ACCENTUAL-PROMINENCE-ENHANCING STRATEGIES IN AUSTRALIAN ENGLISH

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ABSTRACT- Previous studies have documented at least two supralaryngeal strategies that talkers use to highlight accentual prominence on a word. They can lower the jaw more in the stressed vowel, producing a more open vocal tract. They can also manipulate lingual articulation to accentuate the contrastive features of accented syllables. This study examines the acoustic consequences of such supralaryngeal correlates of accenting. Tongue-dorsum and jaw movement were recorded for three female speakers reciting a dialogue designed to elicit different accent placements around words containing high and low vowels. The results showed multiple articulatory strategies that varied across talkers and consonantal context. For example, two of the three speakers lowered the jaw more in accented syllables. However, one of these fronted the tongue in /i:/ to compensate for the jaw lowering in all contexts, whereas the other did so only in the velar context. Moreover, this second speaker (but not the first) also raised the tongue dorsum further away from the jaw to make a narrower constriction during the accented /i:/ vowel in /d/ and /b/ contexts. Despite this inter-talker differences, accenting the word resulted in a consistent raising of the frequencies or amplitudes of spectral peaks in the region of the second and third formants. Thus, the result of these articulatory strategies is a perceptual "sharpening" of the /i:/ timbre, suggesting a "localized hyperarticulation" of the accented high vowel.

INTRODUCTION

At the highest levels of the stress hierarchy, prominence in English involves placing a particular intonational event — a pitch accent — on the rhythmically strongest syllable of the word in focus (e.g. Bolinger, 1958; Pierrehumbert, 1980). While the defining feature of stress at these levels thus is tonal, there often are other supra-laryngeal cues to the accented status of the syllable (Beckman, 1986). Previous articulatory studies suggest at least two strategies for producing this enhanced prominence. Studies of lip and jaw kinematics for sylalbles with low vowels have shown that accent can be associated with slower, larger opening and closing movements. In other words, many speakers make a "bigger" syllable, with significantly lower jaw positions at peak opening (e.g. Summers, 1987; Edwards, Beckman, and Fletcher, 1991; Harrington, Fletcher and Roberts, 1995). Beckman et al. (1992) refer to this as the "sonority expansion" strategy — an accented syllable is associated with a more open vocal tract than is an unaccented syllable. Studies of tongue movement, on the other hand, suggest a second strategy, which de Jong (1995) calls "localised hyperarticulation" (after Lindblom, 1990). De Jong looked at high and mid back vowels in American English, and found them to be associated in some speakers' productions with higher and/or backer tongue body positions. That is, a more peripheral vowel is produced, providing a clear paradigmatic distinction from other vowels that could have occurred in the same accented position.

The evidence for two such different prominence-enhancing strategies raises the question of the relationship between them. Since de Jong also found lower jaw position in accented syllables for at least one of his talkers, one possibility is that the choice of prominence-enhancing strategy is talker-specific. Another possibility is that the different strategies are associated with different vowels. Because the tongue rests on the jaw, greater lowering of the jaw that is not accompanied by an upward bunching of the tongue body results in a more open vowel. If the accented syllable contains a low vowel, this means that the two strategies can work together to make a "bigger" syllable that has a more peripheral (more extremely open) low vowel. In a syllable with a high vowel, on the other hand, "localised hyperarticulation" and "sonority expansion" may conflict. The talker cannot simultaneously enhance the accentual promience of the syllable by producing a more open vocal tract configuration and enhance the clarity of the high vowel specification by producing a closer palatal or velar constriction. This paper reports on a study of the relationship between "sonority expansion" and "localised hyperarticulation" in recordings of accented and unaccented syllables produced by three Australian English speakers. We looked at the acoustic consequences of tongue and jaw articulations for both phonemically high and phonemically low vowels placed in a variety of consonantal contexts. We also investigated the extent of talker-specific strategies.

METHODS

Three female speakers of Australian English produced at least ten repetitions of each of 9 dialogues that followed the model below. The target is the stressed first syllable of the name *Beeber*, which is in a context that elicited nuclear accented tokens (in A's part) versus deaccented token (in B's part). The 8 other dialogues put the same high vowel /i:/ in alveolar and velar contexts by substituting *Deeder* or *Geeger* or targeted the low central vowel /a:/ or the mid vowel /ɜ/ by substituting *Barber*, *Berber*, *Darder*, etc. (In this paper only the data contrasting the low and high vowels will be considered.)

