3966 12	0.39636 0.2275 11	0.25968 0.4406 11	0.18788 0.6032 10	0.78420 0.0072 10	0.06364 0.8525 11	0.29697 0.4047 10	0.11818 0.7293 11	0.32168 0.3079 12	0.34545 0.3282 10	1.00000 0.0000 12

Fig. 359 Results of the Spearman's correlations for experiment four in Group 7.

SPEARMAN CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	SIS1PCT	SIS2PCT	SIS3PCT	ZIZ1PCT	ZIZ2PCT	ZIZ3PCT	SAS1PCT	SAS2PCT	SAS3PCT	ZAZ1PCT	ZAZ2PCT	ZAZ3PCT
SIS1PCT	1.00000 0.0000 15	0.13892 0.6358 14	0.38790 0.1903 13	0.55066 0.0413 14	0.44322 0.1124 14	0.58596 0.0453 12	0.43707 0.1353 13	0.42291 0.1319 14	0.15789 0.6241 12	0.27862 0.3566 13	0.60331 0.0290 13	0.29477 0.3282 13
SIS2PCT	0.13892 0.6358 14	1.00000 0.0000 14	0.32983 0.2951 12	0.46897 0.1060 13	0.63724 0.0191 13	0.55536 0.0609 12	-0.29682 0.3488 12	-0.30897 0.3043 13	0.30580 0.3337 12	0.83451 0.0007 12	0.08436 0.7944 12	0.73111 0.0069 12
SIS3PCT	0.38790 0.1903 13	0.32983 0.2951 12	1.00000 0.0000 13	0.68501 0.0098 13	0.74003 0.0038 13	0.77408 0.0031 12	0.76993 0.0056 11	0.26970 0.3966 12	-0.66059 0.0269 11	0.38179 0.2207 12	0.80638 0.0027 11	0.16781 0.5837 13
ZIZ1PCT	0.55066 0.0413 14	0.46897 0.1060 13	0.68501 0.0098 13	1.00000 0.0000 14	0.79614 0.0011 13	0.85263 0.0004 12	0.37390 0.2312 12	0.06887 0.8231 13	-0.25614 0.4216 12	0.65614 0.0205 12	0.55789 0.0594 12	0.33884 0.2574 13
ZIZ2PCT	0.44322 0.1124 14	0.63724 0.0191 13	0.74003 0.0038 13	0.79614 0.0011 13	1.00000 0.0000 14	0.74035 0.0059 12	0.31283 0.3222 12	0.11310 0.7130 13	-0.44292 0.1725 11	0.61464 0.0254 13	0.61160 0.0346 12	0.45455 0.1186 13
ZIZ3PCT	0.58596 0.0453 12	0.55536 0.0609 12	0.77408 0.0031 12	0.85263 0.0004 12	0.74035 0.0059 12	1.00000 0.0000 12	0.67073 0.0338 10	0.32420 0.3307 11	-0.05936 0.8624 11	0.50685 0.1116 11	0.75610 0.0114 10	0.38246 0.2198 12
SAS1PCT	0.43707 0.1353 13	-0.29682 0.3488 12	0.76993 0.0056 11	0.37390 0.2312 12	0.31283 0.3222 12	0.67073 0.0338 10	1.00000 0.0000 13	0.68604 0.0096 13	-0.37702 0.2530 11	0.05263 0.8710 12	0.57539 0.0396 13	-0.05936 0.8624 11
SAS2PCT	0.42291 0.1319 14	-0.30897 0.3043 13	0.26970 0.3966 12	0.06887 0.8231 13	0.11310 0.7130 13	0.32420 0.3307 11	0.68604 0.0096 13	1.00000 0.0000 14	-0.22105 0.4899 12	-0.12966 0.6729 13	0.47107 0.1042 13	-0.25614 0.4216 12
SAS3PCT	0.15789 0.6241 12	0.30580 0.3337 12	-0.66059 0.0269 11	-0.25614 0.4216 12	-0.44292 0.1725 11	-0.05936 0.8624 11	-0.37702 0.2530 11	-0.22105 0.4899 12	1.00000 0.0000 12	0.03196 0.9257 11	-0.45205 0.1627 11	0.53425 0.0905 11
ZAZ1PCT	0.27862 0.3566 13	0.83451 0.0007 12	0.38179 0.2207 12	0.65614 0.0205 12	0.61464 0.0254 13	0.50685 0.1116 11	0.05263 0.8710 12	-0.12966 0.6729 13	0.03196 0.9257 11	1.00000 0.0000 13	0.22807 0.4759 12	0.57895 0.0486 12
ZAZ2PCT	0.60331 0.0290 13	0.08436 0.7944 12	0.80638 0.0027 11	0.55789 0.0594 12	0.61160 0.0346 12	0.75610 0.0114 10	0.57539 0.0396 13	0.47107 0.1042 13	-0.45205 0.1627 11	0.22807 0.4759 12	1.00000 0.0000 13	-0.28767 0.3910 11
ZAZ3PCT	0.29477 0.3282 13	0.73111 0.0069 12	0.16781 0.5837 13	0.33884 0.2574 13	0.45455 0.1186 13	0.38246 0.2198 12	-0.05936 0.8624 11	-0.25614 0.4216 12	0.53425 0.0905 11	0.57895 0.0486 12	-0.28767 0.3910 11	1.00000 0.0000 13

Fig. 35h Results of the Spearman's correlations for experiment four in Group 8.