Is the phonetic quality of unaccented words unpredictable? An example from spontaneous Finnish

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In spontaneous speech, occurrences of the same word form vary phonetically. Words that do not receive sentence accent tend to be less clearly articulated and shorter in duration in comparison to prominent words. If such an unaccented word is isolated from continuous speech, it may not even be identifiable by listeners, but as part of the speech stream, it is usually easily identified and helps the listener to perceive and organize the spoken message as a whole. Thus, the variability of unaccented words is not random but must follow certain patterns determined by context. In this study, we take a closer look at the Finnish unaccented word-like construction *niinku* in spontaneous conversational speech samples collected from one female Finnish speaker. We provide an analysis of the phonetic variability of the *niinku* structure found in the data, including such properties as segmental duration, segmental make-up, and phonetic quality. We then show what kind of properties are common to all occurrences of this unaccented construction and discuss the conditions that probably govern its acoustic-phonetic quality.

1 Introduction

In spontaneous speech, numerous processes contribute to the exact timings and qualities of speech sounds, making them very difficult to predict. Nevertheless, a model of the phonetics of unscripted speech is needed for the development of different technological applications as well as for a general understanding of the variability in speech.

Finding exact segment boundaries in continuous speech is very difficult. Untrained subjects are not very accurate in speech segmentation and labeling, but they do produce and understand speech as well as trained phoneticians. It can be suspected that the discreteness and the boundaries between speech sounds are not necessarily inherent to our speech system, but they are probably due to our mastery of the western alphabetic script (e.g. Öhman 2000). Another problem is the use of discrete (although often phonetic) symbols in the description of time-varying phenomena. Not only are the segment boundaries fuzzy, but also the labeler's choice of a phonetic symbol is rather subjective and context-dependent.

According to Fant (1973), speech appears to be a continuous succession of varying

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and overlapping patterns where variational features may be considered as more essential than the absolute characteristics of the speech wave. In their revision of the motor theory of speech perception, Liberman & Mattingly (1985) suggested that the speaker's INTENDED PHONETIC GESTURES may be considered as the primitive units of phonological representation. This idea forms the basis of ARTICULATORY PHONOLOGY, which Browman & Goldstein (1990) have further developed, e.g., incorporating task dynamics into the descriptive system. Intuitively, a gestural speech description system can account for phonetic variability better than a system based on a more static view of speech sounds and phonemes. Unfortunately, articulatory phonology has not yet established a general set of phonological gesture primitives. Moreover, there is insufficient evidence of some of its theoretical claims about the mechanisms of speech perception, and Liberman & Mattingly's framework is better taken as a philosophy than a model of speech (Klatt 1989).

Because of the fuzziness of individual speech sound categories, it seems plausible that humans actually do not always recognize sequences of speech sounds or phonemes but some larger patterns (Hawkins 1999: 258–260). Obviously, these patterns are results of articulatory gestures, even if gestural representations may not be directly used in speech perception. In the present study, we search for perceptually recognizable patterns at the word level.

A full understanding of speech cannot be reached unless speech phenomena are viewed as part of human interaction in natural communicative context. A great deal of the cues belonging to a word pattern are always contextual: interpretation relies on semantic and pragmatic information. However, some cues should remain in the acoustic speech signal; arguably, a certain phonetic pattern should be present whenever a word form is perceivable in the speech stream. A 'citation form' or an isolated pronunciation of a word must contain more than the minimal word pattern, since it has practically no contextual cues, and it includes complete utterance prosody. In order to find cases where the pronunciation of words is naturally as far from citation forms as possible, it is reasonable to pick words from unaccented positions in spontaneous speech. By 'unaccented' positions, we refer to those words that do not receive a perceivable sentence accent or stress, whereas any auditorily prominent words are considered 'accented'. Thus, sentence accent is understood here as a perceptual, impressionistic property of words in context.

Unaccented words tend to be less clearly articulated and shorter in duration than accented words. They are also more prone to coarticulation. Unaccented words are more predictable and thus bear less information than accented words. As a result, they need not (and should not) be pronounced as carefully. This idea has been proposed by Lindblom (1990) in his H&H theory: more articulatory effort is used to produce less redundant (i.e. more unpredictable) words (see also, e.g. Aylett 1999). We also argue that although an unaccented word that is isolated from a longer stretch of speech may not be recognizable by listeners, it is usually easily identified when it occurs in continuous speech, helping the listener to perceive and organize the spoken message as a whole. Thus, some kind of common pattern must exist even for a word that is usually unaccented and therefore exhibits great contextual variability.