A: This is Hector Beeber, Colin. Would you order a nameplate for his desk?
B: Okay, should it be the plain "Hector Beeber" coloured blue, or the formal "Dr. Beeber" coloured gold?

The Movetrack electro-magnetometer system (Branderud, 1985) was used to record articulator movement simultaneously with the acoustic signal. An electromagnetic field is generated on a frame above the talker's head and picked up in the two dimensions of the midsagittal plane by four transducer coils glued to the articulators. Out of the eight recorded dimensions we used three: jaw lowering (the vertical coordinate value from the coil placed on the talker's chin), and tongue-body raising and fronting (the vertical and horizontal coordinate values of the coil placed on the tongue dorsum about 4 cm behind the tongue tip). The data were digitised onto a SUN workstation and ESPS/Waves + was used for acoustic segmentation and labelling of the corpus. Formants 1, 2, 3, rms amplitude, and F0 traces were also derived using ESPS signal processing routines. Once acoustic segmentation of target words was completed, mu+ (Cassidy and Harrington, this volume) was used to locate relevant kinematic and acoustic events, and average data around them. For each target vowel, we located the point of maximum jaw opening (where we extracted RMS amplitude and F1 values), and for each /i:/ we located the point of maximum F2 or F3 frequency (where we extracted tongue raising and tongue fronting values). Two-level ANOVA was used to ascertain the size of any effects of accent on these parameters using as a critial $p < 0.05$. (Many of the differences that we report as significant are considerably larger than the critical difference at this level.)

RESULTS

Accented syllables had, on average, significantly longer acoustic vowel durations. They also had substantially lower jaw heights at the point of maxtimal opening for two of our three talkers. The difference was significant for both speakers in all contexts but MDB's /da:d/ and /gVg/ tokens. For JMF (Figure 1), the mean F1 value at peak jaw opening was slightly higher in the accented context for all target vowels except the /a:/ of *Garger*. For MDB, on the other hand, the mean F_1 value at this point was lower in the accented syllable. However, for the same two speakers, rms amplitude rose to a higher value within the vowel of the nuclear accented syllable (shown here for JMF).These patterns were not observed in the third speaker's productions. Talker SAP showed little effect of accent on any of the parameters other than the fundamental frequency.

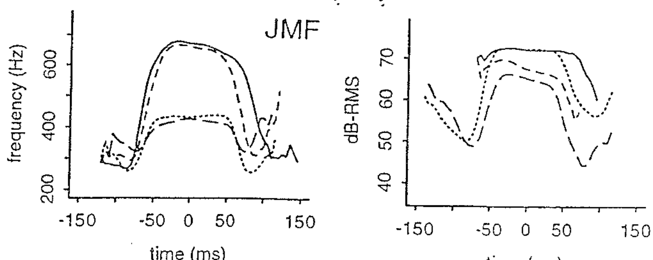

Figure 1. F1 and RMS amplitude traces averaged and lined up at the time of maximum jaw lowering for tokens produced by JMF of nuclear-accented [i:] (Ni), unaccented [i:] (Ui), accented [a:] (NA) and unaccented [a:]. (UA) in /bVb/ contexts.

There were comparable inter-speaker differences for the effects of accent at the point of maximum F2 or F3 in the high vowel. Syllables with labial or alveolar stops showed a consistent second formant peak somewhat after the middle of the vowel, whereas syllables with velar stops showed no F_2 peak but a consistent third formant peak at about the same point. For JMF, these F2 and F3 "target" values were both significantly lower in the unaccented vowels in all consonant contexts, with the exception of the F3 in the velar context. For MDB, there was significant F2 undershoot in unaccented *Beeber* and *Deeder*, but no significant differences in F3 or for F2 in the velar context.

