A STUDY ON ACOUSTICAL ANALYSIS OF LAUGH IN CHILDREN, ADULT FEMALES AND ADULT MALES IN DIFFERENT CONTEXTS

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Abstract

Emotional key called laughter is expressions of happiness that may depend on conditions, situations and mood that are responsible for the different acoustic features, which vary because of glottal source and vocal tract. The study aimed to compare the variation of acoustic patterns of laugh between adult males, adult females and children in different contexts (tickle and humor). The study was carried out between 10 adult males (18-30 years), 10 adult females (18-30years) and 10 children (3-12 years) with no voice problem and have normal intelligence quotient to understand the humor. Recordings done in a sound treated room without any environmental disturbances and special attention taken for appropriate space for sitting arrangement and placement of microphone and laptop. Stimulus used to elicit laugh were tickle and video clips (i.e., funny videos for adults and Tom and Jerry clips for children) for humor. Results of the study found that in adult males, only f_2 and f_3 were the parameters that had a high level of significance ($P<0.05$) to differentiate between tickle and humor, while other parameters like f_0, f_1, pitch max, pitch min and intensity did not get affected in tickle and humor. In adult females, only f_0 ($P<0.05$) varied in different laugh context (tickle and humor), but other parameters (f_1, f_2, f_3, pitch max, Pitch min, Intensity) had no level of significance. In children f_0, f_1, f_3, pitch max and intensity played a very important role to distinguish between tickle and humor and rest of the other parameters showed no difference. Children had highest mean formant frequencies secondary to adult females and were least in adult males for laughs elicited by tickle and humor. When tickle and humor were compared based on their mean values, tickle (1396) was higher than humor (1233). Thus various parameters extracted will help in forensic studies and can throw light on various emotional researches.

Keywords: *Formant frequencies, Vocal fold length, Gender, Age*

Introduction

Laughter is every day, human specific, affective and non verbal vocalization. Laughing is one of the elementary modes of phonic expressions that mostly resembles in all humans. It is considered as the stereotypical and distinctive aspect of positive emotional state of humans. According to Jerome Urbain, Huseyin Cakmak, and Thierry Dutoit (2012), laughter is a key signal in human communication, conveying information about our emotional state but also providing social feedback to the conversational partners. Laughter takes various shapes and depending upon the social interaction and communicative intent of the person involved with its environment. These various types of laughter accordingly affect the acoustics features of laughter. Laughter is characterized by maximally lowered larynx and greatly wide resonators (Luchsinger & Arnold, 1965). Study done on formant characteristics of human laughter by Diana, Darwin, Szameitat and Alter (2011), concludes that an extreme articulation during laughter production, such as wide jaw opening, suggests that laughter can have very high first formant frequencies and formant frequencies show typical gender effects with higher frequencies in female speakers when compared with normal speech production. Provine (1993) recorded laughs in public places like hotels, cinema theatres and drama theatres and has described 1500 different kinds of laughs. Typical laughter has typical /ha/ or /he/ and is of 75 millisecond duration. The time difference between two such sounds is about 210 msec.

Bickley and Hunnicut (1992) examined a small set of laughs and the results indicate that laugh could be described as the sequences of alternating voiced and unvoiced segments. In men and women both, laughter reaches surprisingly high frequencies. Frequency is measured by the rate at which the vocal cords vibrate. Sundaram and Narayanan (2007) remarked that the energy envelop of laughter waveforms oscillates like a physical mass-spring system.

The aim of the study is to compare how acoustic parameters of laugh vary between adult males, adult females and children in different contexts (tickle and humor).

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Method

The study has been carried out by selecting and performing recordings on 30 normal subjects, 10 adult males (18-30years), 10 adult females (18-30years) and 10 children (3-12 years). Those subjects were chosen who fulfilled the criteria of no voice problem and have normal intelligence quotient to understand the humor. Each subject's were requested to visit the clinics of Ali Yavar Jung National Institute of Hearing Handicapped, Northern Regional Centre where suitable recordings could be performed. Recordings were done in a sound treated room without any environmental disturbances, appropriate space for sitting arrangement and placement of microphone and laptop were taken into consideration. Stimuli used to elicit laughter were tickle and humor (video clips). For humor, we used funny videos for adults and cartoon clips for children. Laptop was used to present the video clips for humor, and laughter responses were recorded through digital recorder. Here, a relaxed atmosphere was provided, which could help subjects to elicit a natural laugh in response to the various stimuli. While analyzing in praat 5.3.17 only pure laugh of 3-4sec was taken with a sampling frequency of 44100Hz which was digitized, normalized and cut it into individual laughter sequences.