In this study, we take a closer look at the Finnish unaccented word-like construction *niinku* (which approximately corresponds to a similar use of *like* in English, e.g. *it was like REALly COOL*) in different phonetic contexts. The selected orthographic form *niinku* may at first sight be interpreted as a sort of compound consisting of two Finnish words, *niin* ('so'; adverb) and *ku* ('as', 'when'; written form either *kun*, meaning 'when', 'as', a temporal conjunction; or *kuin*, meaning 'like', 'than', 'as'; a comparative conjunction). In addition to this use as a comparative construction (e.g. in such expressions as *se ui niinku kala* '(s)he swims like a fish'), the word *niinku* can be used as a discourse marker. The meanings and functions of these two types of *niinku* are

apparently not directly related. In this paper, we will only discuss *niinku* as a discourse marker.

As a function word, *niinku* usually occurs in unaccented positions within utterances. It seems to bear very little 'lexical' content; if all occurrences of *niinku* are erased from the transliteration of a sample of spontaneous Finnish, the Finnish-speaking reader does not notice any difference in meaning. The *niinku* construction is practically never used in formal Finnish speech or writing, and using the word outside the most casual situations is generally not appreciated. However, *niinku* is a very common word for some speakers, and it has interactional significance as noted by Kunelius (1998).

Kunelius (1998) found that *niinku* is mostly used for emphasizing adjacent accented words in various ways, for repairs and rearrangements in speech, and for giving the speaker time for speech planning. The various functions of *niinku* are often intertwined and difficult to categorize unambiguously. Kunelius reports that *niinku* often occurs in the 'rheme' part of a sentence, thus separating old and new information; or as a kind of organizer in complex structures. It may sometimes occur as the last word in an utterance, thus signaling utterance finality. *Niinku* also has a strong tendency to form chains with other common function words, e.g. *ja* 'and', *et*(*tä*) 'that' (conj.) and *sit*(*ten*) 'then'. The resulting chains are functionally different from each other.

Finnish orthography has an almost one-to-one relationship with phonemic structure. Since *niinku* is not usually written, the orthographic form was selected on an intuitive basis (and following the work of Kunelius 1998), which is somewhat problematic. Finnish makes a phonemic contrast between long and short vowels and consonants, which is generally reflected in writing. In the case of *niinku*, however, the phonological length of the vowel [i] is very hard to determine, because there are no minimal pairs and the only samples of *niinku* are from unscripted speech. It is difficult to obtain reliable duration data of an unaccented word to support one view or the other. Thus, when we write *niinku* in this article, we are not referring to, e.g. the string of phonemes /n iː ŋ k u/, but to this specific word in its use as a discourse marker in casual Finnish talk.

1.1 Hypotheses

We hypothesize that there are acoustic-phonetic properties common to all occurrences of *niinku*. We will attempt to find such common properties in the duration patterns, the qualities of the phonetic segments, and the prosodic pattern of each token.

We also hypothesize that a great deal of the phonetic variability of *niinku* may be explained and even predicted by its articulatory, prosodic and interactional environment. In this study, we will consider the effects of coarticulation and position in the utterance. The interactional functions of *niinku* will be discussed with regard to glottalization effects inside *niinku*. As found by Ogden (this issue), glottal stops and creaky voice have different phonological and interactional functions in Finnish talk. Glottal stops (or short periods of creak) are often used for marking focal, vowel-initial words, but also for turn-holding. Where the creaky voice extends over several syllables, it is probably caused by the lowering of F0 at a prosodic boundary and may function as a signal of a possible turn transition point. On these grounds and considering the possible functions of *niinku* reported by Kunelius (1998), it is likely that *niinku* sometimes occurs in glottalized stretches of speech.

The present work is still restricted by the traditional speech description method: the segmentation and phonetic labeling of speech samples. The shortcomings of these procedures have been noted above. However, we claim that if words have general acoustic patterns, their common properties can be inferred even if the segment boundaries and phonetic transcriptions are slightly irregular.

