Acoustical and Perceptual Correlates of Infant Cry in Monozygotic Twins: Preliminary Study

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Abstract

Monozygotic (MZ) twins are similar in various aspects. The similarities in the vocal tracts may also make their voices sound similar. The aim of the study was to investigate acoustical and perceptual characteristics of infant cries in monozygotic twins. Five pairs of MZ twins within one year of age participated in this study. Acoustical and perceptual characteristics of cry were measured from hunger cry and pain cry. The results showed significant similarities within the twins. However variability existed with respect to twin pairs and type of cry signal. The results of the present study indicated that there are other factors influencing voice characteristics along with the genetic constitution.

Key words: Monozygotic twins, pain cry, hunger cry, perceptual, acoustical

Monozygotic (MZ) twins have captured the interest of science and have been the source of one of earliest means of investigating the influence of genetics. Since twins resemble each other in many aspects, one expects that their voices also may sound similar at least to a certain degree. Studies with listeners have confirmed this perspective similarity. It has been observed that twins themselves have difficulties identifying their own voices when presented with recording, in random order, of their own voice and voice of other twin (Gedda, Fiori & Bruno, 1960). Investigators in the past have also measured and compared various acoustic characteristics of twin voices, such as voice range in semitones, speaking fundamental frequency and have reported significant similarities between monozygotic twins (Debruyne, Decoster, Gijsel & Vercammen, 2002). Ryalls, Shew & Simon (2004) compared VOT in older and younger female MZ twins. Results revealed greater similarity for the younger than for older female twin pairs. Santosh and Savithri (2004) studied acoustic and perceptual characteristics in five pairs of MZ twins. They also reported similarities between twins with respect to both temporal and spectral acoustic parameters. Despite these indications, no studies exist on early cry characteristics and vocalizations in MZ twins. Accumulation of evidence about the cry characteristics will shed light on the physiological state of the MZ infants. Therefore the goal of the present study was to investigate the acoustic and perceptual characteristics of infant cries in MZ twins.

Method

Subjects: Five pairs of monozygotic twins (MZ) participated in the present study. All the twins were within one year of age. All deliveries were normal and without complications. The infants were full term and their birth weights were normal. All the twins were screened for normal speech and language. The routine postpartum examination by a pediatrician revealed 'healthy' for all the babies. Table 1 shows the demographic data for all the twin pairs.

	Pair 1		Pair 2		Pair 3		Pair 4		Pair 5	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Age(months)	2	2	4	4	1.5	1.5	1.5	1.5	11	11
Gender	f	f	f	f	m	m	m	f	f	f

Table 1: Demographic data of all twin pairs (T- twin, f-female, m-male)

Experiment I: Acoustic analyses

Samples: Two types of cries - hunger and pain cry were selected in the present study. Hunger cry was elicited after 4 hours of feeding. Pain cry was elicited by pricking the sole of the foot. The average duration of the cry sample for all the twin pairs was around 50 sec.

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Procedure: The cry samples were recorded using external microphone connected to digital recorder kept at a distance of 10 cm away from the mouth of the child. The recordings were line fed to the computer memory using 16 kHz sampling frequency with 12 bit A/D converter. Waveform display and spectrogram of Computerized Speech Lab (CSL 4500, Kay Elemetrics) was used for analysis. Each sample was displayed as a broadband spectrogram with a pre emphasis factor of 0.80. The analysis size and bandwidth were set to 100 points, and 'Hamming' window was used. Spectrograms were displayed as monochrome (black on white) and grid size used was 8x8 pixels (x grid -8 pixels and y grid -8 pixels) with a linear vertical axis. Samples were displayed on broadband spectrograms and the target sample was 'zoomed in'. The segment was visually and auditorily verified to make sure of the target sample. Pitch tracking algorithm and multi dimensional voice profile of CSL 4500 was used to extract fundamental frequency contours and voice related parameters. The parameters selected for study were as follows.

1. **Duration of the vocalization**: It is the time difference between the onset and offset of the vocalization. Figure 1 shows the waveform display of duration of vocalization. Thin line indicates the onset of the vocalization and thicker line indicates the offset of the vocalization.