Following are the steps through which recording and analyzing of stimulus were done:

Step-1: Recordings were done in a sound treated room without any environmental disturbances. Special attention was taken for comfortable sitting arrangement, placement of microphone and laptop, proper lightening was also ensured. A chair with an arm rest, well cushioned was placed, each subject was asked to be seated comfortably for recordings.

Step-2: Proper instructions were given by the examiner to the subject about the task in a clear, concise and meaningful way. Subjects were 10 adult males, 10 adult females and 10 children (including both boys and girls). Recordings of laughter was done by two stimuli "tickle and humor". In tickle stimulus, tickling was done by one examiner and recordings were done by another examiner. Digital recorder was used to record the pure laughter sequences of children, adult males and adult females.

Step-3: For humor, again same 30 subjects were taken for the recordings of laugh which was elicited by showing funny videos (funny video clips for adults and cartoon clips for children). The stimulus was given for 2-3 minutes and responses were recorded by the digital recorder.

Step-4: All over 60 recordings were done on 30 subjects by using different stimuli in different contexts. Only pure laugh of 3-4seconds was taken and all the words, sentences and other verbal utterances were deleted from the recording. The acoustic analysis of these laugh responses was done by speech acoustic software i.e.; praat 5.3.17 with a sampling frequency of 44100Hz. Acoustic parameters like f_0 (fundamental frequency), f_1 (first formant frequency), f_2 (second formant frequency), f_3 (third formant frequency), pitch maximum, pitch minimum and intensity were extracted and compared between these subjects.

Results and discussion

Statistical analysis has been carried out in order to find out the difference between tickle and humor for adult males, adult females and children. t-test was administered to find the difference. It was found that in males, only f_2 and f_3 were the parameters that had a high level of significance ($P<0.05$) to differentiate between tickle and humor, while other parameters like f_0, f_1, pitch maximum, pitch minimum and intensity did not get affected in tickle and humor. In females, only f_0 ($P<0.05$) varied in different laugh context (tickle and humor), but other parameters (f_1, f_2, f_3, pitch maximum, pitch minimum, intensity) had no level of significance. In children f_0, f_1, f_3, pitch maximum and intensity played a very important role to distinguish between tickle and humor and rest of the other parameters showed no difference. Based on the observations, the overall mean values were 1396, 1323, 779 (tickle) and 1286, 1200, 928 (humor) for children, females and males respectively. Children had highest mean formant frequencies [f_o (399), f_1 (996), f_2 (2169), and f_3 (3339), pitch maximum (420), pitch minimum (230) and intensity (79)], followed by females [f_o (358), f_1 (1004), f_2 (2135), f_3 (3276), pitch maximum (368), pitch minimum (220) and intensity (72)]. Males showed the least values for acoustic parameters [f_o (291), f_1 (1616), f_2 (1904), f_3 (3081), pitch maximum (300), pitch minimum (180), intensity (73)] for laughs elicited by tickle and humor. When tickle and humor responses were compared based on their mean values, tickle (1396) responses were obtained higher than humor (1233) responses.

Statistical analysis tables of acoustic parameters along with the difference between tickle and humor for adult males, adult females and children are shown below.

In this table 1, standard deviation, standard mean

error and mean is taken out, by doing comparison between the tickle and humor stimuli in males.

Table 1: Group statistics for males

Parameters	Aspect	N	Mean	SD	Std. Error mean
Formant Frequency f_1	Tickle	10	1616	2325	735
	Humor	10	788	98	31
Formant Frequency f_2	Tickle	10	1904	293	92
	Humor	10	1324	299	94
Formant Frequency f_3	Tickle	10	3081	100	31
	Humor	10	2520	357	113
Mean f_0	Tickle	10	291	63	20
	Humor	10	248	35	11
Pitch Minimum	Tickle	10	183	23	7
	Humor	10	169	16	5
Pitch Maximum	Tickle	10	480	47	15
	Humor	10	463	34	10
Intensity Mean	Tickle	10	73	5	1
	Humor	10	73	4	1
Intensity Minimum	Tickle	10	40	21	6
	Humor	10	51	15	4
Intensity Maximum	Tickle	10	86	4	1
	Humor	10	85	2	0.6

In table 2, statistical analysis was done by comparing between the tickle and humor stimuli in males. The statistical analysis ($p \leq 0.05$) reveals that there is significant difference between Tickle and Humor. F_2 and f_3 were significant as compared to other acoustic parameters.

