THE PHONEMIC SYLLABLE IN SAHU:
A COMPUTER-AIDED PHONOLOGICAL ANALYSIS

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Limited aspects of the phonological system of Sahu, a language of the North Halmaheran Family of the West Papuan Phylum, are described. The data and analysis presented represent the Pa'disua dialect spoken in the villages of Awer and Aketola. A description and interpretation is given of the sound features (sonority, timing, and tone) which characterize the syllable, along with illustrative figures of these features as represented by **C**omputerized **E**xtraction of **C**omponents of **I**ntonation in **L**anguage (CECIL) speech analysis. Particular attention is given to the treatment of long vowels and vocoid clusters. Discussion is also given to the sound features that characterize stress.

1. INTRODUCTION

The Sahu language belongs to the western subgroup of the West Papuan Phylum (Voorhoeve, 1984:9). Sahu is spoken in the basins of the Akelamo and Akediri Rivers, around the two dead volcanoes in the south western corner of the northern peninsula of Halmahera. Depending on criteria for classification, the Sahu language comprises of either four dialects or two. These are Pa'disua, Tala'i, Waioli and Gamkonora (with a fifth, Ibu, all but extinct) following Visser and Voorhoeve (1987:5) or alternatively, just Pa'disua and Tala'i according to Grimes and Grimes (1984:26-27). Map 5 indicates the dialect areas as suggested by Visser and Voorhoeve. A fuller treatment of the dialect issue will appear in a forthcoming paper (Severn 1995). The most prestigious dialect is the Pa'disua dialect which is spoken by 4,000-5,000 speakers. There are some 12,000 Sahu speakers all together.

Previous studies have been conducted by the Dutch missionary Fortgens back in the early 20th Century, much later by L.E. Visser from June 1979 until January 1981, as well as in 1980 and 1984 by C.L. Voorhoeve. The latter two researchers jointly produced a dictionary and grammar sketch (Visser and Voorhoeve, 1987).

The data[1] for this report was gathered from speakers of the Pa'disua dialect of the Sahu language in the village of Awer in Northern Maluku from January 1993 to April 1994.[2] Some of the observations are of a preliminary nature and it is hoped that further studies will achieve a more precise and thorough definition. Hereafter, all references to the Sahu language will refer to the Pa'disua dialect.

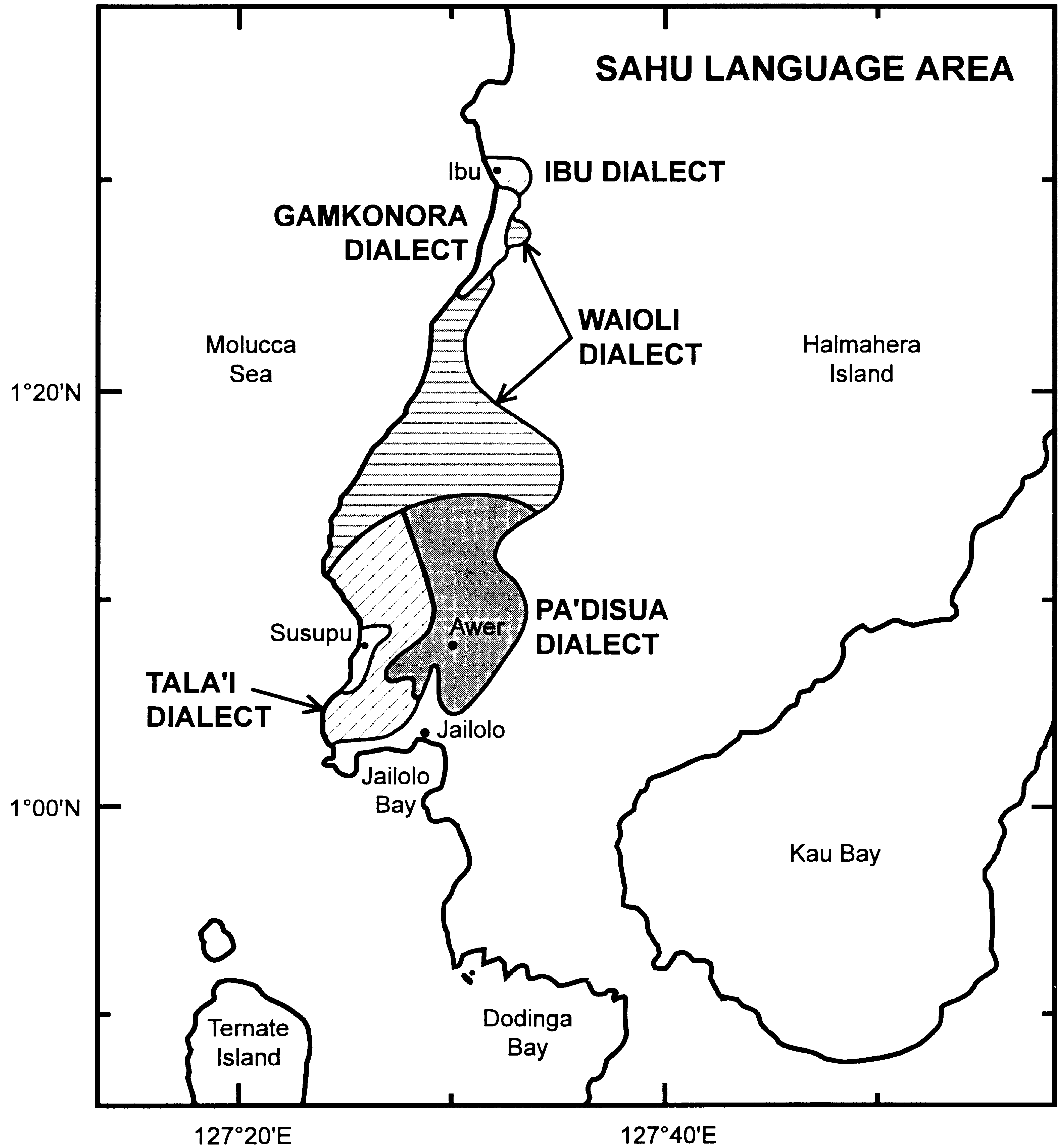
This report will look at the equipment used (Section 2), summarize the phonological inventory (Section 3), define the phonetic and the phonemic syllable types (Section 4), and discuss some interesting non-phonemic features that were found by analyzing the CECIL data (Section 5).

2. EQUIPMENT

Until relatively recently the only available equipment the linguist could call on to help with his analysis was a tape recorder and microphone for recording the data. With the arrival of the portable computer together with related software, assistance was available for collation, analysis and presentation of transcribed data. However the analysis still relied heavily upon the accuracy of the transcribed data and therefore the 'subjective ear' of the linguist. With the advent of speech analysis systems, such as CECIL, objective data could be produced in the form of graphs, frequency plots and spectrograms. These greatly aid the accuracy with which data can be transcribed and enable a more accurate and in-depth analysis of the sound system.

2.1 CECIL

Computerized **E**xtraction of **C**omponents of **I**ntonation in **L**anguage (CECIL)[3] is a speech sound analysis system for the field linguist. The aim of CECIL is to help analyze loudness, tone, intonation and length by



Map 5. Sahu language area indicating general locations of the five dialects: Tala'i, Pa'disua, Waioli, Gamkonora, and Ibu (modified from Visser and Voorhoeve, 1987).

providing accurate representations or measurements of actual physical properties of speech sound waves (etic properties) (Owen and Kelso, 1992:8). The etic properties derived from CECIL are then interpreted phonemically to produce the various phonemic syllable types. CECIL comprises of a speech analysis unit (CI-500) which converts raw sound from a microphone or tape recorder into digital form which then becomes the input to a computer via the parallel port. This signal in turn is analyzed by the primary software tool of the speech analysis system, the CECIL V2.0 program,[4] which produces the following graphs: a frequency graph (for analyzing pitch, tone and intonation) labeled 'Fsmooth'; an amplitude graph (for analyzing the intensity component of stress) labeled 'Loudness', a speech-wave graph labeled 'Data', and a change-in-quality-of-the-sound graph labeled 'Change'.

In addition to the obvious benefits of graphical representation mentioned above, there are other advantages. As the phonetic data is digitized and stored on a computer instead of as an analogue signal on a audio tape, the utterance can be examined in minute time frames (hundredths of a second). Therefore the characteristics of part or all of an utterance can be assessed (e.g. whether there is friction or voicing) along with the mode of articulation (plosive, lateral, etc.). Also the duration of any part of an utterance can be determined. The digitized, computer-stored data allows syllables, vowels, consonants or the entire utterance to be played back instantly and repeatedly, and if desired, at slower speeds. A further aid to language learning is that a speaker's utterance can be listened to and then a language learner's mimicry of that same utterance can be recorded and superimposed graphically on top of the native speaker's utterance. This helps to objectively assess how closely one is mimicking the language and where improvements are needed.

2.2 Additional equipment used

In gathering Sahu language data to be processed by CECIL, a Sony Walkman Professional WM-D6C was used, in conjunction with a Crown 'Sound Grabber' microphone.[5] This type of microphone can either be hand-held or can be laid on a surface some distance from the speaker, since it is both sensitive and directional. This type of microphone particularly lends itself to recording vernacular language material since the speaker quickly forgets its presence and thus produces a more natural recording.

3. OUTLINE OF CONSONANTS AND VOWELS

Sahu has an phoneme inventory of twenty-four consonants[6] (including two semi-vowels) and six vowels. However two of the consonants ([f] and [h]) and one vowel ([ə]) are loan phonemes.

Modes of articulation	Bilabial	Alveolar	Alveo-palatal	Velar	Glottal
Plosives - voiced	p	t		k	' (ʔ)
Plosives - voiceless	b	d		g	
Implosives	ɓ	ɗ	ʄ	ɠ	
Nasals	m	n	ny (ɲ)	ng (ŋ)	
Affricate - voiced			c (tʃ)		
Affricate - voiceless			j (dʒ)		
Fricatives	f	s			h
Vibrant		r			
Lateral		l			
Semivowels	w	y			

	Front	Central	Back
Closed	i	ə	u
Open	e	a	o

Each of the front and back vowels /i, e, u, o/ has a predictable variant [ɪ, ɛ, ʊ, ɔ], respectively. These vowels along with the consonants are the focus of a more complete paper on the phonology of Sahu (Severn and Severn 1995).