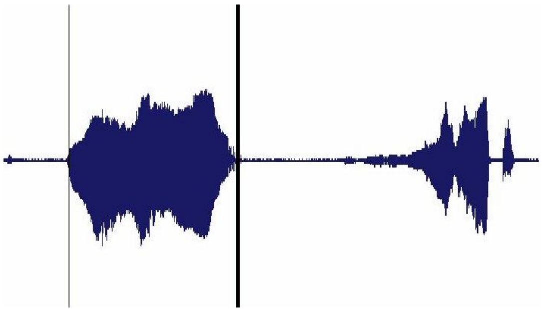

Figure1: Waveform display of duration of vocalization (ms).

2. **Second pause**: It is the time difference between the first and second vocalizations. Figure 2 shows the waveform display of the vocalization and second pause. Thin line indicates the offset of one vocalization and thicker line indicates the onset of the next vocalization.

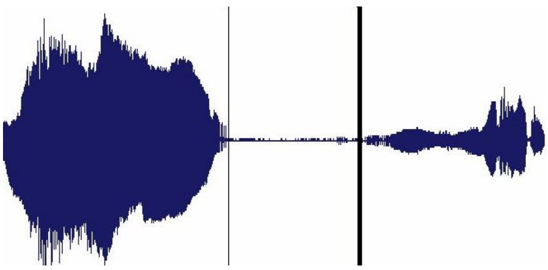

Figure 2: Waveform display of the vocalizations and the second pause (ms).

3. **Melody type**: Melody type of fundamental frequency was classified as falling, rising-falling, rising, flat, falling-rising, steeply rising-falling, rising-steeply falling. Figure 3 illustrates different types of melodic patterns.

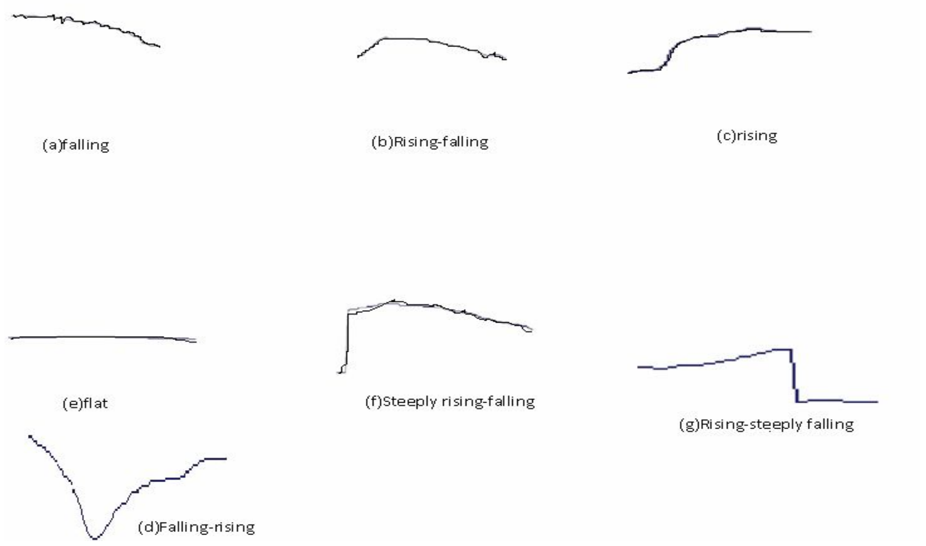

Figure 3: Illustration of different types of melodic patterns.

4. **Mean fundamental frequency (mF_0)**: Average fundamental frequency for all extracted pitch periods, represented in Hertz (Hz).

5. **Highest fundamental frequency (HF_0):** Highest fundamental frequency for all the extracted pitch periods, represented in Hertz (Hz).

6. **Lowest fundamental frequency (LF_0):** Lowest fundamental frequency for all the extracted pitch periods, represented in Hertz (Hz).

7. **Jitter %**: It provides an evaluation of the variability of the pitch period within the analyzed voice sample. It represents the relative period to period (very short term) variability.

8. **Shimmer %**: It provides an evaluation of the variability of the peak to peak amplitude within the analyzed voice sample. It represents the relative period to period (very short term) variability of the peak to peak amplitude.

9. **Noise to harmonics ratio**: It is the ratio between the noise in the glottal signal and the sound pressure level of the harmonics. This can be obtained by measuring the intensity of the harmonics and the noise.

Experiment II: Perceptual analyses

Material: The recorded cry samples of experiment I served as the material for experiment II also.

Procedure: A 5-second cry sample from one twin was paired with the other twin sample with a gap of 5 seconds and was saved on to the computer. Separate tokens were made for hunger and pain cry. These pairs of samples were presented to ten trained listeners and they were instructed to rate the samples as 'same' or 'different' based on perceptual measures of cry signal, such as rate, quality, pitch, melody and loudness.

