FORMANT FREQUENCIES OF LAUGHTER IN CHILDREN WITH AND WITHOUT HEARING IMPAIRMENT

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ABSTRACT

The present study extracted the formant frequencies (F_1 , F_2) of laughter produced by Children with Hearing Impairment (CHI) and compared it with normal hearing children. Laughter of fifteen male CHI in the age range of 5-12 years were elicited using funny movie clips and compared with age and gender matched normal peers. The laughs were stored separately for each speaker onto a computer memory and frequency of the first two formants at the midpoint of the laughter was extracted using PRAAT -5114 software. The results revealed that CHI showed a slightly reduced F_1 though statistically not significant and statistically higher F_2 which is statistically significant compared to normal hearing children. This indicates that CHI used a relatively more neutral and less distinctive tongue configuration compared to the normal peers. This study throws light on the coordination of subsystems of speech/laughter in CHI. Further studies are required to justify the present findings with more number of samples.

Key words: laughter, formant frequencies, burst, bout

INTRODUCTION

Laughter is the biological reaction of humans to moments or occasions of humour: an outward expression of amusement. The study of humour and laughter, and its psychological and physiological effects on the human body, is called Gelotology. Savithri (2000) reported that laughter is one of the elementary forms of phonic expression that are very similar in all human beings. Laughter is produced by chopping an outward breath into a series of short vocal vocalizations, both voiced and unvoiced, that repeat about every one fifth of a second (Bachorowski, Smoski, & Owen, 2001 ; Provine, 2000; Provine & Yong, 1991; Vettin & Todt, 2004). Laughter requires the coordination of respiration, phonation and resonance. Respiratory cycle consists of inspiration, inspiration pause, expiration and expiration pause. No matter where in a respiration cycle, laughter typically begins with an initial forced exhalation followed by a more or less sustained sequence of high expiration and low amplitude. Laughing is characterized by maximally lowered larynx and greatly widened resonators (Lushsinger & Arnold, 1965). Formants are the spectral peaks of the sound spectrum (Fant, 1960). Formants are particularly important because they are essential components in the intelligibility of speech. For example, distinction of the vowel sounds can be attributed to the differences in the frequency of first three formants. The process of articulation determines the frequencies of the vocal formants. Sundberg (1974) has identified portions of the vocal anatomy which he associates with the formant frequencies. The jaw opening, which constricts the vocal tract toward the glottal end and expands it towards the lip end, is the deciding factor for the first formant. This formant frequency rises as the jaw is opened wider. The second formant is sensitive to the shape of the body of the tongue, and the third formant is sensitive to the tip of the tongue. Savithri (2000) reported that formant frequencies of adult laughter coincided with /a/ in both males and females. Szameital & Alter (2000) reported that laughter syllables showed higher formant speech than normal speech vowels.

Need for the study

Persons with Hearing impairment often have been described as having difficulty in moving the articulators correctly from one phoneme to the next (Calvert, 1961; Monsen, 1978, Smith, 1972). Furthermore, as a result of not hearing their own vocalizations, Children with hearing impairment (CHI) would also have had less opportunity to acquire experience guided control over concomitant respiratory functions, as well as laryngeal, oral and other vocal tract musculature. As most of the

studies on laughter acoustics were done on normal adult and child population, laughter acoustics in CHI has been poorly focussed. This indicates that research in this area is inadequate and the acoustic features of laughter produced by CHI needs to be examined.

Aim of the study

The aim of the study was to investigate formant frequencies (F_1, F_2) of laughter produced by CHI and compare it with those of normal hearing children.

METHOD

Participants: Two groups of subjects participated in the study. Group I consisted of fifteen boys with HI in the age range of 5-12 years. Subjects in group I had congenital bilateral severe/profound sensori-neural hearing loss; they had no structural or neurological problems. They were hearing aid users for at least two years. Subjects in group II were age and gender matched to subjects in group I and they had normal speech, language and hearing (informal assessment).

Stimuli: Eight short movie clips compiled on a Digital Video disk (DVD) was used as stimuli. Five funny movie clips from comedy movies (Mr. Bean) /funny TV serials (just for laughs)/cartoons (Tom &Jerry) were used. The rest three were taken from dramas or science fantasy films and will be emotion inducing but not humorous. The latter was included in the DVD to make the cover story as plausible as possible; thereby helping to ensure that any laugh sounds produced would be spontaneous and natural. In order to appeal to both PHI and normal college students, the clips were emphasized on physically based actions with minimum reliance on dialog.

Procedure: Participants were seated in a noise free recording room and oriented towards a 15.6 inches high definition Toshiba Satellite L650 laptop. Participants were told that the only task will be to sit back, relax and watch a series of movie clips. Participants vocalizations was recorded using Zebronics head worn microphone, with the microphone arm running parallel to the cheek, and the tip positioned 1 inch from the left corner of the mouth.