4. DEFINING THE PHONEMIC SYLLABLE

The physical evidence for the *phonetic* syllable in Sahu is straightforward: it is characterized by a peak of sonority. In Sahu this peak of sonority consists of a simple or complex vocoid with or without the presence of simple contoids at the syllable margins. Complex contoids in Sahu are restricted to loan words. Figure 1[7] is a graphical representation of the raw acoustic data of the utterance [**ɛse**] 'to rub', showing clearly the two areas of intensity correspond to the vowels [ɛ] and [e].

The *phonemic* syllable, however, is a more difficult problem. The main defining criteria are vowel, tone, and duration. In some languages a compound definition of vowel and tone, or vowel and timing, fits better. As will be shown, CECIL particularly helps to accurately analyze tone and duration, which are normally difficult qualities to assess well by the unaided human ear.

We will look at each of these defining criteria in turn, and use the analysis of the phonetic data derived from CECIL to determine how the phonemic syllable and the phonemic syllable types are best defined for the Pa'disua dialect of the Sahu language.

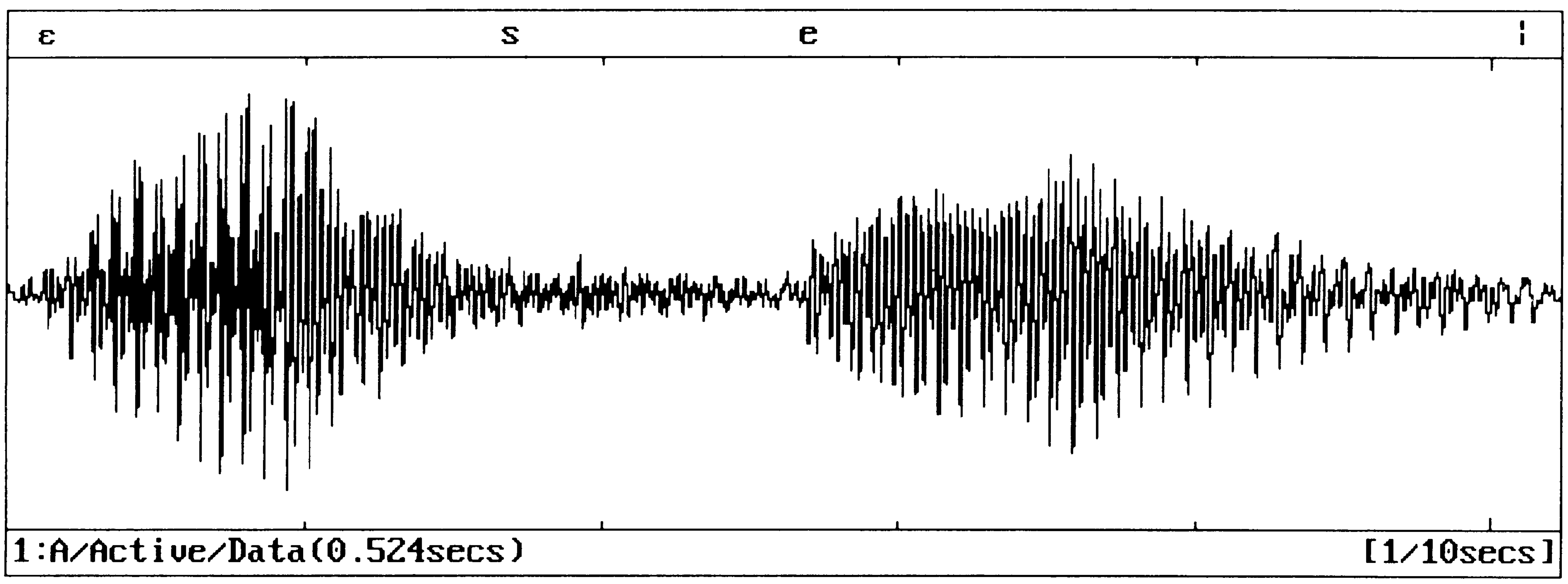


Figure 1. Graphical representation of [**ɛse**], /ese/ 'to rub'.

4.1 Timing

For the phonemic syllable to be defined by timing, as in the case of Japanese, each syllable would be the same duration irrespective of the consonant margins or vowels within it. Therefore all single syllable words would be of the same duration as each other; all two syllable words would be of the same duration as each other, etc. The following utterances were taken from the same speaker during the same session and a sample word (/**bele**/ 'banana') was placed amongst the data to verify the speakers consistency duration-wise for the same word. It was found for a sample of five utterances of /**bele**/ (interspersed with other words) that percentage variations in length of the utterance were less than 5%. Therefore speaker consistency was such that utterances could be measured with confidence for precise duration. Figures 2, 3 and 4 ([**bɛle**] 'banana' 0.275 sec, [**mɛme**] 'mother' 0.529 sec, and [**lɛʔa**] 'where' 0.469 sec) are sufficient to show that the duration of each syllable is dependent upon the vowel and consonant margins. Therefore the phonemic syllable for Sahu is not defined in terms of duration.

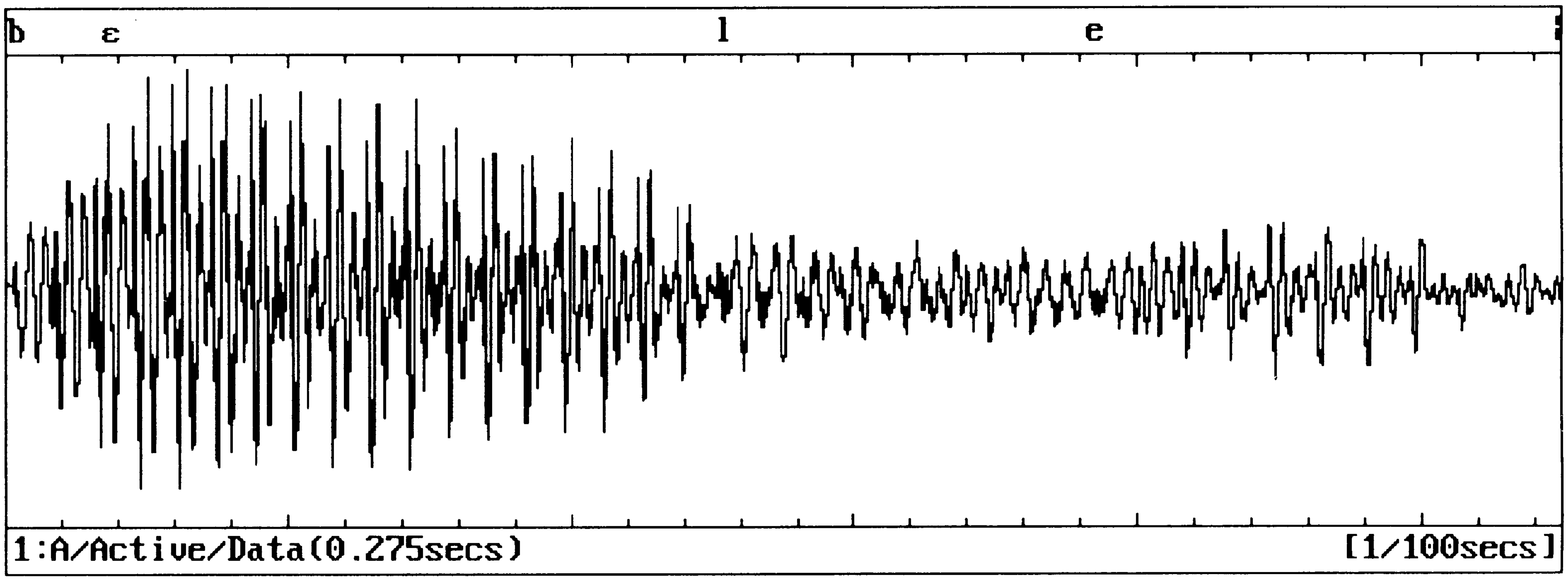


Figure 2. Graphical representation of **[bεle]**, **/bele/** 'banana'.

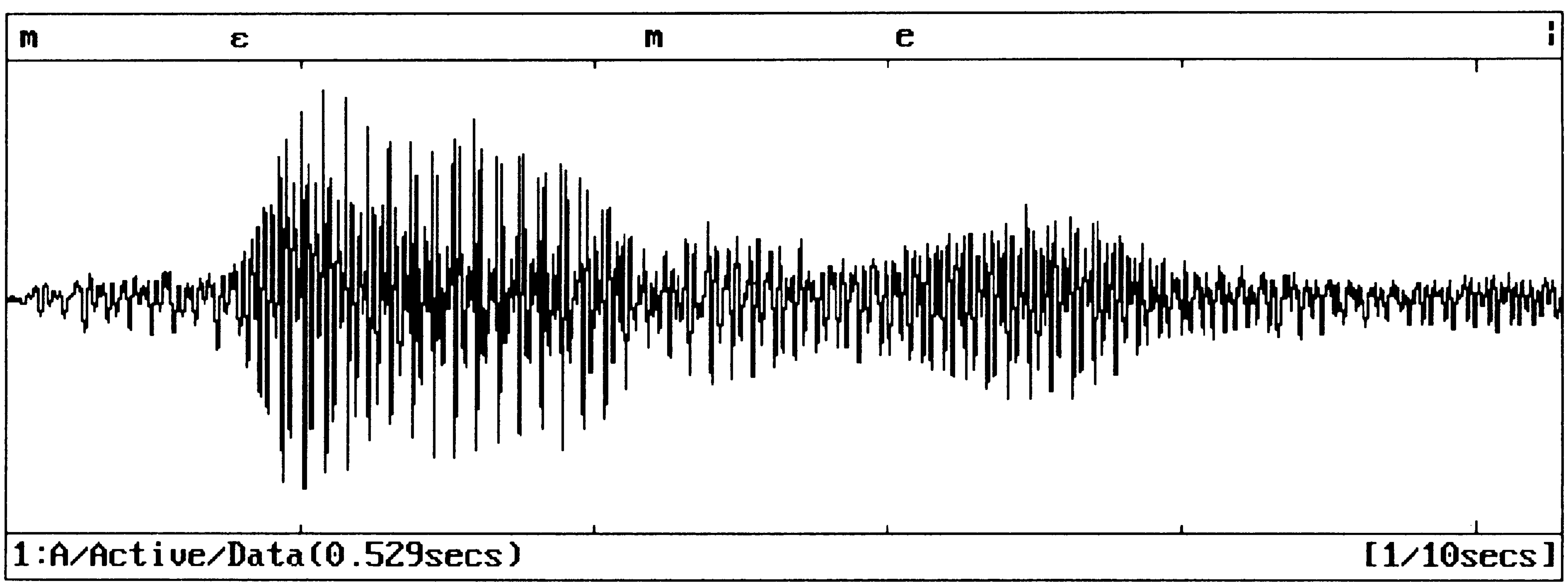


Figure 3. Graphical representation of **[mεme]**, **/meme/** 'mother'.