2 Methods

2.1 Recordings

Tokens of *niinku* were collected from a spontaneous dialogue involving two female Finnish speakers (ML, age 24, and NA, 27), who are also the first two authors of this article. At the time of the recording (October 1998), the speaker-authors did not know which aspect of their speech would be studied two years later.

The speakers sat in an anechoic room, facing each other with a few meters' distance, and talked freely on self-chosen topics for one hour. Two high-quality microphones attached to headsets were used to record each speaker on a separate channel of a DAT tape. The recorded material was then transferred to a computer with a sample rate of 44.1 kHz and a quantization of 16 bits.

Since one of the speakers (NA) has a particularly strong tendency to use *niinku* when speaking spontaneously (*niinku* was her most frequent word with 352 occurrences within one hour), her speech was chosen for further analysis. In order to ensure maximal spontaneity of the sample, the first five minutes of the recorded conversation were excluded.

2.2 Segmentation and transcription

The transcription work and all measurements were done with the Praat program (Boersma). All utterances of the speaker NA were transliterated and utterance boundaries marked. Different labeling tiers were used for different events in the speech signal: one tier for utterances, one for words, one for phones (phonetic segments) and one for sentence accent marks (see figure 1). In our previous labeling work, phonemic units turned out to be difficult to define from spontaneous Finnish speech, so a phonemic transcription was not considered useful; for similar reasons, the quasi-orthographic transliteration of the utterance level demanded many compromises.

Starting from the sixth minute of the conversation, the first 101 occurrences of the *niinku* construction were segmented and narrowly transcribed by one trained phonetician. Segmental length was not marked. Two words adjacent to each token of *niinku* were segmented and transcribed as well. Phonetic transcription work was done by listening and by inspecting both acoustic spectrograms and intensity curves.

Word boundaries were marked within those utterances that contained at least one *niinku*. Those words that were perceptually considered as prominent were marked as being 'accented'. Several accented words were allowed in one utterance, but different levels of accent were not distinguished.

3 Results

3.1 Frequencies of word forms

We created a simple frequency dictionary of all word forms in all utterances of speaker NA. Disregarding the fact that some ambiguous word forms (homonyms) were counted together, some interesting figures are worth a mention. 1688 different word forms occurred in speaker NA's utterances within one hour of conversation. In this special frequency dictionary for NA, the first 79 word forms were function words. *Niinku* was by far her most common word with 352 occurrences out of a total of 6029 word tokens.

