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GROUP AND INDIVIDUAL DISCRIMINABILITY IN MONOZYGOTIC TWINS' INFANT CRY: A PILOT STUDY

SKUPINSKO IN INDIVIDUALNO RAZLIKOVANJE JOKA ENOJAJČNIH DVOJČKOV: PILOTNA RAZISKAVA

DANIELA LENTI BOERO & FRANCESCA ROCCA

ABSTRACT

Group and individual discriminability in monozygotic twins' infant cry: A pilot study

The aim of this study was to investigate the acoustic structure of groups of monozygotic twins, recorded both at term and at earlier developmental ages. Cries from three groups of monozygotic twins affected by severe prematurity, and two groups of monozygotic twins affected by moderate prematurity for a total of 13 infants were recorded. Results show that wails sampled from cries uttered by groups of monozygotic twins were ascribed to the correct group, both at early developmental age, and at term, and also that wails of single individual twins were ascribed to the proper individual within its group. Present results suggest that the fixed components of cry structure are most important in shaping the acoustic characteristics of the cry, but also that intrauterine experience might influence the temperamental characteristics of monozygotic twins.

Key words: Infant cry, twinship, prematurity, sonospectrographic analysis.

IZVLEČEK

Skupinsko in individualno razlikovanje joka enojajčnih dvojčkov: pilotna raziskava

Namen te raziskave je ugotoviti zvočno strukturo joka skupin enojajčnih dvojčkov, posnetega ob rojstvu in med zgodnjim razvojem. Avtorici sta posneli jok treh skupin enojajčnih dvojčkov, resno prizadetih zaradi zgodnjega poroda in dve skupini, zmerno prizadetih zaradi zgodnjega poroda, skupaj 13 otrok. Rezultati kažejo, da je mogoče vzorce joka po zvočnih parametrih posnetega v družbi bratca oz. sestrice pripisati pravilni skupini tako med zgodnjim razvojem kot tudi ob porodu, mogoče je tudi prepoznati jok posameznega dojenčka v okviru skupine. Očitno so stalne komponente zvočne strukture najpomembnejše za oblikovanje zvočnih značilnosti joka, morda pa na značajske značilnosti dvojčkov vplivajo tudi prenatalne izkušnje v maternici.

Ključne besede: dojenčkov jok, dvojčki, predčasni porodi, sono(spektro)grafska analiza.

Addresses – Naslovi

Daniela Lenti Boero
Corso di laurea in Scienze Psicologiche e delle Relazioni di Aiuto
<http://www.disat.unimib.it/bioacoustics>
Università della Valle d'Aosta – Université de la Vallé d'Aoste
Chemin des Capucins 2A
11010 Aosta
Italy
E-mail: d.lentiboero@univda.it

Francesca Rocca
Clinica Pediatrica
Dipartimento di Medicina
Chirurgia e Odontoiatria
Facoltà di Medicina e Chirurgia
Università degli Studi di Milano
Via di Rudinì 80
Italy

INTRODUCTION

Behavioural genetics lies at the intersection of genetics and psychology, and monozygotic twins are considered a natural laboratory for behavioural studies aimed at understanding human behaviour (SEGAL 1999). Infant crying was proved to provide acoustic information about individual identity, infant development, and disorders of CNS, including prematurity (VALANNE et al. 1967, CISMARESCO & MONTAGNER 1990, MENDE et al. 1990, LENTI BOERO 1995, LENTI BOERO et al. 1993, LENTI BOERO et al. 1998, 2000, LENTI BOERO et al. 2002, WERMKE et al. 1996, 2002). However, this aspect was never investigated in twins, although they could be interesting model for group and individual acoustic differences. In addition, twins, and especially monozygotic twins frequently are born preterm, thus allowing investigation about ontogeny of individual difference, since cries might be recorded at least since the 28^{th} week of conceptional age (LENTI BOERO et al. 1993). The aim of the present study is to investigate cry in monozygotic preterm twins.