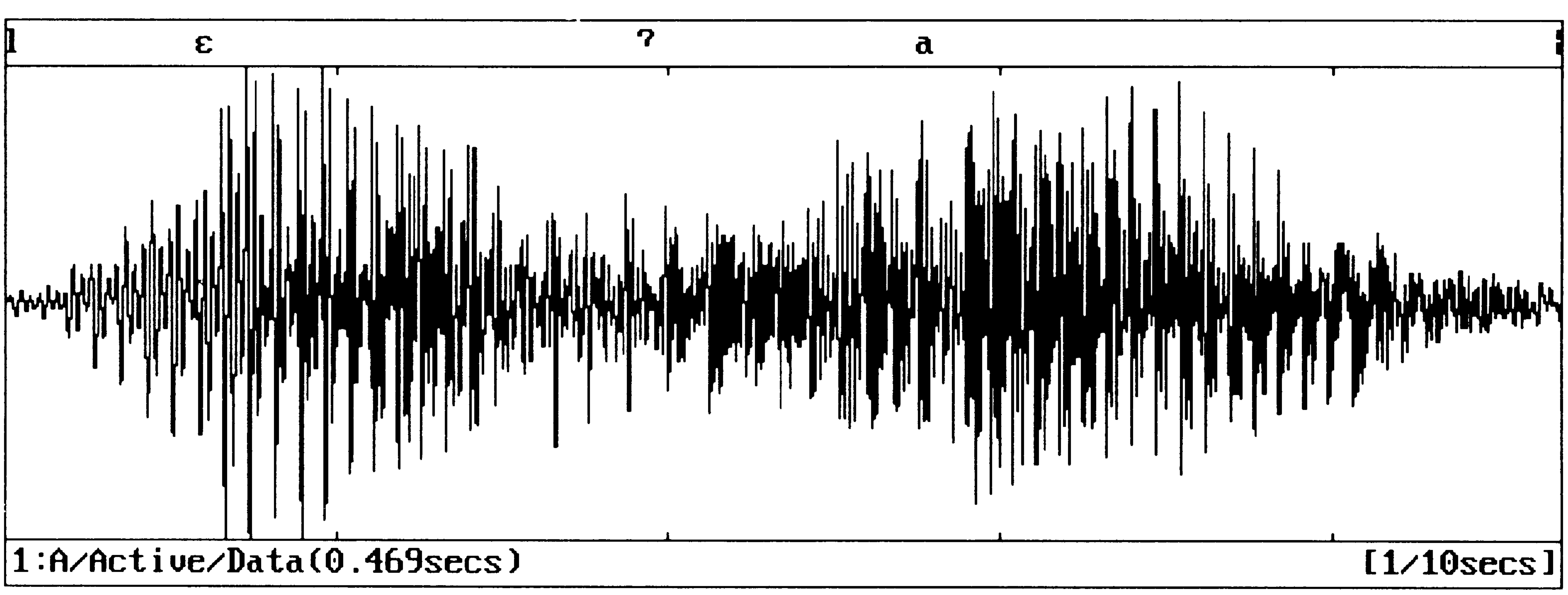


Figure 4. Graphical representation of **[leʔa]**, **/le'a/** 'where'.

4.2 Tone

As mentioned above, CECIL can produce graphs of the phonetic data. One of the graphs produced is a Fsmooth graph which shows the frequency in Hz (vertical axis) versus time (horizontal axis). Furthermore a single point pitch measurement (semitones) can be obtained from the screen. The Fsmooth graph is used to interpret tonal languages of the contour type (by contrasting tone contours) or of the register type (by contrasting tone levels). Tonal contrastive features are found in many African and Papuan languages.

The Loudness graph gives a measure of relative intensity (vertical axis) versus time (horizontal axis). This graph overlaid on top of the Fsmooth graph shows whether the frequency contour is independent of the amplitude plot and, therefore, whether frequency and amplitude are independent of each other. CECIL can produce this composite graph on the screen which can then be printed. In the case of English, frequency and amplitude tend to vary in harmony (Hunt 1991:5). Thus, some English speakers regard stress as a combination of frequency and amplitude. This is not always the case in other languages, as is shown by Figures 5 and 6.

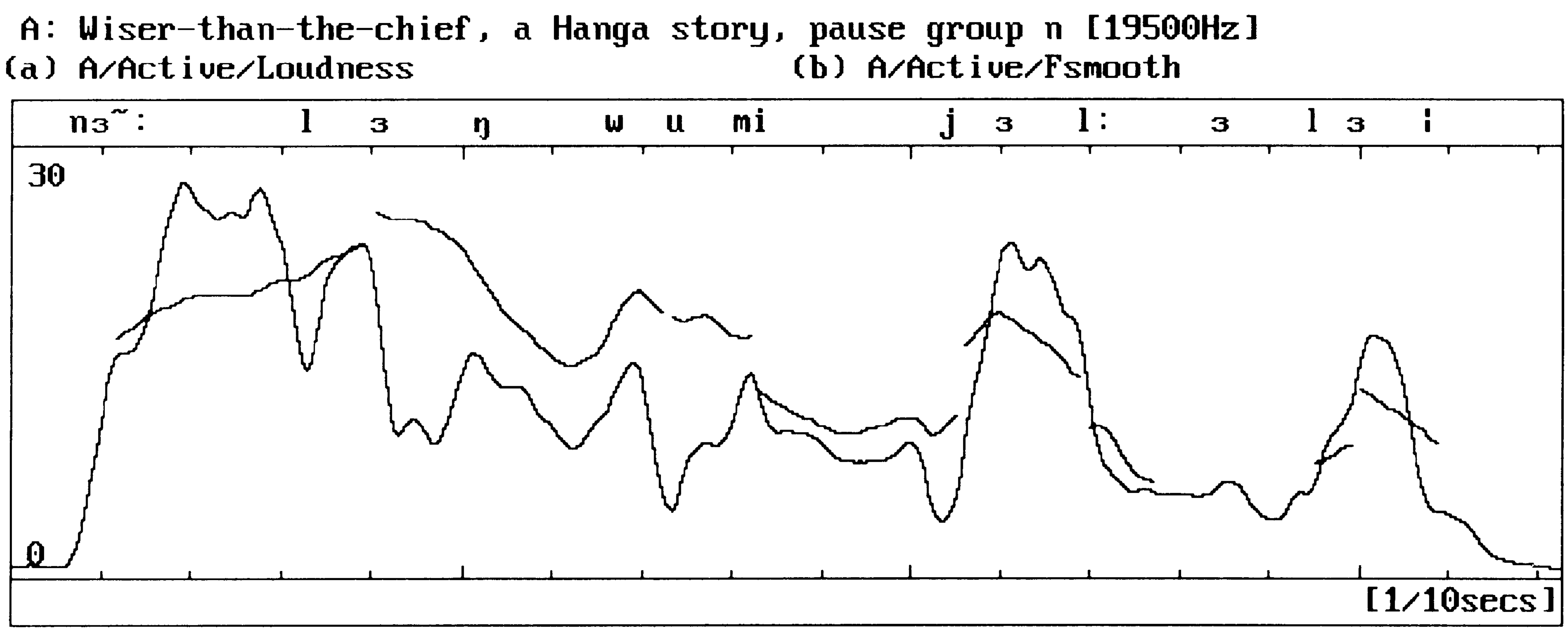


Figure 5. Graphical representation of an utterance from Hanga 'When the chief heard about the matter'.

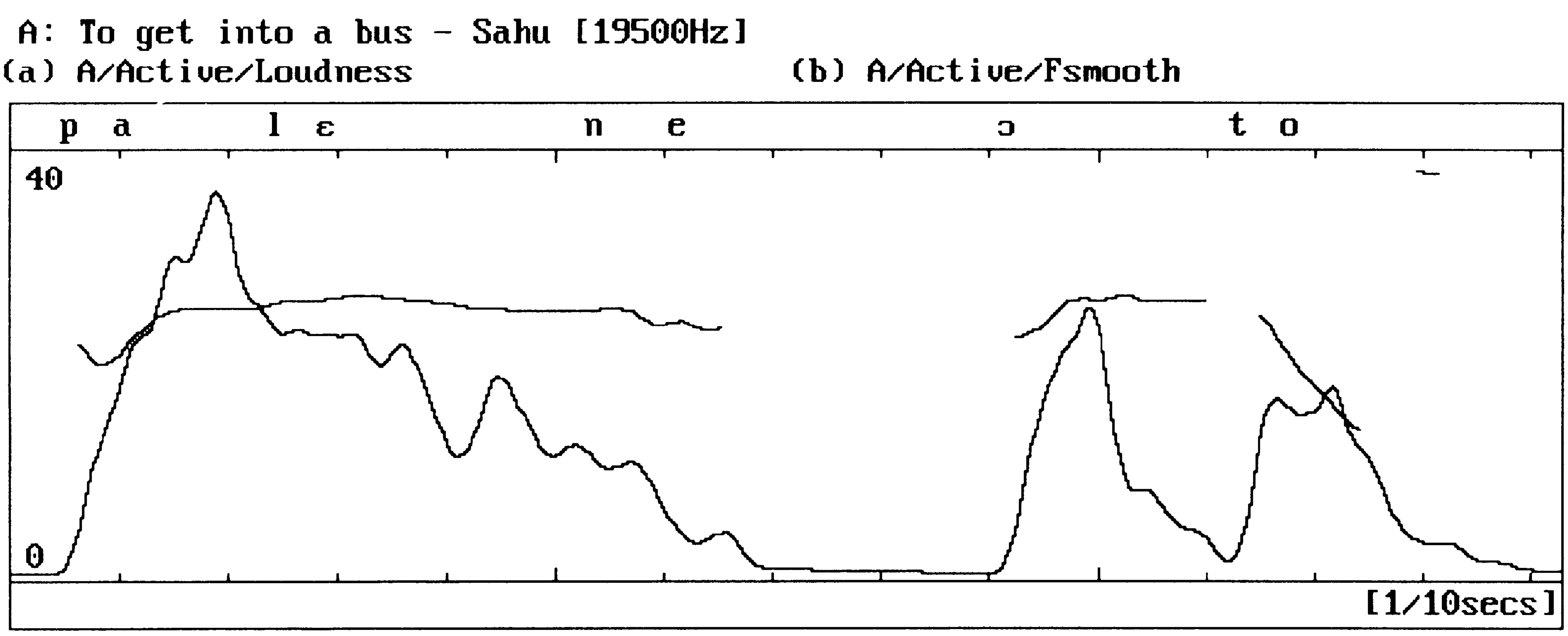


Figure 6. Graphical representation of **[palɛne ɔto]**, **/palene oto/** 'to get on a bus'.