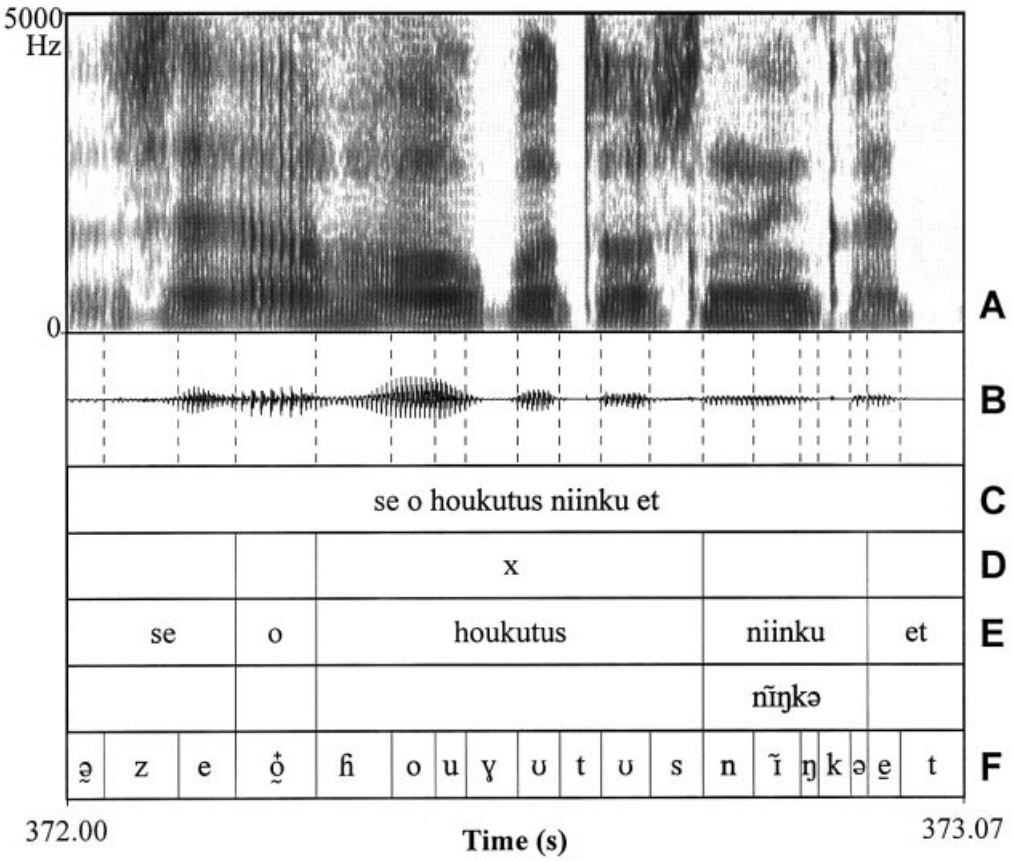

Figure 1 The transcription levels used in segmentation and labeling. Acoustic spectrograms (A) were used with the sound waveform (B) to support decisions on segment boundaries and phonetic labels. Boundaries were marked for all utterances (C), for words in all utterances containing *niinku* (E), and for phones within *niinku* and its adjacent words (F). Perceived sentence accent was marked with an x on the corresponding word (D).

3.2 Interaction, prosody and glottalization

In 58 cases out of 101, some or all voiced segments of *niinku* were glottalized. Glottalization occurred only in the beginning of *niinku* in 17 cases, only in the end in 11, and throughout the word in 30 cases. In order to explain the glottalization, the discourse functions and prosodic patterns were examined for those utterances that contained at least one *niinku*. The interactional analysis was performed following the classificatory system in Kunelius (1998).

In as many as 75 tokens of *niinku*, speech planning or word search was involved in some degree; this may be seen as one of the main functions of the word. In 35 cases, *niinku* occurred in the rheme, thus emphasizing new information. 20 occurrences of *niinku* were interpreted as signals of continuity or turn-holding; those in utterance-final positions were always glottalized and often chained with the word *et*(*tä*). On the other hand, a turn switch occurred straight after *niinku* in only three cases. In two of these, *niinku* was fully glottalized; in the third one, only the beginning of the word was creaky – the utterance was a direct question. 18 tokens of *niinku* were associated with repair

sequences or some kind of reorganization (e.g. change of angle) and in ten of these cases, *niinku* was at least partially glottalized.

In case all voiced segments of *niinku* were glottalized, it might be explained by either glottalization on both sides (16 cases), or optional glottalization on the left and an utterance boundary to the right (8 cases). These glottalization patterns are usually connected with turn-holding. In 13 of the fully glottalized cases, there were no accented words within three words on either side.

In cases where *niinku* was not glottalized at all (N = 43), neither was there any glottalization in the closest segments preceding or following *niinku*. This rule was only broken in three cases where the word-initial vowel in the following word was slightly glottalized – a common phenomenon in Finnish accented words.

Glottalization in the beginning of *niinku* was apparently caused by preceding glottalization, and in these cases the end was not glottalized because of a following utterance boundary or false start. Reasons for mere word-final glottalization of *niinku* were again somewhat unclear, although the following glottalized segments and/or utterance boundaries certainly seemed to have an effect.

3.3 Phonetic quality

In total, 64 different transcriptions of *niinku* were made for 101 tokens. If glottalization is excluded from the transcriptions (see table 1), the four most common versions were [nĩŋkʊ] (38 occurrences), [nĩŋku] (6), [nĩŋgʊ] (5) and [nĩŋɣʊ] (4). A schematic overview of the common phonetic properties of all *niinku* tokens is shown in figure 5. It is stated that *niinku* consists of:

1. an alveolar nasal portion (C1), followed either by
2. a close or close-mid nasalized vowel (V1) or, at least, some palatalization in the nasal consonant, which glides to
3. a velar nasal and/or other velar closure or approximant (C2), which is then
4. released or opened to a vowel-like, usually non-nasal portion (V2). The final release-to-vowel phase usually includes at least slight rounding, but this property is weaker if the next event is a pause, an unvoiced consonant, or a central vowel sound.

Table 1 The transcriptions of all tokens of *niinku* (N = 101). The glottalization diacritics are excluded.

