Acoustic Correlates of Neutral versus Angry Affect in Real and Non-Word Sentences

Heather Flowers, M.Ed., M.H.Sc.[1], Tim Bressmann, PhD[1]
[1]Dept. of Speech Language Pathology, University of Toronto, 500 University Avenue, Toronto, ON, M5G 1V7, Canada

1. INTRODUCTION

To date, only a handful of studies have investigated the acoustic parameters of affect in speech (Hammerschmidt & Jürgens, 2007; Pell, 2001; Banse & Scherer, 1996; Williams & Stevens, 1972). They have demonstrated an increase in fundamental frequency (Williams & Stevens, 1972; Hammerschmidt & Jürgens, 2007; Banse & Scherer, 1996) and amplitude when speakers used a hot angry voice compared to a neutral voice or other affective states (Hammerschmidt & Jürgens, 2007; Banse & Scherer, 1996).

The present study sought to identify changes in three acoustic parameters when participants adopted a hot angry affective state. This study investigated changes in fundamental frequency, amplitude, and nasalance in two sentence types, a real oral sentence (without any nasal phonemes) and a non-word balanced sentence (with oral and nasal phonemes).

We hypothesized that mean fundamental frequency (f0) and sound pressure level (SPL in dB) would increase in sentences spoken with a hot angry affect. Conversely, we expected nasalance to decrease with a hot angry affect. We posited that increases in vocal cord tension would entail a higher f0 and dB SPL. Also, synergistic recruitment of velopharyngeal muscles would result in a tighter velopharyngeal port closure and less transmission of acoustic energy through the nasal passage.

2. METHOD

We chose to investigate if the parameters mean f0, dB SPL and nasalance conformed to these physiologically driven hypotheses in the speech of normal speakers. We recruited 10 speakers with prior acting experience by posting billboard advertisements at the University of Toronto. The participants were six female and four male speakers with a mean age of 28.9 years (range 18 to 43 years). All spoke standard Canadian English.

The participants read two repetitions of each sentence in the two experimental conditions. The sentences were counterbalanced according to emotional state (neutral versus hot angry) and type (non-nasal versus balanced). Each set contained four sentences, i) the neutral non-nasal sentence, "He had two rock lizards" (Lewis & Watterson, 2003), ii) the neutral balanced non-word sentence, "Hat sundig pron you venzy" (Banse & Scherer 1996), iii) the hot angry non-nasal sentence, "He had two rock lizards" and iv) the hot angry balanced non-word sentence "Hat sundig pron you venzy".

Participants recorded the sentences using the NasalView headset (22.05 kHz, 16 bit recording, Tiger Electronics Inc., Seattle, WA). This headset has a sound separation plate positioned on the participant's prolabium to permit separate recordings of speech sounds from the nose and the mouth. Preamplification and soundboard settings were constant for both sets and experimental conditions. We used the Praat speech analysis software to analyse mean f0 and amplitude in dB (Boersma & Weenink, 2004). The NasalView software was used to extract the nasalance values for all 80 sentences.

3. RESULTS

We computed differences in mean f0, dB SPL and nasality using repeated measures ANOVAs with two factors, emotion and sentence type (SAS, 9.1; see Table 1).

Table 1. Two factor ANOVA table for three dependent measures (pitch, amplitude and nasalance)

Measure	Emotion	Type	Emotion by Type
Pitch (f0)	$p<.01$ (F=278.50)	NS	NS
Amplitude (dB SPL)	$p<.01$ (F=109.12)	$p<.01$ (F=63.08)	NS
Nasalance (dB SPL)	$p<.01$ (F=12.54)	$p<.01$ (F=935.01)	$p<.01$ (F=268.67)

There were significant differences in mean f0, dB SLP and nasalance for emotion. Similarly, there were significant differences in mean amplitude and nasalance according to sentence type. The ANOVA for nasalance also revealed an interaction between sentence type and emotion (see Figure 1).

A review of the changes in mean values according to sentence type and emotion revealed higher f0 and dB values with a hot angry affect in both the non-nasal sentence and the non-word phonemically balanced sentence (see Table 2). Nasalance, on the other hand, remained unchanged in the hot angry non-nasal sentence, but decreased in the angry

non-word sentence. An incidental finding was the higher mean dB value in the non-word sentence.

Table 2. Mean f0, dB SLP and nasalance values by sentence type.