Figure 5 comes from an African language, Hanga, in which the frequency (0-300 KHz) and relative intensity traces (vertical axis) are effectively independent.[8] In Figure 6, a composite graph of Loudness and Fsmooth (Frequency, 0-400 KHz) of the Sahu utterance 'to get on a bus' shows very clearly that though the initial syllable in both **/palene/** 'to get on' and **/oto/** 'bus' are stressed (carrying both intensity and length), the frequency does not rise and in fact stays nearly level throughout the duration of the utterance. No contrastive minimal pairs have been found in Sahu. Furthermore, the lack of change in pitch gives additional support that Sahu is not a tonal language.

4.3 Vowels

Looking at the univalent data below, without using CECIL, the following phonetic and phonemic syllable patterns can be posited: V, CV, CVC.

/a/	'particle preceding a male's name'
/ne/	'this'
/ge/	'that'
/la/	'healed'
/ra/	'at'
/si/	'first before something else'
/lom/	'to collect'
/gam/	'village'

However there is ambivalent data in that both long vowels and vocoid clusters are present. These are interpreted, below, with the aid of CECIL.

The following are examples of vocoid clusters:

[ˋɓeɪti]	'taro'	**[ˋpie]**	'papaya'
[mɛˋrɛɔso]	'weak'	**[ˋtʃɔe]**	'to steam'
[bʊˋbʊe]	'k.o. baby cradle'	**[mɛˋlɛʊʔu]**	'k.o. bird'
[mɔˋɗuo]	'how many'	**[bɔˋtɔʊʔu]**	'fly'
[ˋɲaɔʔo]	'fish'	**[ˋrɔasa]**	'hoarse'
[ˋbiɔno]	'face'	**[ˋrɔɪmi]**	'to count'
[ˋsui]	'to smoke'	**[ˋgiʊ'u]**	'saucepan'
[kʊlʊˋwaɪʔi]	'small centipede'	**[ˋsiala]**	'bucket'
[ŋaˋŋaɛle]	'to yawn'	**[ˋpɛala]**	'small bald patch'
[kaˋnaʊʔu]	'to say'	**[ˋguaʔe]**	'mango'

The following are examples of long vowels:

[ˋpi:ʔi]	'to rub clean'	**[ˋu:tu]**	'hair'
[ˋtu:su]	'to pay a debt'	**[ˋtu:ʔu]**	'afterwards'

4.3.1 Long Vowels

For the linguist unaided by any speech analysis system, it is difficult to distinguish the long and extra long vowels with certainty. However CECIL greatly aids the linguist in determining the duration of part or all of the utterance. The horizontal axis of the CECIL graphs indicates time, plus CECIL can expand a section of the graph so that the boundaries of a particular 'sound' can be more easily defined. Finally CECIL gives the duration in seconds at the bottom of each graph, measured to 0.01 second or in the case of the Snapshot graph (Figure 5, 8 and 9, plot 2), measured to 0.001 second.

Phonetically, Sahu has three vowel lengths (excluding the phenomenon of lengthened final vowels, which is outside the scope of this paper): normal, long, and extra long. Both long and extra long vowels, as one would expect, only occur in stressed syllables. In Figure 7 we see an example of a long vowel, **/memese/** 'forehead'. The Loudness graph shows that stress, defined as a function of intensity, length, and sometimes pitch (see Section 5.1), is on the initial syllable. Also, the ratio of the length of the first vowel to the second, though they are identical vowels, is 1.7:1.[9] Therefore since the long vowel is a) conditioned by stress and b) not contrastive with normal vowels in identical or analogous environments, it is classed as non-phonemic.

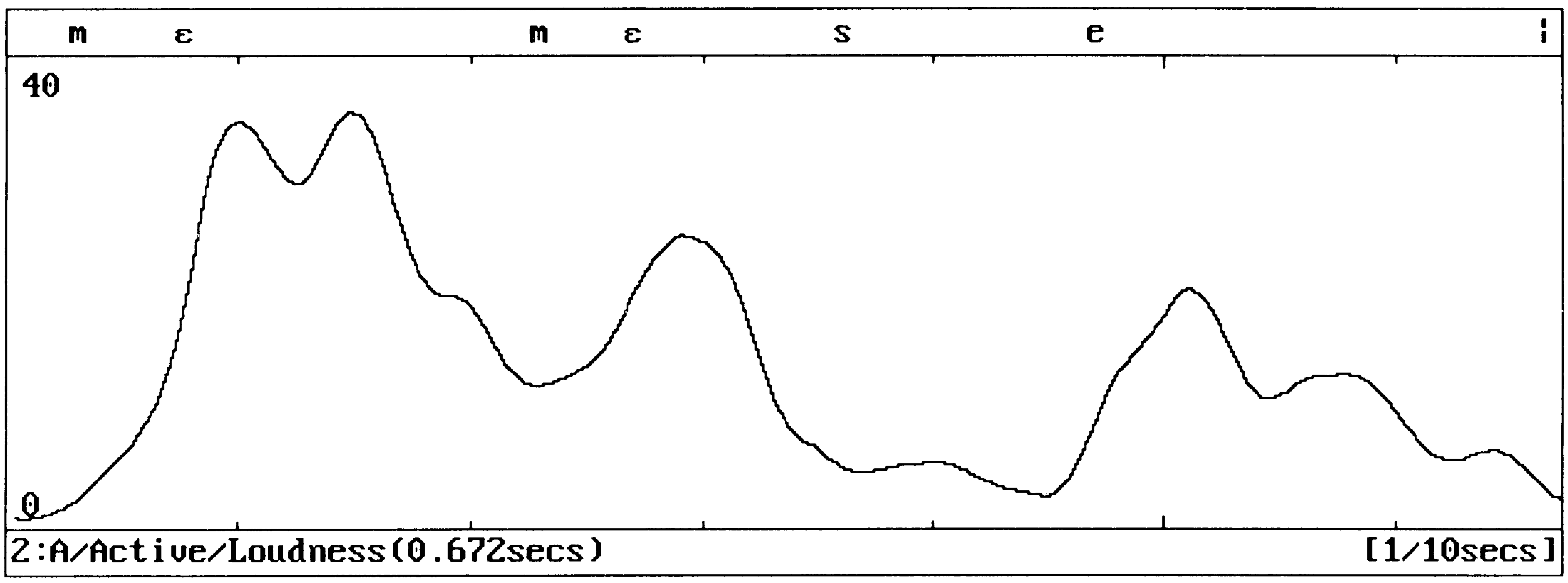


Figure 7. Graphical representation of **[mɛmɛse]**, **/memese/** 'forehead'.

However in the case of the extra long vowel, though they are of low functional load (only nine examples observed so far), one contrastive pair has been found: **/tuusu/** 'to pay a debt' and **/tusu/** 'a noise' (Figures 8 and 9). The question is whether they are to be phonemically interpreted as one long vowel or as two geminate vowels.

Before we look at Figures 8 and 9 some clarification is necessary. Figure 8 **[tu:su] /tuusu/** and Figure 9 **[tʊsu] /tusu/** represent contrastive pairs. They were recorded consecutively at the same session. Both figures have an expanded plot of the /u/ in the initial syllable (below the graph labeled 'Active/Data'). The graphs look more different than you would expect, but this is because of the different scale for the time axis (horizontal). The utterance [tu:su] is 0.7 seconds while [tʊsu] is just 0.46 second, but since the horizontal axis is the same physical distance the latter is more expanded in appearance. Furthermore though in English the centralist variants of the [i] and [u], namely the [ɪ] and [ʊ], are shorter in duration than [i] and [u]; this is a function of the English language and is not part of their inherent quality. In Sahu the stressed [ʊ] is about 1.5 times longer than the unstressed [ʊ].[10] Furthermore, both the unstressed and stressed variant duration values of /i/ overlap to a large degree.

It is clear, before any measurements are taken, that /u/ in the initial syllable (Figure 8, plot 2) is much longer. Compared with the word final /u/ in the same word, the initial /u/ is 1.5 times longer. This would suggest a lengthened vowel but not one of double length. However, in Sahu the word-final vowels are often lengthened, particularly in two or three syllable words (see Figure 10 **[kʊmʊtu]** 'fibrous leaf sheath of the sugar palm' and Figure 3 **[meme]** 'mother'). Therefore, since a word final vowel does not provide a good basis for comparison, to find a true ratio to a normal length /u/ it is necessary to compare the duration of the /u/ of the initial syllables of **[tʊsu] /tusu/** with **[tu:su] /tuusu/** (see Figures 8 and 9). This gives a ratio of 1:2.46.