Table 2: t-test for males

Parameters	t-test for equality of means		
	T	Df	Sig. (2-tailed)
Formant Frequency f_1	1	9	0.29
Formant Frequency f_2	4	18	0.00
Formant Frequency f_3	4	10	0.001
Pitch Mean f_0	1	18	0.08
Pitch Minimum	1	18	0.14
Pitch Maximum	0.9	18	0.37
Intensity Mean	-0.1	18	0.88
Intensity Minimum	-1.2	18	0.23
Intensity Maximum	0.8	12	0.40

In table 3, standard deviation, standard mean error and mean are taken out, by doing comparison between tickle and humor stimuli in females.

In table 4, the statistical analysis for different acoustic parameters was done by applying T-test to find out the significant difference between the tickle and humor in female, reveals that f_0 ($p \leq 0.05$) was significant as compared to other acoustic parameter.

Table 3: Group statistics for females

Parameters	Aspect	N	Mean	SD	Std. Error mean
Formant Frequency f_1	Tickle	10	1004	258	81
	Humor	10	925	87	27
Formant Frequency f_2	Tickle	10	2135	511	161
	Humor	10	1944	98	31
Formant Frequency f_3	Tickle	10	3276	398	125
	Humor	10	3212	179	56
Pitch Mean f_0	Tickle	10	359	27	8
	Humor	10	345	6	2
Pitch Minimum	Tickle	10	262	25	8
	Humor	10	252	23	7
Pitch Maximum	Tickle	10	509	15	4
	Humor	10	500	14	4
Intensity Mean	Tickle	10	72	5	1
	Humor	10	74	4	1
Intensity Minimum	Tickle	10	35	12	3
	Humor	10	40	9	2
Intensity Maximum	Tickle	10	84	4	1
	Humor	10	86	4	1

Table 4: t-tests for females

Parameters	t-test for equality of means		
	t	Df	Sig.(2-tailed)
Formant Frequency f_1	0.9	18	0.37
Formant Frequency f_2	1	18	0.26
Formant Frequency f_3	0.4	18	0.65
Pitch Mean f_0	1	9.9	0.17
Pitch Minimum	0.9	18	0.36
Pitch Maximum	1	18	0.22
Intensity Mean	-0.9	18	0.33
Intensity Minimum	-1	18	0.31
Intensity Maximum	-0.5	18	0.58

Table 5: Group statistics for children

Parameters	Aspect	N	Mean	SD	Std. Error mean
Formant Frequency f_1	Tickle	10	996	138	43
	Humor	10	886	64	20
Formant Frequency f_2	Tickle	10	2074	332	105
	Humor	10	1956	616	195
Formant Frequency f_3	Tickle	10	3339	74	23
	Humor	10	2735	460	145
Pitch Mean f_0	Tickle	10	399	11	3
	Humor	10	348	22	7
Pitch Minimum	Tickle	10	174	71	22
	Humor	10	195	64	20
Pitch Maximum	Tickle	10	517	9	3
	Humor	10	449	46	14
Intensity Mean	Tickle	10	79	3	1
	Humor	10	75	6	2
Intensity Minimum	Tickle	10	48	9	2
	Humor	10	44	2	0.6
Intensity Maximum	Tickle	10	89	2	0.7
	Humor	10	84	6	1.9

In table 5, standard deviation, standard mean error and mean is taken out, by doing comparison between the tickle and humor stimuli in children (both boys and girls).

Table 6: t-test for children

Parameters	t-test for equality of means		
	t	Df	Sig. (2-tailed)
Formant Frequency f_1	2	12.7	0.04
Formant Frequency f_2	0.5	13.8	0.60
Formant Frequency f_3	4	9	0.00
Pitch Mean f_0	6	18	0.00
Pitch Minimum	-0.6	18	0.51
Pitch Maximum	4	9.8	0.001
Intensity Mean	1.5	18	0.14
Intensity Minimum	1.5	9.9	0.15
Intensity Maximum	2	11.9	0.04

In table 6, the statistical analysis for different acoustic parameters was done by applying T-test to find out the significant difference between the tickle and humor in children, reveals that f_0, f_1, f_3, Pitch maximum and Intensity were significant.