Analyses: The responses of the listeners were tabulated and mean percent "same" was calculated for all the five pairs using the following formula- Total no. of same * 100/10. A cutoff score of 70% was taken as the significant difference for the mean percent same responses.

Results

Experiment I: Acoustic analyses

Duration of the vocalization: The results of the paired sampled t-test showed significant difference only in pair1 for both hunger and pain cry and in pair 5 and pair 4 for hunger and pain cry, respectively. Table 2 shows mean, SD, t value, degrees of freedom and significant difference (2 tailed) for duration of the vocalization in all twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	228.68	115.44	2.487	29	0.019
		T2	290.41	99.39			
	Pair 2	T1	178.26	85.53	1.118	19	0.278
		T2	148.71	102.39			
	Pair 3	T1	274.85	466.60	0.745	24	0.463
		T2	209.57	108.63			
	Pair 5	T1	332.11	979.47	3.297	19	0.04
		T2	161.64	835.85			
Pain cry	Pair 1	T1	444.57	193.28	2.360	29	0.025
		T2	306.84	242.39			
	Pair 2	T1	255.52	94.70	0.725	19	0.477
		T2	224.59	158.36			
	Pair 4	T1	202.80	220.01	2.379	19	0.028
		T2	87.99	57.86			
	Pair 5	T1	257.43	269.13	2.237	19	0.038
		T2	116.24	54.17			

Table 2: Mean, SD, t values, degrees of freedom (df) and significant difference values of duration of vocalization (ms) for all the twin pairs for hunger cry and pain cry.

2. **Second pause**: Paired sampled t-test showed significant difference only in pair1 and pair 5 for both hunger and pain cry and in pair 4 for pain cry. Table 3 shows mean, SD, t value, degrees of freedom and significant difference (2 tailed) for second pause in all the twin pairs.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	886.72	361.04	2.334	29	0.027
		T2	1105.64	453.92			
	Pair 2	T1	766.63	381.81	1.857	19	0.079
		T2	1089.71	693.85			
	Pair 3	T1	775.25	395.95	1.548	24	0.135
		T2	978.71	711.86			
	Pair 5	T1	1467.44	883.41	2.398	19	0.027
		T2	964.21	514.45			
Pain cry	Pair 1	T1	1276.78	358.84	3.409	29	0.02
		T2	901.76	415.22			
	Pair 2	T1	966.57	426.93	0.026	19	0.980
		T2	969.37	387.33			
	Pair 4	T1	1406.35	551.88	2.879	19	0.010
		T2	952.38	450.35			
	Pair 5	T1	1025.44	644.17	0.193	19	0.849
		T2	1065.04	806.51			

Table 3: Mean, SD, t values, degrees of freedom (df) and significant difference values of second pause (ms) for all the twin pairs in hunger cry and pain cry.

3. **Melody**: Chi square test showed significant agreement in pair 2 and pair 4 for both hunger cry and pain cry, and in pair 1 only for pain cry. Table 4 shows the percentage of agreement for different melodic patterns within the twin pairs for both hunger cry and pain cry.

Type of cry	Pair 1	Pair 2	Pair 3	Pair 4	Pair 5
Hunger cry	33.3	66.6	40.0	60.0	-
Pain cry	100.0	66.6	-	80.0	46.6

Table 4: Percentage of agreement for melodic patterns for hunger cry and pain cry.

4. **Mean fundamental frequency**: Paired sampled t-test showed significant difference ($p<0.05$) in pair 5 for both hunger cry and pain cry and in pair 4 for pain cry. Table 5 shows mean, SD, t value, degrees of freedom and significant difference (2-tailed) for mean fundamental frequency (Hz) in all the twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	394.24	59.98	1.512	9	0.165
		T2	426.39	53.15			
	Pair 2	T1	412.48	15.84	0.230	9	0.824
		T2	406.81	73.19			
	Pair 3	T1	421.74	70.47	1.146	9	0.281
		T2	395.81	75.45			
	Pair 5	T1	400.65	29.98	8.625	9	0.000
		T2	504.75	37.76			
Pain cry	Pair 1	T1	449.19	42.65	1.484	9	0.172
		T2	417.85	42.90			
	Pair 2	T1	414.05	31.22	0.786	9	0.452
		T2	422.49	20.15			
	Pair 4	T1	465.43	95.00	2.488	9	0.035
		T2	402.69	101.46			
	Pair 5	T1	430.65	37.05	5.312	9	0.000
		T2	490.72	60.18			

Table 5: Mean, SD, t values, degrees of freedom (df) and significant difference values of mean fundamental frequency (Hz) for all the twin pairs for hunger and pain cry.