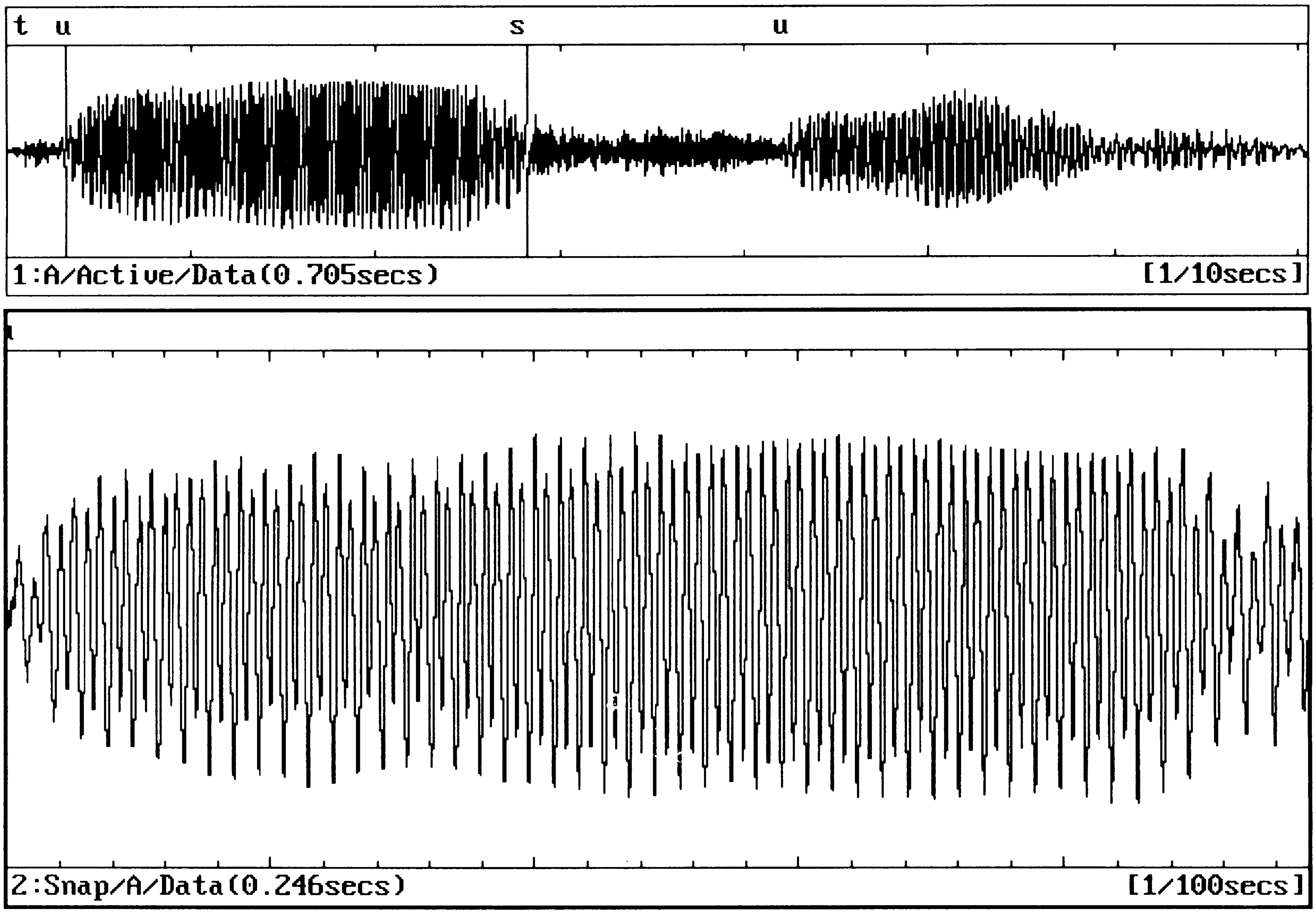


Figure 8. Graphical representation of **[tu:su]**, **/tuusu/** 'to pay a debt'.

Additionally, the frequency and intensity peaks are not uniform throughout the duration of the extra long [u] (see the composite Loudness and Fsmooth graph of Figure 11). Higher pitch and intensity also occurs during the first half of the extra long [u]. Both of these factors give further evidence (along with the timing ratio) for the existence of a two-vowel vocoid cluster, with stress on the first vowel. This concurs with the stress rule for vocoid cluster as described in Section 5.2.

The lengthened vowel of **[tu:su]** is therefore interpreted phonemically as two geminate vowels, /uu/, for the following reasons:

1) This lengthened vowel is more than twice the duration of a normal vowel.
2) The frequency and intensity peaks are not uniform throughout the duration of the extra long [u]. In this example the higher pitch and intensity occur on the first [u].

4.3.2 Vocoid Clusters

As Visser and Voorhoeve have noted (1987:18), vocoid clusters are not uncommon, with up to three vowels in a cluster. There are also long vowels. The questions to be addressed are:

1) From a phonetic standpoint, do these clusters consist of:
   a) all equally prominent segments?
   b) all glides?
   or c) a mixture of glides and segments?
2) How are these clusters to be interpreted phonemically?

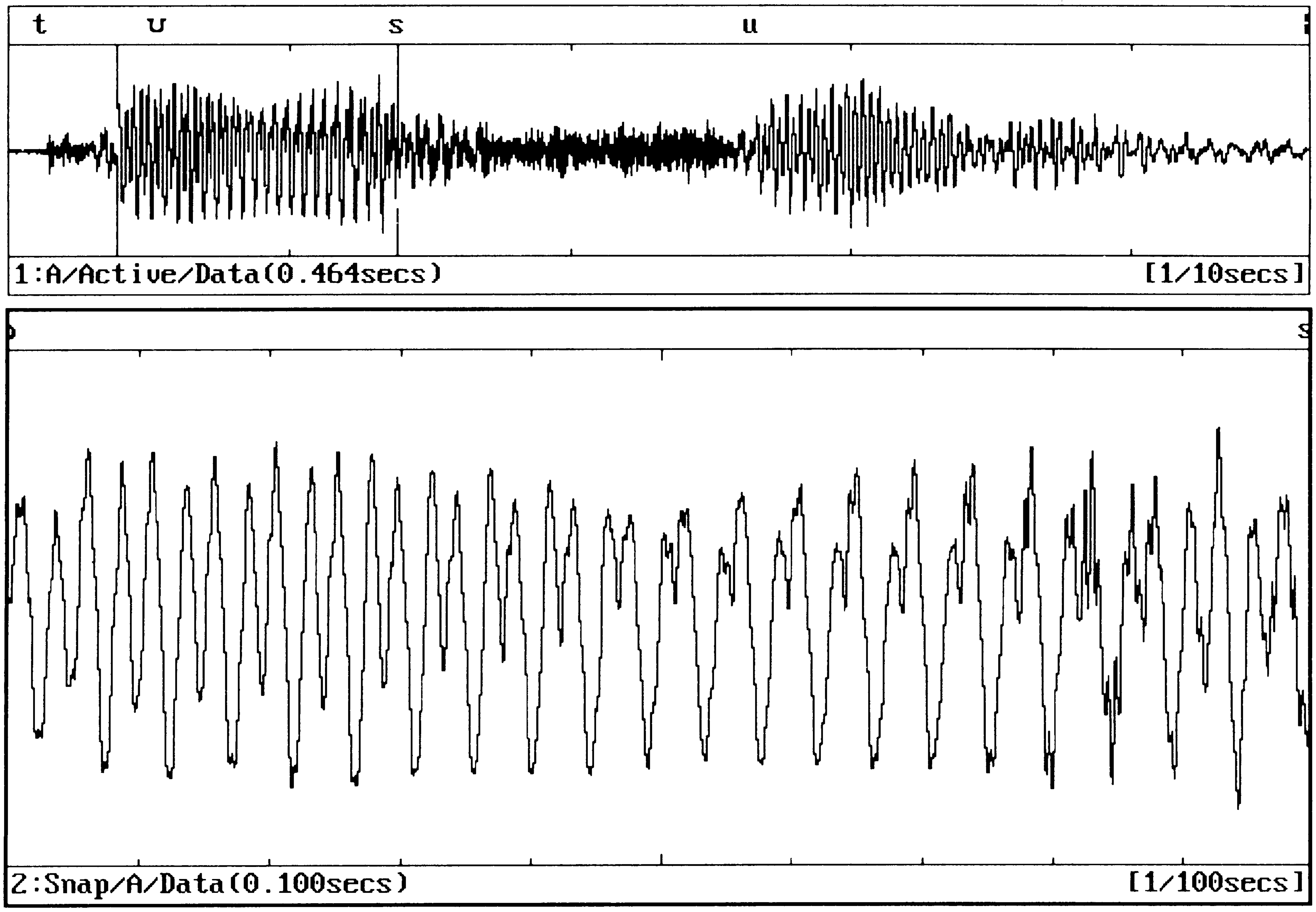


Figure 9. Graphical representation of **[tʊsu]**, **/tusu/** 'a noise'.

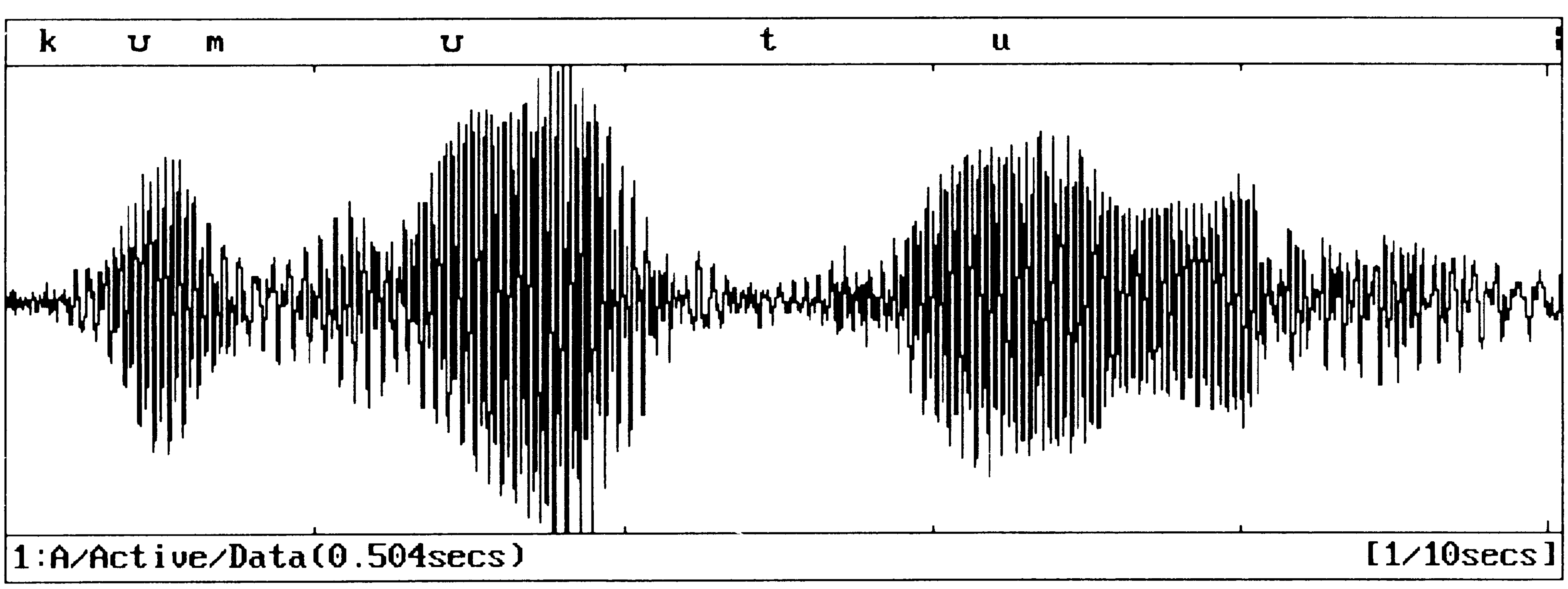


Figure 10. Graphical representation of **[kʊmʊtu]**, **/kumutu/** 'leaf sheath of a sugar palm'.