Table 7: *Comparison of means of acoustic parameters among children*, *males and females*

Parameters	Aspects	Mean of children	Mean of males	Mean of females
Formant frequency F1	Tickle	996	1616	1004
	Humor	886	788	925
Formant frequency F2	Tickle	2074	1904	2135
	Humor	1956	1324	1944
Formant frequency F3	Tickle	3339	3081	3276
	Humor	2735	2520	3212
Pitch mean F_o	Tickle	399	291	359
	Humor	348	248	345
Pitch maximum	Tickle	174	183	262
	Humor	195	169	252
Pitch minimum	Tickle	517	480	509
	Humor	449	463	500
Intensity mean	Tickle	79	73	72
	Humor	75	73	74
Intensity maximum	Tickle	48	40	35
	Humor	44	51	40
Intensity minimum	Tickle	89	86	84
	Humor	84	85	86

In table 7, comparisons of mean values were done between children, males and females. Overall result reveals that mean of f_1 was higher in males followed by females then children in tickle stimuli and in humor it was higher in females followed by children then males. F_2 was higher in females followed by children then males in tickle stimuli and in humor it was higher in children followed by females then males. F_3 was higher in children followed by females then males in tickle stimuli and in humor it was higher in females followed by children then males. F_0 was higher in children followed by females then males in tickle and humor stimulus. Pitch maximum was higher in females followed by males then females and in humor pitch maximum was higher in females followed by children then males. Pitch minimum was higher in children followed by females then males in tickle stimuli and in humor stimuli; it was higher in females followed by males then children. Mean intensity was higher in children followed by males then females in tickle stimuli and in humor it was higher in children followed by females then males. Intensity maximum was higher in children followed by males then females in tickle stimuli and in humor it was higher in males followed by children then females. Intensity minimum was higher in children followed by males then females in tickle stimuli and in humor it was higher in females followed by males then children.

In our study, an overall increment in various spectral characteristics and more significant features seen in children followed by females and then in males for both tickle and humor except for f_1 and f_3, where males and females had higher values respectively. The reason could be the difference in size, vocal fold membranous length, elastic properties of tissue, and glottal shape among males, females and children (Titze 1989). Diana et al 2009 reported a similar result, where they found an increase in all the formant frequencies including fundamental frequencies in both females and males.

In another study done by Savitri (2000), males formant frequencies for laugh were higher than their habitual frequencies, but females had same habitual and formant frequencies for laugh. Similar findings were obtained in our study with tickle and humour, where females and children's habitual and formant frequencies were same, but males had higher formant frequencies compared to their habitual frequency. The third observation was that all the acoustical parameters of tickle were higher as compared to humor among all the subjects. This could be because of the increased physical effort like forceful intake of large amount of air, which in turn can affect the laryngeal property of an individual and hence affecting the acoustical parameters.

Diana, Darwin (2011), study reveals that first formant of laughter vowels is characterized by

exceptionally high frequencies which may be a result of a wide jaw opening or constricted pharynx usually found in "pressed voice". Some of the other researchers also supported the above findings, where he said that reliable depiction of both laryngeal levels is essential because of the likelihood of rapid fluctuations in the control of airflow through the larynx during incidents of laughter. It can also be because of the postural differences in laughter as compared to the normal speech.

Conclusion

Laughter is a research subject for many disciplines including emotional, psychological and forensic research of nonverbal speech. We have found that age and gender affects the acoustics of laugh because of difference in size, vocal fold membranous length, elastic properties of tissue, and glottal shape among different subjects according to Titze (1989). We concluded that acoustic parameters obtained by tickle and humor stimuli were higher in children than females and least in males, whereas the overall responses obtained for humor responses were lower as compared to tickle stimuli. It was found that in males (f_2 and f_3), females (f_0) and in children (f_0, f_1, f_3, pitch max and intensity) were the parameters that had a higher level of significance ($P<0.05$) and played a very important role to distinguish between tickle and humor. It was also observed from the above mean values that children and females had same habitual and formant frequencies, while male had higher formant frequencies compared to that of their habitual frequencies.

The various parameters extracted will help in forensic studies and can throw light on various emotional researches.

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