Acoustic Analysis: Following Bachorowski, Smoski & Owren (2001) study, laughter is defined relatively inclusive as being any perceptual vocal event that an ordinary person would categorize as laugh sounds. Speech sounds interfering with laughter will be excluded as it would alter the acoustic properties of laughter (Nwokah, Hsu, Davis & Fogel, 1999). Each laughter file was labeled at the bout and burst levels based on spectrographic representations. A bout was defined as one entire laughter episode, and a burst as a discrete sound (note, syllable, or call) occurring within that episode. Grammer & Eibl- Eibesfeldt (1990) also classified laughs as voiced and unvoiced. The former is laughter based on vowel like somewhat melodic sounds produced through regular synchronized vocal fold vibration in the larynx. The latter in contrast is laughter based on noisy sounds in which the vocal folds either do not vibrate or vibrate in an irregular desynchronized fashion. The laughs were stored separately for each speaker onto a computer memory at mono channel, 16 bit resolution and 44 kHz sampling rate using PRAAT -5114 software (Boersma & Weenick, 2009). Frequencies of the first two formants at the midpoint of the laughter were extracted using PRAAT -5114 software. The laughs were depicted as wide band bar type spectrograms. Figure1 shows the spectrogram for a normal laugh.

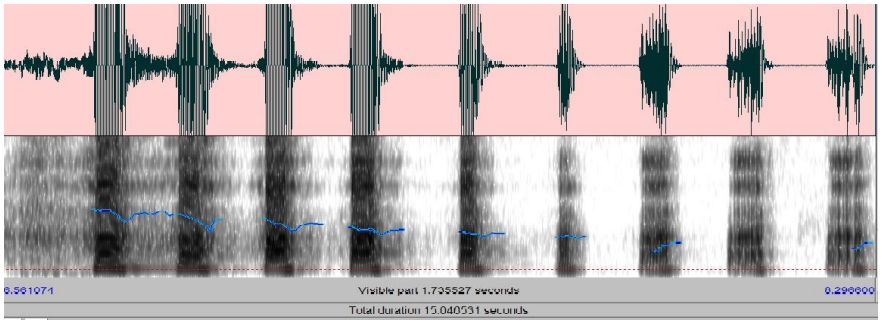

Figure 1: Waveform, F0 contour and Bar type Spectrogram of a laughter.

RESULTS

Mean F1 of CHI was 900 Hz while Mean F1 of normal children was 928 Hz. Mean F2 of CHI was 1852 Hz while those of normal children were 1462 Hz. The average number of bouts in children was 3. Results of the t- test indicated a significantly lower F_1, and a higher F_2 in group I compared to group II [t (45) =7.52, p< 0.001]. Table 1 shows the mean F_1 and F_2 in both groups.

Table 1: Mean F_1 and F_2 frequencies of laughter in CHI and Normal Children

	Group I	Group II
Mean F_1 (Hz)	900	928
Mean F_2 (Hz)	1852	1462

Isovowel lines were drawn with F_1 on X axis and F_2 on Y axis (figure 2). It was observed that the isovowel lines of group I and group II were separated very clearly.

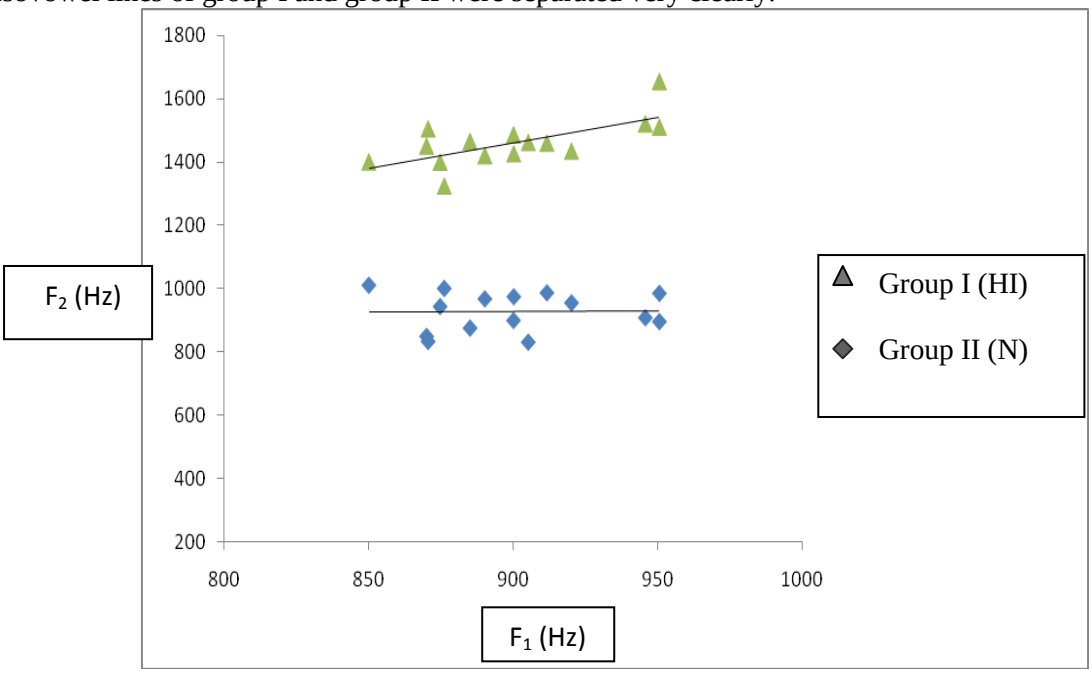

Figure 2: Isovowel lines of F1 and F2 frequencies for both the groups.