IPA word	Tokens	IPA word	Tokens	IPA word	Tokens	IPA word	Tokens
nĩŋkʊ	38	nĩŋkə	2	nĩŋʔʊ	1	nĩŋɣʊ	1
nĩŋkʊ	2	nĩŋkə	1	nĩŋk	1	nĩŋɣu	1
niŋkʊ	1	nĩŋkɵ	1	nĩŋgʊ	5	nĩŋɣɤ	1
niŋkʊ̊	1	nĩŋkʊu	1	nĩŋgʊ	2	nĩŋɣo	1
nĩŋku	1	nĩŋkʷ	1	nĩŋgu	1	nĩŋɣʊũ	1
nĩŋku	6	ndiŋkⁿʊ	1	nĩŋgə	1	nĩŋɣə	1
nĩŋkũ	1	nŋkʊ	1	nĩŋgɵ	1	nĩɣɤ	1
nĩŋkuɦ	1	nŋku	1	nĩŋgɤ	1	nĩɣʊ	1
niŋkoh	1	nĩkᵒ̯	1	nigʊ	1	nĩɣʊ	1
nĩŋkɤ	1	nĩŋkʷᵒ̯	1	nĩg̃	1	nĩŋu	1
niŋxʷ	1	nĩŋkɵ	1	nĩŋɣʊ	4	nĩŋũ	1
nĩku	1	nĩŋkə	1	nĩŋɣ̊ʊ	1	nĩŋʊ	1
nĩkʊ	1						

Since *niinku* consistently starts with the alveolar nasal consonant [n], the initial portions C1 and V1 do not exhibit audible variability that could be attributed to coarticulation with the preceding segments. The final segments of *niinku* vary more, but the probable coarticulation effects with the following word are very difficult to separate from variability caused by the prosodic pattern. One tendency is that the final [o] only occurs in pre-pausal positions.

Not only did the adjacent words influence the phonetics of *niinku*, but *niinku* also seemed to affect adjacent segments. In particular, it was common for the initial nasality of *niinku* to spread to the preceding segments. Thus, if a word is demarcated from continuous speech according to segment boundaries, some of the perceptual cues for the word will tend to be excluded, since the articulatory gestures (e.g. the velic opening for nasality) often extend over word boundaries.

3.4 Duration

When measuring segment durations, we ran into difficulties: the transcriptions of *niinku* had four to six IPA symbols, diacritics excluded. This prevented a comparison of relative durations across tokens. In order to make the various transcriptions comparable with each other, we tentatively suggest that *niinku* exhibits a more general constriction-opening-constriction-opening movement pattern (here described as C1-V1-C2-V2), and that we can therefore bundle the different numbers of different phonetic symbols together for constriction phase 2 (C2) as well as for opening phase 2 (V2). Now all tokens of *niinku* can be represented as four phases, and the internal durations are roughly comparable (see figure 2). This analysis can be said to be articulatorily or gesturally motivated: looking at the transcriptions, the consonant symbols after the first vowel-like phase consistently refer to velar consonants, and perhaps it is not significant if one or two different manners of articulation occur in this C2 phase. Similarly, due to the great frequency of *niinku* for this speaker, there are very broad limits to the articulatory gestures in the final opening phase, and it may thus be represented with a varying number of symbols in the IPA transcription. As long as the overall gestural pattern of the word is the same, comprehension in proper context will not be affected.

The mean duration for each of the five segments preceding *niinku* was 72 ms ($s = 51$ ms, minimum 33), and for each of the five following segments 81 ms ($s = 54$ ms, minimum 29 ms). The mean duration of segments within *niinku* (four to six segments as transcribed in IPA) was only 49 ms ($s = 11$ ms, minimum 24 ms). The mean duration of all four phases of *niinku* (as defined above) was 59 ms (C1 = 61 ms, V1 = 43 ms, C2 = 88 ms, V2 = 45 ms). Thus, the velar constriction phase (C2) is the longest and the [i]-like vowel phase (V1), the shortest. As mean proportions of the total duration, C2 takes up 36.8% and C1 26.1%, whereas V1 and V2 have relative durations of only 18.6% and 18.5%. The consonants thus usually reserve about 63% of the total duration of *niinku*. However, in some cases the situation is reversed, as can be seen in figure 3.