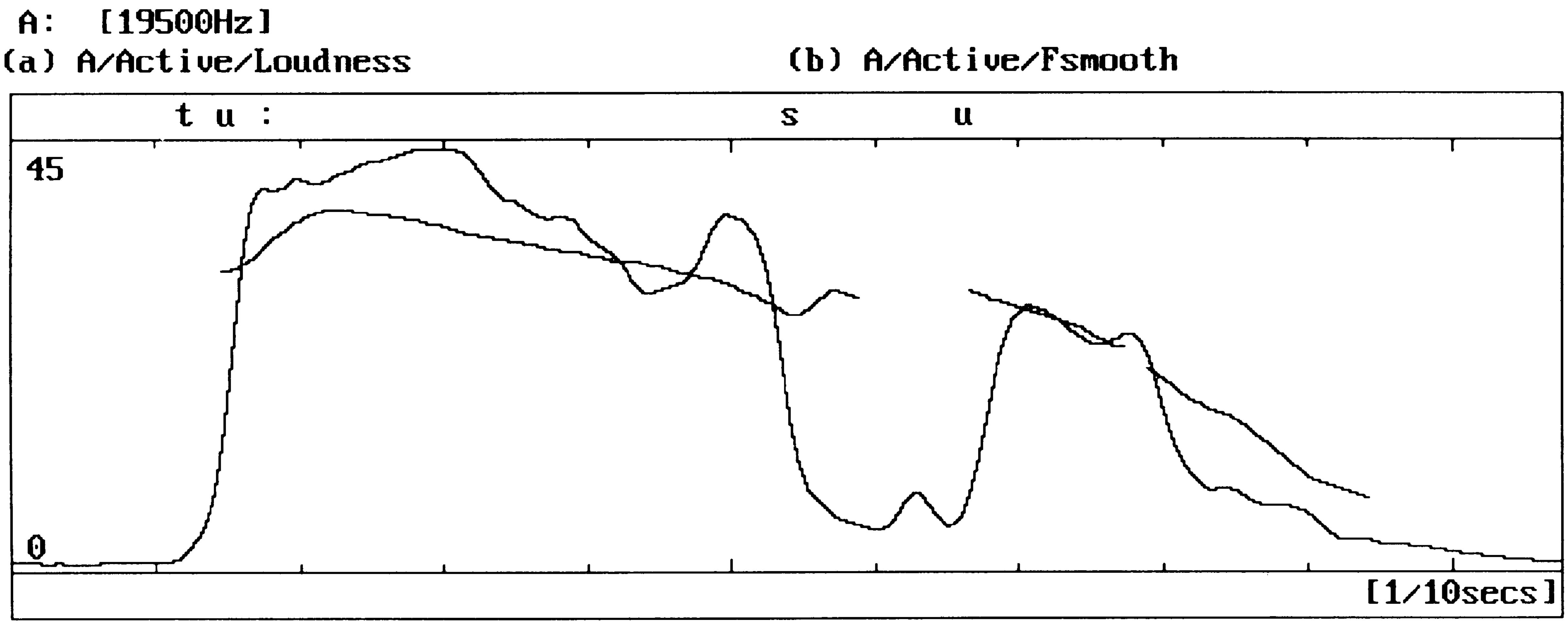


Figure 11. Graphical representation of **[tu:su]**, **/tuusu/** 'to pay a debt'.

4.3.2.1 Non-glides

Looking at Figure 12a **/moini/** 'finished', we can see that the vocoid cluster is made up of two nearly-equal-length vowels. Also, their intensities (Figure 12b) are similar in that neither is overtly prominent (which is the main characteristic of a 'glide').

Phonemically they are interpreted as two vowels for the following reasons:

1) There are contrastive minimal pairs e.g. **/gu'u/** 'to hold' and **/giu'u/** 'saucepan', **/sai'i/** 'to wander' and **/sa'i/** 'tasty'.
2) They are both 'normal' length vowels.
3) They both carry similar intensity in that neither is overtly prominent.
4) They are occurrences of geminate vowels in the same position e.g. **/tuusu/**, **/pii'i/**.

This analysis is further supported by the Sahu speakers who write these diverse vocoid clusters as two vowels, i.e. **/mɔini/**.

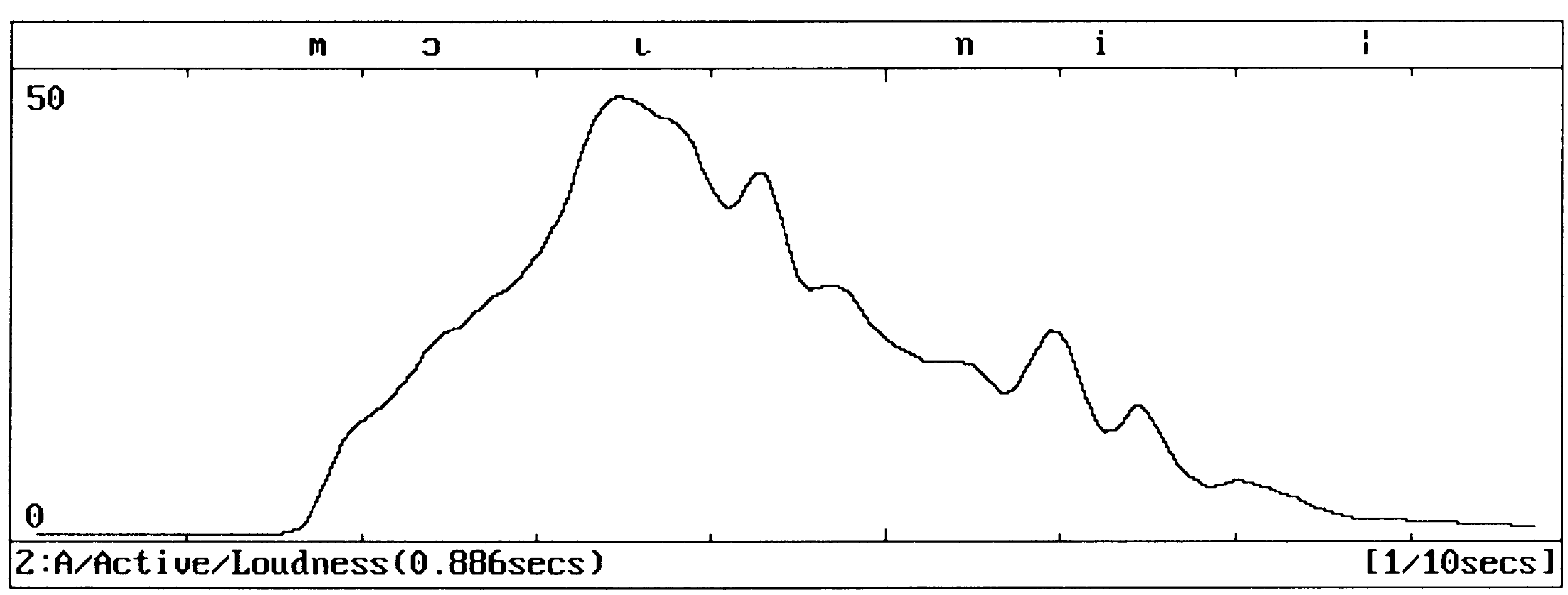


Figure 12a. Graphical representation of **[mɔɪni]**, **/moini/** 'finished'.

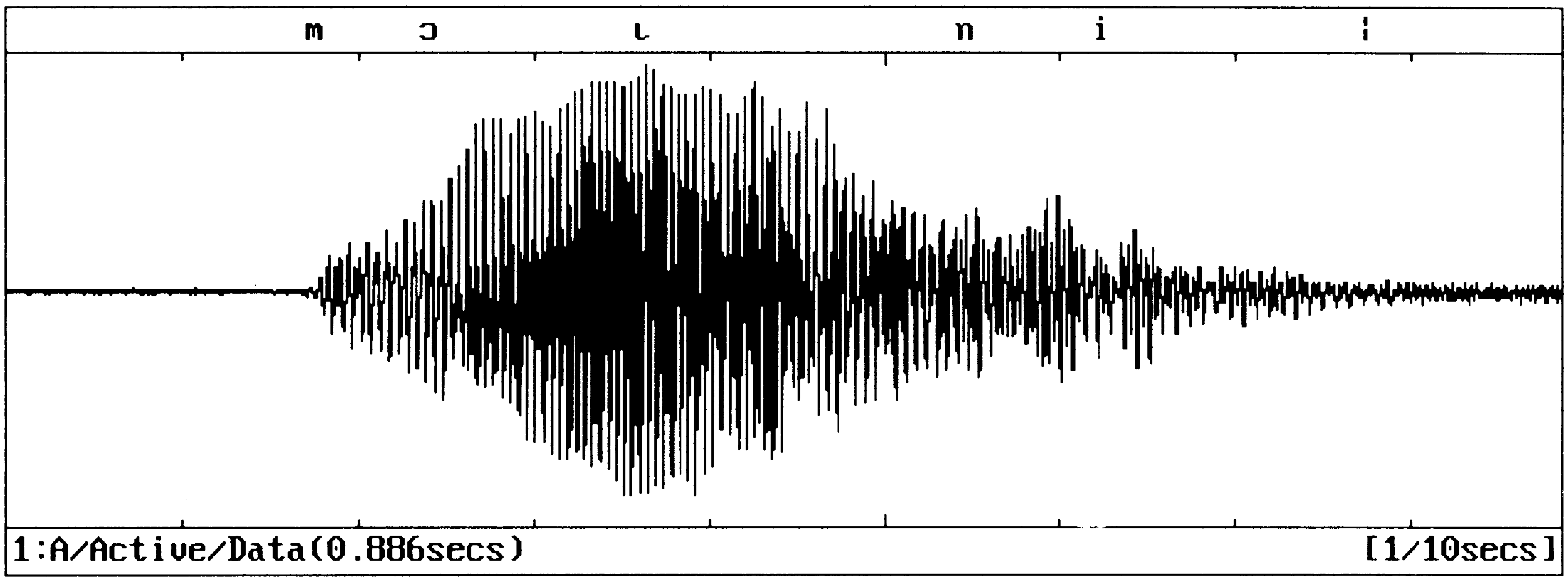


Figure 12b. Graphical representation of **[mɔɪni]**, **/moini/** 'finished'.