5. **Highest fundamental frequency:** Paired sampled t-test showed significant difference ($p<0.05$) in pair 5 for both hunger cry and pain cry and in pair 2 and pair 1 for hunger and pain cry, respectively. Table 6 shows mean, SD, t value, degrees of freedom and significant difference (2-tailed) for highest fundamental frequency (Hz) in all the twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	614.88	27.65	0.832	9	0.427
		T2	599.36	52.95			
	Pair 2	T1	511.53	42.08	-3.273	9	0.010
		T2	580.04	48.48			
	Pair 3	T1	629.46	44.75	1.220	9	0.254
		T2	580.37	104.74			
	Pair 5	T1	549.73	68.14	-4.429	9	0.002
		T2	629.88	39.06			
Pain cry	Pair 1	T1	627.39	23.44	2.437	9	0.038
		T2	578.27	57.68			
	Pair 2	T1	512.94	50.31	-1.188	9	0.265
		T2	543.71	51.18			
	Pair 4	T1	602.67	94.77	0.823	9	0.432
		T2	557.49	120.56			
	Pair 5	T1	579.45	75.58	-2.492	9	0.034
		T2	638.74	16.36			

Table 6: Mean, SD, t values, degrees of freedom (df) and significant difference values of highest fundamental frequency (Hz) for all the twin pairs for hunger and pain cry.

6. **Lowest fundamental frequency:** The results of the paired sampled t-test showed significant difference ($p<0.05$) in pair 5 for hunger cry only. Table 7 shows mean, SD, t value, degrees of freedom and significant difference (2-tailed) for lowest fundamental frequency (Hz) in all the twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	4.16	1.36	2.352	9	0.043
		T2	2.88	1.36			
	Pair 2	T1	1.92	1.057	0.814	9	0.436
		T2	2.23	0.99			
	Pair 3	T1	4.10	1.54	1.026	9	0.332
		T2	3.46	2.17			
	Pair 5	T1	1.53	0.94	0.088	9	0.932
		T2	1.58	1.35			
Pain cry	Pair 1	T1	2.52	0.96	0.702	9	0.501
		T2	2.73	0.75			
	Pair 2	T1	3.09	2.10	0.220	9	0.831
		T2	2.87	1.53			
	Pair 4	T1	1.83	0.76	0.913	9	0.385
		T2	2.72	2.77			
	Pair 5	T1	2.04	0.70	1.343	9	0.212
		T2	1.78	0.55			
		T2	1.78	0.55			

Table 7: Mean, SD, t values, degrees of freedom (df) and significant difference values of lowest fundamental frequency (Hz) for all the twin pairs for hunger and pain cry.

7. **Jitter %:** The results of the paired sampled t-test showed significant difference ($p<0.05$) only in pair 1 for hunger cry. Table 8 shows mean, SD, t value, degrees of freedom and significant difference (2-tailed) for Jitter in all the twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	207.80	78.00	-0.991	9	0.348
		T2	247.16	109.31			
	Pair 2	T1	278.39	99.67	0.615	9	0.554
		T2	255.89	88.84			
	Pair 3	T1	253.39	100.35	0.521	9	0.615
		T2	232.04	109.37			
	Pair 5	T1	252.21	122.04	-2.377	9	0.041
		T2	368.03	66.24			
Pain cry	Pair 1	T1	228.28	83.58	0.231	9	0.822
		T2	216.92	85.87			
	Pair 2	T1	277.58	74.74	0.315	9	0.760
		T2	268.72	111.27			
	Pair 4	T1	320.14	104.28	1.771	9	0.110
		T2	255.59	113.79			
	Pair 5	T1	307.47	61.34	-1.649	9	0.134
		T2	348.64	89.03			

Table 8: Mean, SD, t values, degrees of freedom (df) and significant difference values of jitter % for all the twin pairs for hunger and pain cry.