The mean duration of the whole *niinku* construction was 240 ms (standard deviation 53 ms). The distribution of *niinku* durations with regard to utterance position is shown in figure 2. The durations seem to exhibit pre-pausal lengthening (see figure 4).

4 Discussion

Minimally, *niinku* is pronounced by moving the mass of the tongue from front to back with two constriction phases: first a front closure with nasal voicing, then a back (velar) constriction or closure usually involving a final lip constriction. Very little articulatory

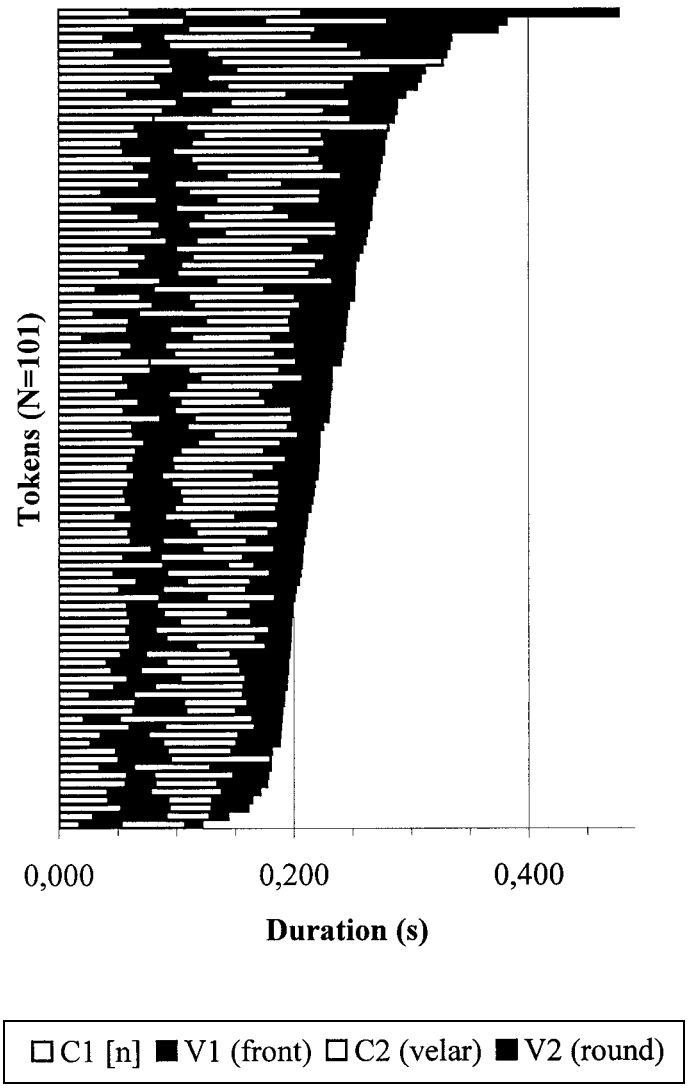

Figure 2 The durations of 101 tokens of *niinku* and its components, sorted according to total duration. Different tokens of *niinku* had a different number of segments in the phonetic transcription. Since it was found that all occurrences practically consisted of a front nasal [n], a front vowel, a velar consonant phase (be it one or two segments in the transcription), and a final rounded vowel phase, the durations were calculated for each of these four phases in order to make them roughly comparable across tokens.

effort is used, resulting in short segmental durations and the spreading of such articulatory features as nasality. According to our present results, the places of articulation in the two constriction phases seem to remain relatively stable in all occurrences of *niinku*. Similar results have been obtained by Duez (1995) for French, where reduced consonants maintained their place of articulation. The tendency appears to function more generally at least for American English (e.g. Blumstein & Stevens