4.3.2.2 Glides

The non-glide example above is in marked contrast with the following example **[ɓeɪti]**, **/ɓeiti/**. In this case (Figures 13a and 13b) of **[ɓeɪti]**, **/ɓeiti/** 'taro' the vowels are not in equal prominence (the main characteristic of a glide). It is clear from Figure 13a that the [e] is longer than [ɪ] and also the [ɪ] is on the down slope of the peak of intensity (Figure 13b) contributing very little to the intensity peak. Therefore the lack of intensity and length lead to the conclusion that [ɪ] is of negligible prominence compared to [e]. In contrast, the [e] has both intensity and length and is concluded to be the stressed syllable. Therefore /ei/ would be classed phonetically as an off-glide [e$^{\text{I}}$]. In other words, the first vowel is overtly prominent in comparison to the second.

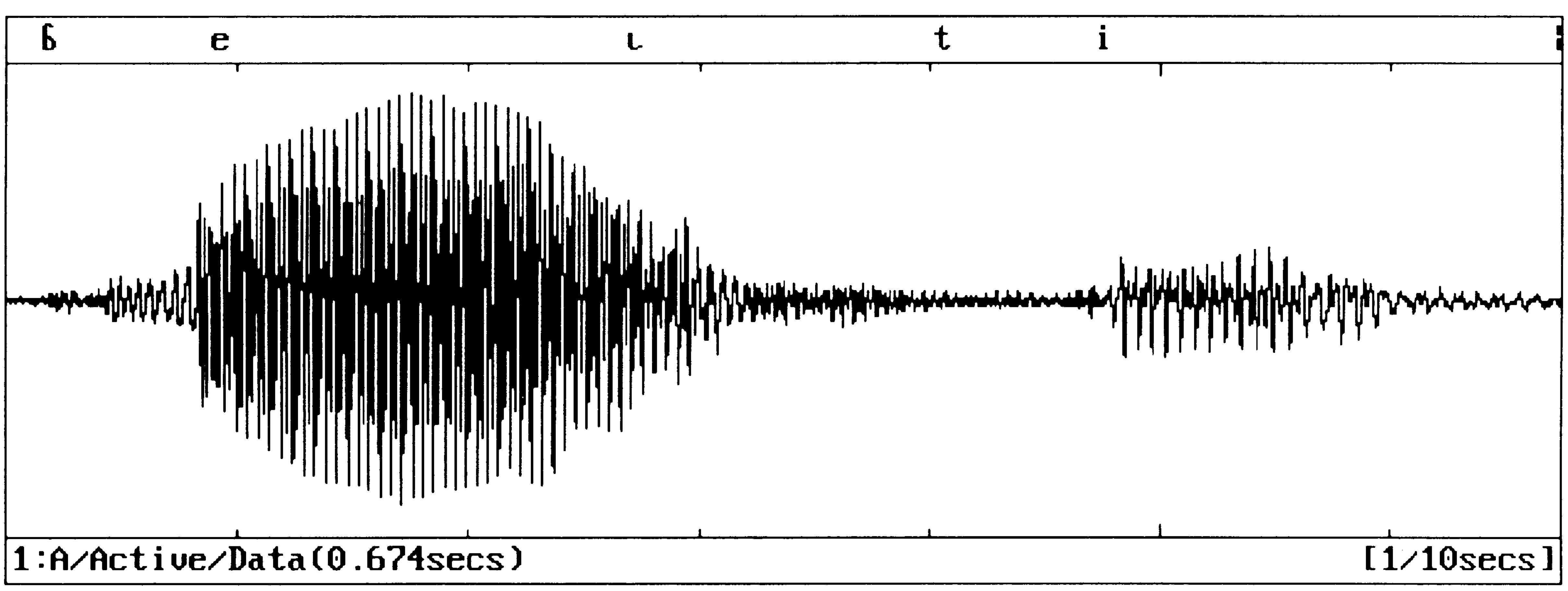


Figure 13a. Graphical representation of **[ɓe$^{\text{I}}$ti]**, **/ɓeiti/** 'taro'.

However, phonemically off-glides are interpreted as two phonemic syllables for the following reasons:

1) The duration of the initial stressed vocoid glide cluster [ei] (0.37 sec), is equivalent to the duration of the initial stressed vocoid non-glide clusters [ai] (0.39 seconds) in /**paiti**/.

2) Off-glides occur in the same positions as geminate vocoid clusters (as in /**tuusu**/) and non-glide vocoid clusters (as in /**moini**/); this would lead to an interpretation of two phonemic vowels (/e/ and /i/) and not just one. If not, **[ɓe$^{\text{I}}$ti]** would be interpreted as /**ɓeti**/ rather than /**ɓeiti**/.

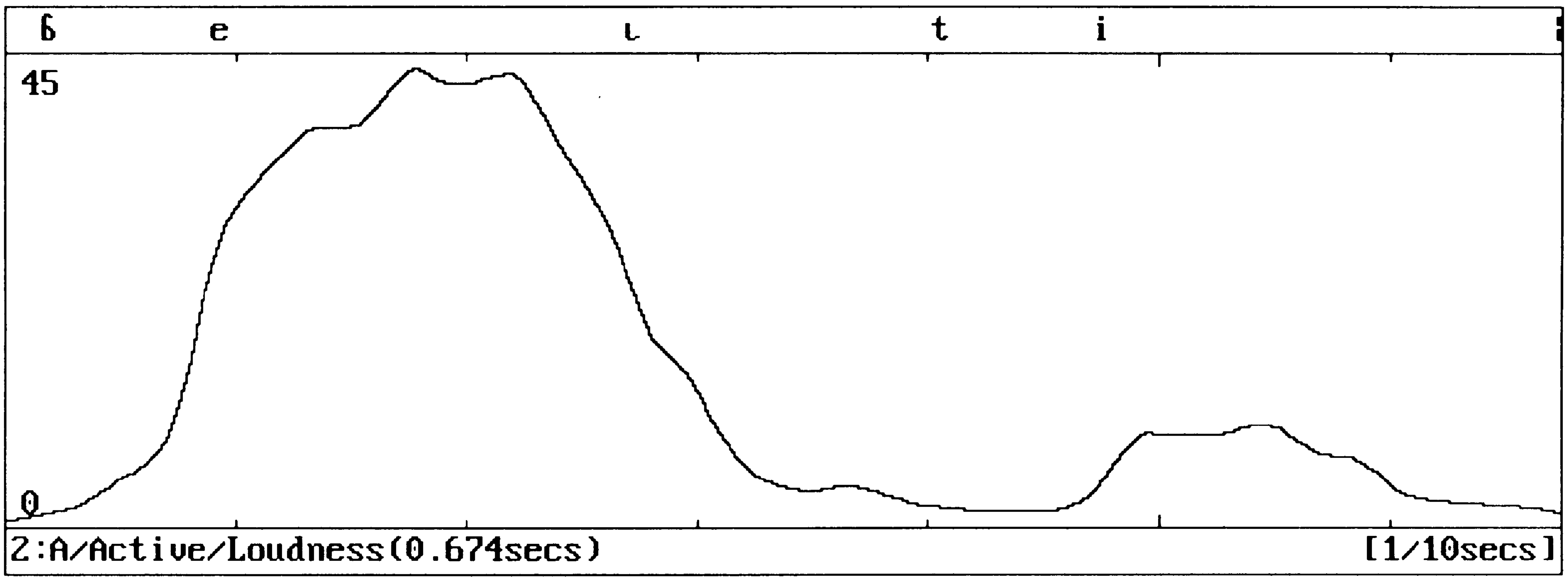


Figure 13b. Graphical representation of **[ɓeᴵti]**, **/ɓeiti/** 'taro'.

Interestingly, the Sahu speakers write the word **[ɓeᴵti]** as **/ɓeiti/** and **[giuʔu]** as **/giu'u/**, i.e. as two phonemic vowels units. This lends a bit of further support to the above analysis.

In conclusion, the vocoid clusters are phonetically a mixture of off-glides (such as **[ɓeᴵti]**), and equally prominent vowels (such as **[mɔɪmi]**). However, phonemically, both vowel glides and equally prominent vowel clusters are interpreted as two phonemic vowels for the reasons stated above.

4.4 The Phonemic Syllable Defined

In conclusion, the ambivalent phonetic syllable types are: V (long) V: (extra long), and VV (off-glides). Since the long (non-contrastive) vowel is conditioned by stress, the extra long (contrastive) vowel has been interpreted as two geminate vowels (Section 4.3.1) and the vocoid clusters, non-glides (Section 4.3.2.1) and glides (Section 4.3.2.2) as two phonemic vowels. The ambivalent phonetic data has not added any further syllable patterns to those derived from the univalent data presented in Section 4.3. Therefore, the phonemic syllable is defined as a single vowel nucleus with the following syllable structure: V, CV, CVC.

5. SOME NON-PHONEMIC FEATURES

5.1 What Constitutes Stress in Sahu?

In using the term stress, I am referring to phonetic stress which can be a compound of loudness (intensity), frequency (pitch), and length. In Sahu, stress is normally a compound of intensity and length but can also have a frequency (pitch) component (see Section 5.3). The stress rules have not been fully determined yet, but only one example has been elicited where stress seems to be the only contrastive feature. Also, if a word is uttered with the stress placed incorrectly the Sahu speaker does not recognize that utterance as having any meaning whatever; they certainly do not recognize it as another word having contrastive stress. Although the area of stress needs further investigation, at this present time it seems safe to assume that stress is non-contrastive and therefore non-phonemic.

However, stress (as defined above) does play a part in distinguishing between off-glides and syllabic vocoid clusters. The less prominent vowel in a vowel glide carries very little or no stress, whereas two equally prominent vowels in a vocoid cluster do carry stress.