8. **Shimmer %**: Paired sampled t-test showed significant difference ($p<0.05$) only in pair 1 and pair 2 for hunger cry and in pair 5 for pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	15.36	3.42	2.753	9	0.022
		T2	11.60	2.85			
	Pair 2	T1	5.70	3.95	3.004	9	0.015
		T2	9.94	5.92			
	Pair 3	T1	13.72	3.49	1.348	9	0.211
		T2	11.49	4.82			
	Pair 5	T1	7.96	2.27	2.123	9	0.063
		T2	4.97	3.37			
Pain cry	Pair 1	T1	10.29	4.10	1.124	9	0.290
		T2	11.88	2.17			
	Pair 2	T1	6.47	4.31	0.240	9	0.815
		T2	6.04	2.93			
	Pair 4	T1	7.89	2.85	1.176	9	0.270
		T2	9.60	3.37			
	Pair 5	T1	9.18	4.24	2.598	9	0.029
		T2	6.75	3.67			

Table 9: Shows mean, SD, t value, degrees of freedom and significant difference (2-tailed) for all the twin pairs for both hunger and pain cry.

9. **Noise to harmonics ratio**: Paired sampled t-test showed significant difference ($p<0.05$) in all the twin pairs for hunger cry. Table 10 shows mean, SD, t value, degrees of freedom and significant difference (2 tailed) for noise to harmonics ratio in the entire twin pairs for both hunger and pain cry.

	Pairs		Mean	SD	t	df	Sig
Hunger cry	Pair 1	T1	0.56	0.16	2.773	9	0.022
		T2	0.36	0.15			
	Pair 2	T1	0.15	0.04	3.226	9	0.010
		T2	0.30	0.15			
	Pair 3	T1	0.51	0.13	2.252	9	0.050
		T2	0.36	0.20			
	Pair 5	T1	0.27	0.06	3.210	9	0.011
		T2	0.20	0.69			
Pain cry	Pair 1	T1	0.32	0.15	1.004	9	0.342
		T2	0.38	0.13			
	Pair 2	T1	0.23	0.19	0.606	9	0.559
		T2	0.18	0.08			
	Pair 4	T1	0.30	0.18	1.775	9	0.110
		T2	0.43	0.21			
	Pair 5	T1	0.32	0.14	0.958	9	0.363
		T2	0.28	0.10			

Table 10: Mean, SD, t values, degrees of freedom (df) and significant difference values of noise to harmonics ratio (NHR) for all the twin pairs for hunger and pain cry

Experiment II

Perceptual analysis: For hunger cry, all the twin pair samples were judged similar on pitch, melody and loudness. But on rate only two cry pairs and on quality, three pairs were judged to be the same. For pain cry, cries in all the twin pairs were judged similar on pitch, quality and loudness. However, two pairs on rate and no pairs on melody were judged similar. Table 11 shows the Percentage "same" response for the all the twin pairs as rated by listeners for different perceptual categories.

Type of cry	Pairs	Rate	Pitch	Quality	Melody	loudness
Hunger cry	Pair 1	63	86	56	90	76
	Pair2	66	83	83	86	100
	Pair 3	83	90	90	90	90
	Pair4	80	93	93	90	100
Pain cry	Pair 1	66	100	93	66	83
	Pair 2	56	86	90	56	100
	Pair 3	90	90	96	56	93
	Pair 5	90	80	100	56	93

Table 11: Mean percent "same" for all the twin pairs for different perceptual categories in both hunger and pain cry.

Discussion and Conclusion

The results of the present study showed several points of interest. Duration of vocalization, second pause, melody type, the mean fundamental frequency, highest and lowest fundamental frequency, jitter, shimmer and NHR showed significant similarities within twins. This result in general supports the previous findings that there is lot of resemblance in voice of the monozygotic twins (Shew & Simon, 2004; Santosh & Savithri, 2004). The results of the present study also shows that there is similarities within the twins in timing characteristics (duration of vocalization, second pause), acoustic parameters ($mF_{0,}$ Jitt, Shim, NHR) as well as intonation (melody type) of the cry. Perceptually, except melody pattern of the cry, all the samples were rated as significantly similar within twins. The findings of the present study in general supports the previous findings that there is lot of resemblance in voice of the monozygotic twins (Ryells, Shew & Simon, 2004; Santosh & Savithri, 2004). However, variability existed with respect to twin pairs and type of cry signal. So, it is clear that individual voice is determined by much more than genetic constitution alone. However, the results of the present study are preliminary and involved only five pairs of MZ twins, which warrant a more detailed examination of characteristics of the voice characteristics in larger number of twins.

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