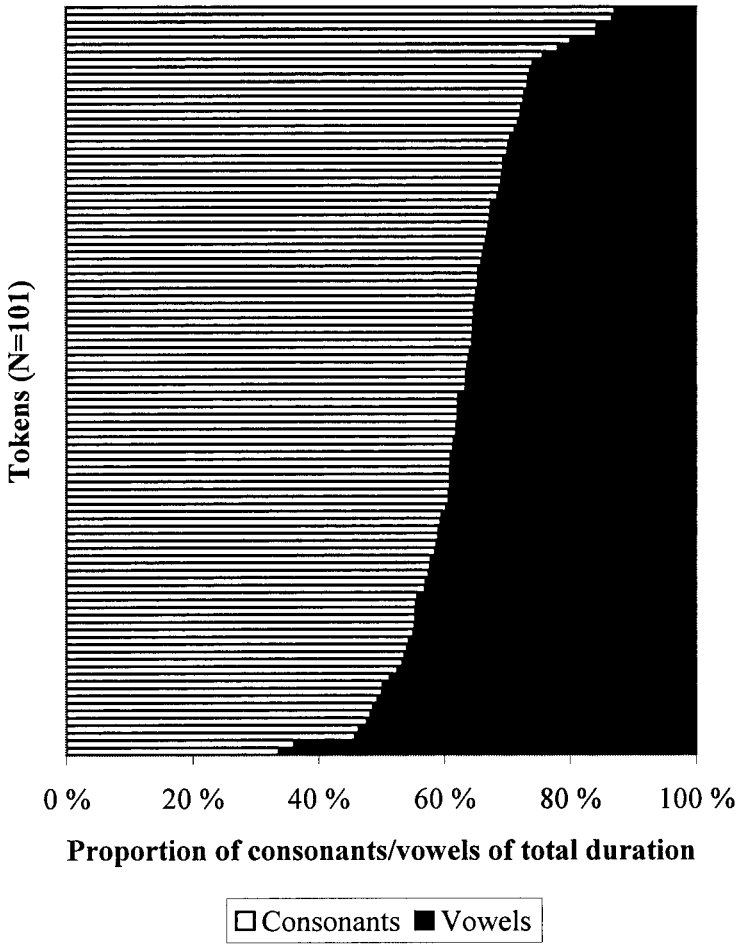

Figure 3 The proportions of consonant and vowel segments of the total duration of *niinku*. The tokens are sorted according to consonant duration. The mean proportion of consonants was 63% of total duration, but the proportions may occasionally be quite different.

1980), where the syllable onset usually preserves its 'canonical identity' (Greenberg 1999).

Niinku has many functions as a discourse marker. Interactional factors often explain why some tokens of *niinku* are glottalized and others are not, but a full analysis of glottalization effects remains to be done.

5 Conclusions

The results of the present study bring up interesting phonological and psycholinguistic questions. What is the target form (i.e. the intended form) of *niinku*? How do we tell which of its variants should be held as primary, or 'psychologically real'? The meaning of a word largely depends on its use and function. If we ask a Finnish speaker to

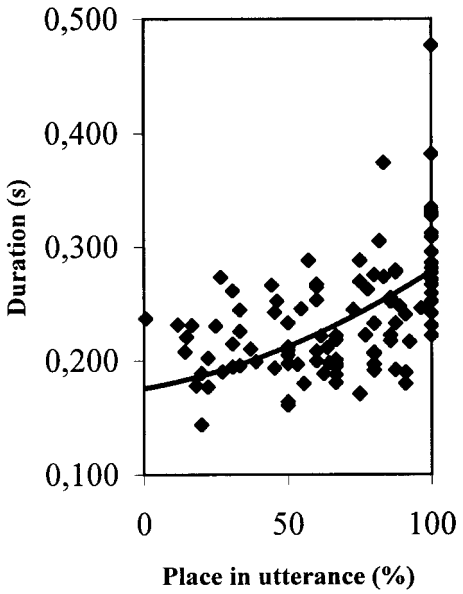

Figure 4 The duration of *niinku* vs. place in utterance. The place value of each *niinku* was calculated as a percentage from the total number of words in the utterance. Thus, a place value of 100% indicates that *niinku* occurred as the last word of the utterance. The data seem to exhibit pre-pausal lengthening. A second-order polynomial function that seemed to fit the data best is shown as a trendline.

produce *niinku* in isolation (or to read it aloud), it is not warranted to call the result the target form, or the reference form, or the canonical pronunciation of *niinku*, since it no longer is quite the same 'word'. Indeed, why should the speaker intend to pronounce *niinku* 'clearly' even though this word is usually not stressed?

If we are interested in a general model for spontaneous speech, a segmentation and labeling method that is based on discrete, sequential sound segments will not lead to very fruitful results. As for this study, only one person was responsible for the labeling work and prosodic analysis. It is known that even trained phoneticians tend to disagree on segment boundary placement and the phonetic symbols that should be used, and that labelers are not 100% consistent with their own decisions – no matter how much practice and models they get. The different acoustic-phonetic features that result from certain types of articulatory movements simply do not perfectly coincide in time with the segments they 'belong to'.