5.2 The Stress Rule for Vocoid Clusters

Though the stress rules have not yet been fully determined, after analyzing the Loudness graphs for vocoid clusters it is apparent that there is a univalent stress pattern for the vocoid clusters. The stress is carried by the syllable with the consonant onset, irrespective of the vowels within the cluster (Figure 14 **[mɛ`rɛɔso]** 'soft'). Some examples of vocoid clusters are as follows (the mark ` denotes stress):

[`ɓeˀti]	'taro'	**[`pie]**	'papaya'
[mɛ`rɛɔso]	'weak'	**[`tʃɔe]**	'to steam'
[bʊ`bʊe]	'type of baby cradle'	**[mɛ`lɛʊʔu]**	'type of bird'
[mɔ`ɗuo]	'how many'	**[bɔ`tɔʊʔu]**	'fly'
[`ɲaɔʔo]	'fish'	**[`rɔasa]**	'hoarse'
[`biɔno]	'face'	**[`rɔimi]**	'to count'
[`sui]	'to smoke'	**[`giʊ'u]**	'saucepan'
[kʊlʊ`waiʔi]	'small centipede'	**[`siala]**	'ember'
[ŋa`ŋaɛle]	'to yawn'	**[`pɛala]**	'small bald patch'
[ka`naʊʔu]	'to say'	**[`guaʔe]**	'mango'

The only exceptions to date are loan words in which the stress pattern follows the original loan word, for example **[bi`asa]** (loan word from Indonesia **[bi`asa]** 'usual').

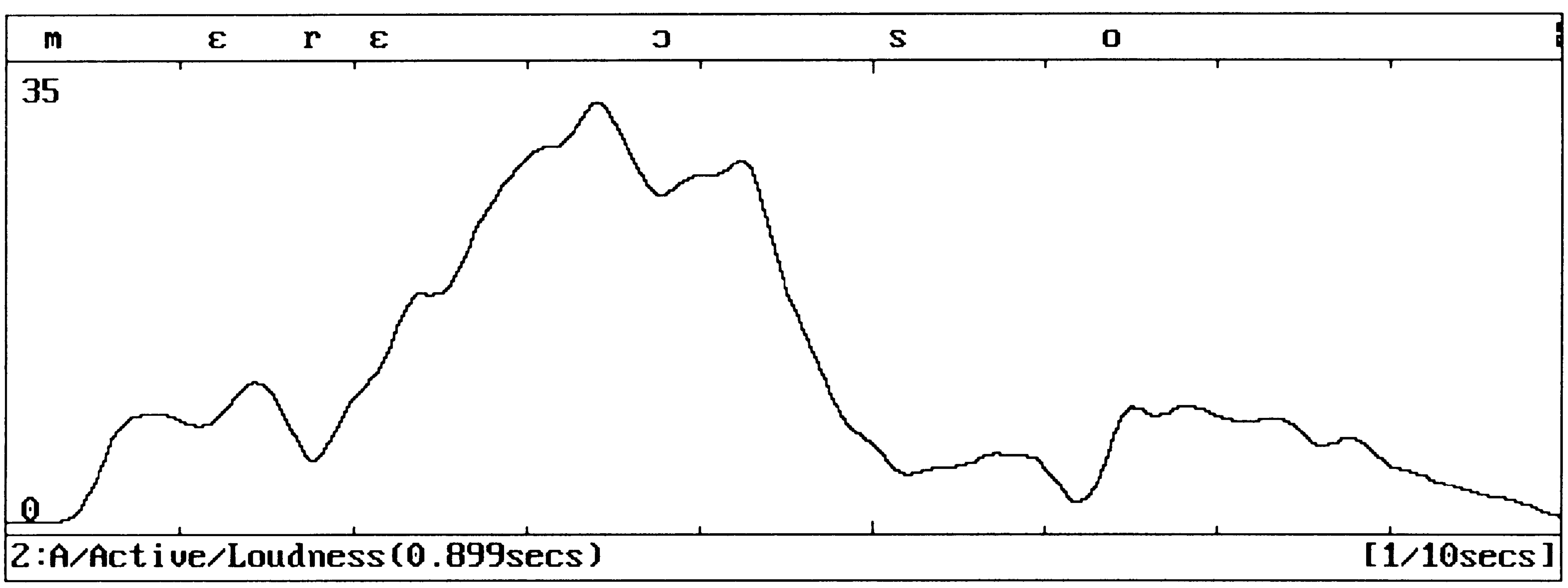


Figure 14. Graphical representation of **[mɛ`rɛɔso]**, **/mereoso/** 'soft'.

5.3 Pitch

It has already been mentioned that Sahu is not a tonal language in that pitch is not a contrastive feature (see Sec 4.2). However pitch does play a part as a marker. If the stress (loudness/intensity and length) is on the first syllable, then the pitch graph is virtually flat (Figures 6 and 11). However, if the stress is on another syllable, then there is a clear pitch change (see Figure 15 **/piri'i/** 'old'). This would suggest that stress is minimally indicated by loudness and length, with pitch as an additional constituent if stress is not word initial. Once again, further investigation is needed to be able to verify this preliminary finding.

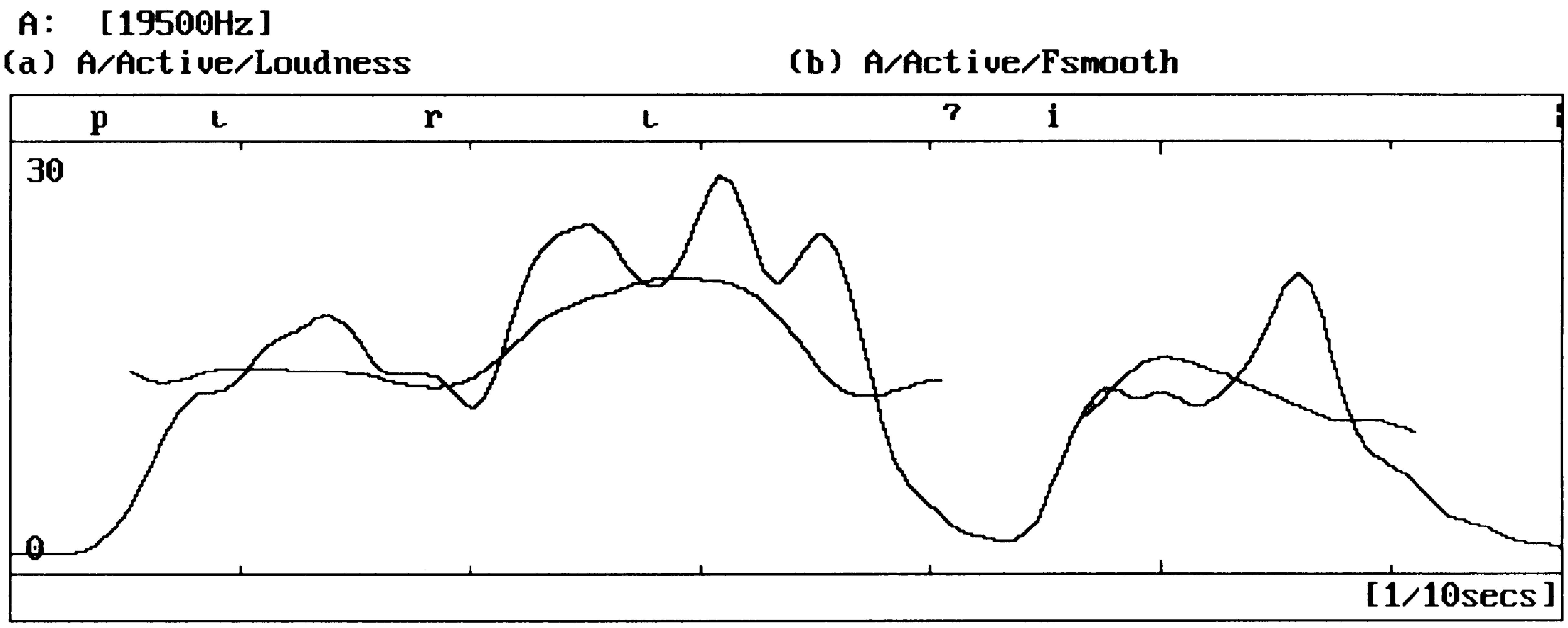


Figure 15. Graphical representation of [pɪ'rɪʔi], /piri'i/ 'old'.

6. CONCLUSION

The CECIL speech analysis unit has aided the definition of the phonemic syllable by providing quantitative, detailed evidence that verifies the more qualitative conclusions of previous researchers (Visser and Voorhoeve, 1987:19). Furthermore, it has provided insights into a number of previously unstudied aspects of Sahu phonology: the existence of geminate vowels (Section 4.3.1), glides (Section 4.3.2.1), defining the components of stress (Section 5.1), clarifying the stress rule for vocoid clusters (Section 4.2), and including pitch as a component of stress for non-initial stress (Section 5.3). Further studies using the CECIL system will undoubtedly reveal more valuable information on both phonetic and phonemic levels, as well as on the suprasegmental level.

NOTES

1. All phonetic data in this report will be represented between [] brackets closely following the IPA symbols (1989). Phonemic data will be shown between // brackets. Stress, when marked, is denoted by a grave accent mark preceding the stressed syllable. The symbol | will denote the end of an utterance on the CECIL graphs.

2. This particular fieldwork represents a cooperation between the Indonesian Institute of Sciences, (LIPI) and the Summer Institute of Linguistics. In particular I would like to thank Dr. E. K. M. Masinambow (LIPI), without whom this cooperation would not have been possible. Thanks are also due to the people of Awer and in particular the village head, Mr. Yohanis Eno. The villagers not only helped with the recording of the Sahu language but also took my wife and I, together with our three children, into their homes and hearts. I am also grateful to Jan Perry for help in manuscript preparation, and to my coworkers who have provided welcomed comments on earlier drafts of this paper.

3. The CECIL system was originally developed by Geoffery Hunt, Phil Bassett and Geoff Haydock in Britain in 1988. Later the speech analysis unit (CI-500) was modified by Rich Kelso of Jungle Aviation, Avionics and Radio Services Inc. (JAARS), manufactured by JAARS and distributed by Summer Institute of Linguistics.

4. An additional program, SPECTROGRAM, further analyses the entire range of frequencies (the CECIL program concentrates on the fundamental frequency of the vocal chords).

5. The microphone was kindly donated by Crown International, Elkhart, Indiana, USA.

6. The phonetic symbol, where different from its phonemic counterpart, is shown in [ ] brackets.

7. The Horizontal axes are marked in 0.1 sec intervals and the vertical axes are relative amplitude of the sound waves. These units are the same for all subsequent figures unless otherwise stated.

8. The figure [19500 Hz] appears at the end of the title above the plot. This refers to the sampling rate and not the fundamental frequency of the vocal chords, which is usually in the range of 100-350 Hz.

9. The ratio of the duration of the same vowel in stressed and unstressed situations is typically in the range of 1.5:1 to 1.7:1.

10. See Footnote 9.

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