Figure 2 shows averaged tongue dorsum trajectories for accented (solid lines) and unaccented (dotted lines) high vowels aligned and averaged at these formant "target" points (marked "T" on each trajectory) — i.e., F2 peak in *Beeber* and *Deeder* and F3 peak in *Geeger*. Decreasing x-axis values (towards the left of the display) correspond to tongue fronting, increasing y-axis values (towards the top of the display) correspond to tongue raising. Speaker JMF (top row) showed lesser tongue raising in accented syllable (in keeping with the lower jaw), and also a greater degree of tongue fronting, whereas speaker MDB (bottom row) had greater tongue raising for accented *Beeber* and *Deeders*, and only *Geeger* patterned like JMF's tokens. Examination of the time course of tongue dorsum articulation for MDB's high vowels in alveolar and bilabial tokens highlight an additional aspect of the hyperarticulation strategy. In these tokens the time of tongue dorsum peak was considerably later than the time of the jaw minimum. It is not surprising to see a substantial latency between peak tongue raising and jaw lowering, since many researchers have noted the diphthongal nature of this vowel in Australian English (see, e.g., Bernard, 1989). For MDB, however, accent had the effect of increasing this latency further — from about 30 ms to as much as 60 ms. This pattern of delaying the peak tongue raising further in relation to peak jaw lowering in accented syllables was not apparent in the other speakers' productions. In summary, two speakers appear to hyperarticulate the tongue body to produce a sharper timbre in the accented high vowel. However they use different articulatory manoeuvres to achieve this acoustic goal. And speaker SAP again showed effectively no accent effect on lingual articulation or higher formant frequencies.

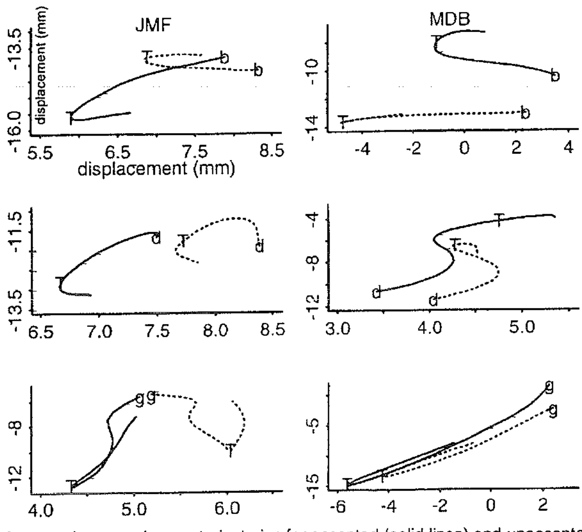

Figure 2. Averaged tongue dorsum trajectories for accented (solid lines) and unaccented syllables(dotted lines). The x and y axes correspond to horizontal and vertical movement of the tongue dorsum, respectively and all units are in mm.

DISCUSSION

The data reported here confirm prior suggestions of two different strategies to enhance the percept of prosodic prominence for a nuclear accented syllable. There was evidence of sonority expansion for both high and low vowels in the significantly lower jaw minimum in nuclear-accented syllables compared to post-nuclear unaccented syllables, and there was evidence of an independent localised hyperarticulation for the high vowel in the signficantly higher or fronter tongue body position. For the low vowel, the increase in jaw opening corresponded to a larger RMS amplitude (an acoustic correlate of sonority expansion) and also to a higher first formant frequency (an acoustic correlate of the vowel's paradigmatic specification as a low pharyngeal vowel — i.e. of localised hyperarticulation). For the high vowel, on the other hand, the increase in jaw opening conflicts with the paradigmatic specification of the narrow palatal constriction and can be interpreted only as sonority expansion.

There was also evidence for two different ways to locally hyperarticulate the palatal constriction in nuclear-accented /i:/. One speaker produced a more fronted constriction, thus reconciling sonority enhancement and localised hyperarticulation by assigning them to different articulatory subsystems. Although the lower jaw resulted in a slightly higher F1 for this speaker, the fronter lingual articulation raised F2 and F3, so that the listener can recover both the intent to lessen the impedance in the vocal tract by opening the mouth wider, and the intent to sharpen the vowel's timbre. A second speaker raised the tongue dorsum rather than fronted it. This could have the potential effect of masking the sonority cue to accent, but it did not. Rather the two potential prominence-enhancing strategies were reconciled by timing the hyperarticulation manoeuvre (tongue dorsum raising) later than the sonority expansion manoeuvre (jaw lowering). A third speaker showed evidence neither prominence enhancing strategy. Nonetheless, her nuclear accented syllables were perceptibly accented. Apparently, the F0 contour can convey the accent pattern even without substantial supra-laryngeal enhancement of the rhythmic prominence associated with nuclear accent placement.

As the literature on motor equivalence suggests, more than one articulatory strategy can be used by a talker to produce a particular phonetic goal. The articulation of stress contrasts is no exception. Speakers in our study produced the auditory percept of a nuclear accented syllable via a combination of laryngeal and supralaryngeal adjustments or by laryngeal adjustments alone.

NOTES

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