The old and persistent question of invariant linguistic units and their representations in speech is still unsolved. 'Phonological awareness', i.e. an analysis of phonemic structure, does not appear to be obligatory for speech perception (Hawkins 1999: 258–260). Due to our mastery of the alphabetic script, it has been tempting to assume that there are invariant phonemes, or discrete and stable 'target' values for speech sounds (Öhman 2000). Apparently, this invariance cannot be directly manifested in traditional phonetic transcriptions of continuous speech. The target patterns must be more movement-oriented. They must be allowed to depend on the prosodic context and the function of the word or syllable. Moreover, all words are not equally probable at all times, implying that a maximal amount of phonetic/phonemic cues is seldom necessary (Lindblom 1990).

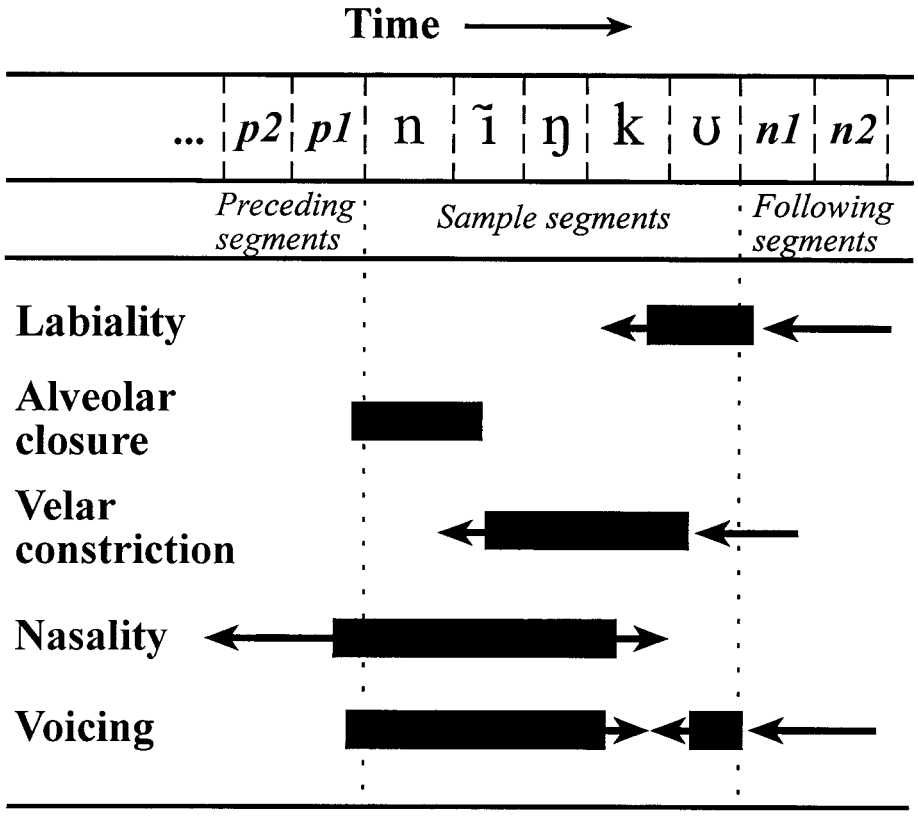

Figure 5 A schematic drawing of the minimal, common phonetic properties of *niinku*. This overview is an interpretation of the acoustic waveforms of 101 tokens and their phonetic transcriptions. The black bars show the assumed articulatory phases and their approximate temporal overlapping. The arrows refer to the possible spreading of articulatory features; e.g. the topmost left arrows show the anticipation of the labiality setting: the end of each *niinku* occurrence is usually slightly rounded, but this may be influenced by following segments. Glottalization effects are not shown.

We thus have many conceptual and methodological problems in our way. It does not pay to model words as fully specified strings of phonemic/phonetic symbols, since they emphasize variability and disguise the assumed patterns. Naturally, the use of phonetic alphabets has produced a lot of essential scientific information – and will continue to do so. However, only by looking at time-varying, real-life phenomena in their context can we find plausible explanations and working models for the human speech system.

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