METHODS

A total of 13 preterm infants of both sex entered this study. They were subdivided in three groups of monozygotic twins (n=9, (7 males), mean +- SD infant per group = 3 +-1) affected by severe prematurity (29 and 32 weeks of conceptional age, Apgar score between 7 and 10 at 1min and between 8 and 10 at 5min; mean weight at birth: gr 1554 +- 223), and two groups of monozygotic twins (n=4 (2 males), mean +- SD of infant per group = 2 +-0) affected by moderate prematurity (34 and 35 weeks of conceptional age, Apgar score between 7 and 10 at 1min and between 8 and 10 at 5min; mean weight at birth: gr 1943 +- 195). All twins had normal neurological function for their age, and were not affected by any pathology possibly related with prematurity. For both groups of severe and moderate preterm, cries were recorded on Sony digital audio tape DT-90 by means of DAT sound recorder TASCAM DA-P1 and of a SHURE-BG 4.0 unidirectional microphone positioned about 5 cm from the mouth of the crying babies. Recording contexts were blood withdrawal for routine screening (at 33 weeks for severe preterm and at 35 weeks for moderate preterm) and manipulation stimuli of routine neurological examination for paediatric controls at term (40 weeks of conceptional age) (DUBOWITZ 1999). For obvious ethical reasons it was not possible to perform neurological examinations on preterm infants with infusion needles, and to perform unnecessary blood withdrawal when twins came for medical controls, however, although eliciting stimuli were different at two life's phases, they were identical for all infants in each phase.

A total of 230 cries were digitized by means of an Audiomedia II card and the software Sound Designer II (Digidesign Inc.), sampling rate = 44.100 Hz, sample size = 16 bits (= 2^{16} value resolution). In order to have a homogeneous sample along the time axis I subdivided each cry in subsamples of four to six wails each; the first subsample was collected at the beginning of the cry, the last subsample at the end of the cry, and the others along the time axis at homogeneous intervals, calculated dividing the time left.

Spectrograms were produced by means of the software Canary 1.2 (Chariff et al. 1995) mounted on Powermac 7600 with 45 Megabytes of RAM and a high resolution screen (Trinitron Applevision, 17 inchs), the following parameters were applied: FFT (Fast Fourier Trasform) size: 8192 points, frame length: 2048 points, filterbandwith: 85.49 Hz, window function: Hanning, clipping level: - 100, amplitude: logarithmic, overlap: 93.75, the grid resolution for displaying spectrograms was set at 2.902 ms and 5.383 Hz.

There is a lot of confusion concerning the nomenclature of human cry, in the present study cry is defined as a long signal composed by multiple wails (i.e. cry units). Those units are defined as voiced, when the fundamental frequency is evident, the first harmonic well traced, and the corresponding waveform is uninterrupted, voiceless, when the fundamental frequency and first harmonic are blurred, but the corresponding waveform is evident, and partially voiced, when some fragments of the fundamental frequency and first harmonic above it are evident and well traced (as in voiced wails) and some part are blurred (as in voiceless wails), and the waveform is evident (Lenti Boero et al.1998, 2001). In order to provide independent agreement on voicing characteristics of each wail, spectrograms were printed by means of a high resolution Laser printer and two independent observers judged the voicing characteristics separately, concordance was achieved for 94% wails, allowing 216 wails for analysis.

The following quantitative parameters were measured twice by means of a cursor manually positioned on the selected point in the spectrogram by each of two independent observers: 1) length of wails (from start to end of each wail), 2) interval to next wail (from end of a wail to start of the next, this interval could include cough, or sobs, that were discarded, on the base of acoustic perception of sounds by two concordant observers, non concordant intervals were discarded), 3) time for reaching maximum frequency, parameter 1 and 2 were measured on all wails, regardless on voicing, while parameter 3 was measured only on voiced wails); 4) starting, end, maximum and minimum frequency (fundamental frequency parameters (in Hz)), were measured on voiced wails and gave four data points for each parameter for each wail, data points were averaged before entering statistical tables. Dynamic gamma (defined as the difference from maximum to minimum frequency in each wail) was derived from the difference between the averages of maximum and minimum frequency. Peak frequency (the frequency with the highest acoustic energy) was measured automatically by Canary after manual selection of the appropriate waveform portion.