Measure	Real Oral Sentence		Non-word Balanced Sentence	
	Neutral	Angry	Neutral	Angry
Pitch (f0)	165.71	218.92	165.64	211.68
Amplitude (dB SPL)	64.42	74.14	67.06	76.21
Nasalance (dB SPL)	23.72	22.04	47.57	38.62

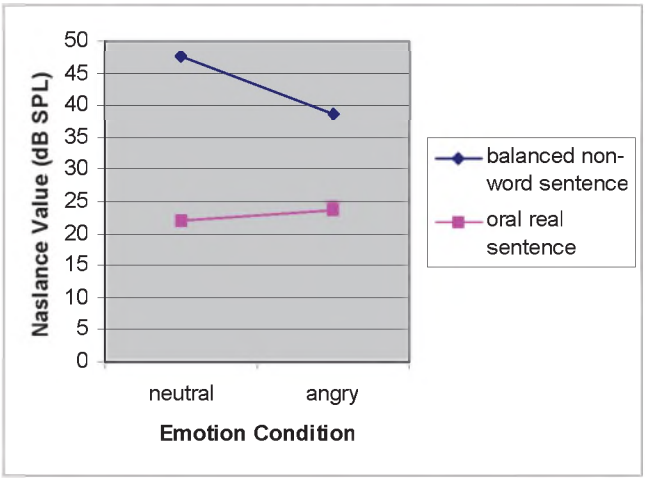

Figure 1. Interaction between sentence type and emotion.

4. DISCUSSION

The findings that mean f0 and dB increase with a hot angry affect support the previous literature (Williams & Stevens, 1972; Hammerschmidt & Jürgens, 2007; Banse & Scherer, 1996) and confirm our hypothesis. The incidental finding of a mean increase in dB in the non-word sentence in both the neutral and hot angry condition may relate to increased effort producing an unfamiliar sentence without semantic content.

The decrease in the mean nasalance in the hot anger condition in the phonemically balanced non-word sentence points to a more tightly sealed velopharyngeal port, also suggestive of increased physiological effort. There was no similar decrease in nasality in the non-nasal sentence for the hot angry condition.

Given that there was no nasal consonant in the real sentence, the velopharyngeal port was already maximally closed in the non-nasal condition. Consequently, an even tighter seal in the hot angry condition did not lead to decreased nasal emission.

These findings reflect velar-laryngeal interactions. Adopting a hot angry affective state or repeating a non-word phrase resulted in increased amplitude. The hot angry affect led to a concomitant increase in pitch and decrease in nasalance.

Further research needs to be conducted to determine if adopting a more relaxed or calmer affective state alters speech acoustics such that amplitude and pitch decrease with a concomitant increase in nasalance.

In the future, this type of research may prove useful in the remediation of impaired interactions between subsystems, such as the larynx and the velum. Using non-word sentences or adopting a hot angry affective state may provide a means to stimulate increased vocal amplitude or decreased nasalance.

ACKNOWLEDGEMENTS

We thank Jayanthi Sasisekaran for testing participants and for extracting nasalance values for this study.

REFERENCES

Awan, S.N. (1996). Development of a low-cost nasalance acquisition system. In: Powell T, Ed. Pathologies of Speech and Language: Contributions of Clinical Phonetics and Linguistics. New Orleans, LA: International Clinical Linguistics and Phonetics Association, 211-217.

Awan, S.N. (1998). Analysis of nasalance: NasalView. In: Zeigler W., Deger K, Eds. Clinical Phonetics and Linguistics. London: Whurr-Publishers, 518-525.

Banse, R. and Scherer, K.R. (1996). Acoustic Profiles in Vocal Emotion Expression. Journal of Personality and Social Psychology, 70, 614-636.

Boersma, P. and Weenink, D. (2004). Praat. Doing phonetics by computer (version 4.2). [Computer Program]. Retrieved from http://www.praat.org/.

Hammerschmidt, K. and Jürgens, U. (2007. Acoustical Correlates of Affective Prosody. Journal of Voice, 21, 531-540.

Lewis, K.E. and Watterson, T. (2003). Comparison of nasalance scores obtained from the Nasometer and the NasalView. Cleft Palate Craniofacial Journal, 40, 40-45.

Pell, M.D. (2001). Influence of emotion and focus location on prosody in matched statements and questions. Journal of the Acoustical Society of America, 109, 1668-1680.

SAS Software, Version 9.1of the SAS System for Windows. Copyright (2004). Trademarks of SAS Institute Inc. Cary, NY, USA.

Williams, C.E. and Stevens, K.N. (1972). Emotions and Speech: Some Acoustical Correlates. Journal of the Acoustical Society of America, 52, 1238-1250.

AUTHOR NOTES

This work was conducted at the Voice and Resonance Laboratory, while Heather Flowers was completing M.H.Sc. studies in the Department of Speech Language Pathology at the University of Toronto. The current address is 500 University Avenue, Toronto, ON, M5G 1V7.