DISCUSSION

Jeyalakshmi, Krishnamurthy & Revathy (2010) also reported variation in pitch and formants for deaf children compared to normals. Studies on vowel production by English-speaking profoundly hearing impaired children have reported formant frequencies deviating from normal values (Angelocci et al., 1964; McGarr and Gelfer, 1983). Limited control of tongue shape by speakers with profound hearing loss has been reported in studies of tongue movement using glossometric technique (Dagenais & Critz-Crosby, 1992), as well as electromyographic technique (McGarr & Gelfer, 1983). The results of the present study are in consensus with those of the above studies. Comparison of the F_1 and F_2 in two groups showed a slightly reduced F_1 (tongue height), and higher F_2 (front-back placement of the tongue) which is statistically significant .This indicates that CHI used a relatively more neutral and less distinctive tongue configuration compared to normal children. This may be due to the fact that speakers with a profound hearing loss have difficulty in perceiving the acoustic cues of vowel identity. The reduction in F_1 and the increased F_2 in CHI indicate lower and fronted tongue position. For this reason, they may rely mainly upon visual information to perceive and produce vowel. The fact that tongue height and lip configuration are more easily seen than front-back placement could account for the fact that CHI learnt to produce vowel like laughs in a fronted tongue position were

able to produce almost distinct F1, but not F2, values for the vowels in the present study. Comparing the results of the present study with that of Savithri (2000) indicated that children had a reduced number of bouts compared to that of adults. As children have reduced vital capacity compared to that of adults, the number of bouts may be less in children.

CONCLUSIONS

The present study investigated the formant frequencies of laughter in children with and without hearing impairment. This study throwed light on the tongue position in CHI. The results of the present study has contributed to the literature on laughter. Future research on the development of laughter and laughter in postlingual HI is warranted.

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REFERENCES

Angelocci, A., Kopp, G., & Holbrook, A. (1964). The vowel formants of deaf and normal hearing eleven to fourteen year old boys. *J. Speech Hear. Disord.* 29, 156-170.

Bachorowski, J.A., Smoski, M.J., & Owren, M.J. (2001). The acoustic features of human laughter, *J. Acoust. Soc. Amer*.110, 1581-1597.

Boersma, P. & Weenink, B. (2009). Praat: doing phonetics by computer (Version 5.1.14) [Computer program]. Retrived from http://www.praat.org.

Calvert, D. (1961). Some acoustic characteristics of speech of profoundly deaf individuals, Unpublished doctoral dissertation , Stanford University.

Dagenais, A., & Critz-Crosby,P. (1992) . Comparing tongue positioning by normal hearing and hearing-impaired children during vowel production, *J. Speech Hear. Res.* Vol.35 35-44.

Fant, G. (1960). Acoustic Theory of Speech Production, The Hague, Netherlands :Mouton & Co

Grammar, K., & Eibl-Eibesfeldt, I. (1990). The ritualization of laughter. *Acta Colloquii*, Ed. W. Koch (Bochum, Brockmeyer), pp. 192-214.

Jeyalakshmi, C., Krishnamurthi. V., &.Revathy, A (2010). *Signal & Image Processing : An International Journal* .1, 14-25.

Lushinger, R., & Arnold, G. E. (1965). Voice, speech and Language, London: Constable, 1965.

McGarr, N.S., & Gelfer, C. (19883). Simultaneous measures of vowels produced by a hearing impaired speaker. *Language and Speech*, 26, 233-246.

Monsen, R. B. (1978). Towards measuring how well hearing impaired children speak. *J. Speech Hear. Res.* 17: 386-398.

Nwokah, E. E., Hsu, H.C., Davis, P., & Fogel, A. (1999). The integration of laughter and speech in vocal communication: A dynamic systems perspective. *J. Speech Lang. Hear. Res*. 42, 880-894.

Provine, R. R. (2000). *Laughter: A Scientific Investigation*, NewYork: Viking Publications.

Provine, R. R. & Yong, Y. L. (1991). Laughter : A stereotyped human vocalization, *Ethology* , 89, 115-124.

Savithri, S. R. (2000). Acoustics of Laughter, *J. Acoust. Soc. India*, 28,233-238.

Smith, C. R. (1972). Residual hearing and speech production of deaf children, Unpublished doctoral dissertation, The City University of New York, 1972

Sundberg, J. (1974). Articulatory interpretation of the 'singing formant, *J. Acoust. Soc. Amer*. 55, 838-844.

Szameitat, P & Alter, K (2000). Differentiation of emotions in laughter at the behavioral level. Vol 9(3), Jun 2009, 397-405.

Vettin, J., & Todt, D. (2004). Laughter in conversation : Features of occurrence and acoustic structure, *J. Nonverbal. Behav.* 28, 93-115.