Discriminant functions on weighted data were calculated with the advanced subprogram provided by SPSS. All quantitative parameters were entered with the stepwise method employing Mahalanobis distances. Criterium for the function was F=3.84 and F=2.71, respectively for entering and removing. In comparing proportion of correct attribution of wails to groups or individual twins GLIM3 was employed (Aitkin et al. 1989).

RESULTS

Groups of twins at term did not differ in weight. At birth, the two groups of severe preterm aged 32 weeks were significantly different in weight from the group aged 29 weeks (SPSS, univariate anova: $F=4.71$; $DF=2,6$; $P=0.059$) but were not significantly different between them (SPSS, univariate anova: $F=0.03$; DF 1,5; $P=0.869$). However, weight was not significantly different at the time of recording (33 weeks for all groups).

Group discrimination. A first attempt was to verify if twins in this sample could be discriminated as groups, and at which developmental age. Results are given in tab. 1. At term 74% of wails of both groups of severe and moderate preterm were correctly discriminated, this proportion is highly significant (GLIM, $\chi^2=70.54$, df=1, $P<0.0001$), also the proportion of severe and moderate preterm groups successfully discriminated at term (four over five) was significant (GLIM, $\chi^2=3.855$, df=1, $P< 0.05$).

Sixty-five percent of the wails of severe preterm recorded at 33 weeks of conceptional age were correctly discriminated, this proportion is significant (GLIM, $\chi^2=14.62$, df=1, $P<0.0005$). Difference in weight at birth did not influence the proportion of wails correctly discriminated (GLIM, $\chi^2=0.09$, df =1, ns).

However, the proportion of groups of severe preterm successfully discriminated in the early phase (two over three), was not statistically significant (GLIM, $\chi^2=0.679$, df=1, $P>0.1$), possibly due to the small sample size. Unfortunately, not enough wails were available for discrimination at earlier age for moderate preterm groups.

Individual discrimination of single twins within groups. Could single twins be discriminated within their groups? Results are given in tab. 2. Wails uttered by severe premature twins were successfully discriminated within their groups both when recorded at term (66%) and when recorded in earlier period (64%), (GLIM, $\chi^2=20.61$, df=1, $P<0.0001$, and $\chi^2=11.59$, df=1, $P<0.001$, respectively for term and the earlier period). Wails uttered by individual moderate premature infants recorded at term were successfully discriminated in 83% of the cases (GLIM, $\chi^2=11.64$, df=1, $P<0.001$).

Nine over eleven (81%) infants belonging to severe and moderate group were correctly discriminated at term (GLIM, $\chi^2=9.639$, df=1, $P<0.005$), but the proportion of severe premature infants recorded in earlier phase of life that could be successfully discriminated (four over six) was not significant (GLIM, $\chi^2=0.679$, df=1, $P>0.1$), probably due to small sample size. Unfortunately, not enough wails were available for discrimination at earlier age of moderate preterm groups.

DISCUSSION

As in other studies on twin infants cry (Wermke et al. 2002) the focus on fundamental frequency is mainly justified by the dominance of laryngeal processes in early sound production. Discriminant function analysis is an objective statistical device for taking groups apart. In the first part of this pilot study wails sampled from cries uttered by groups of monozygotic twins were ascribed to the correct group, both at early developmental age, and at term. In the second part, wails of single individual twins were ascribed to the proper individual within its group.

The sound structure of the human infant cry is related to the shape and dimension of the phonatory apparatus (a fixed component related to the anatomy and body size of the infant, (TITZE 1994)), and to temperamental individual characteristics in response to stressful stimuli (a variable component due to the fact that muscles of the human larynx allow slight dimensional changes of vocal fold length (LENTI BOERO et al. 1998)). Present results for group discrimination suggest that the fixed components of cry structure are the most important in shaping the acoustic characteristics of the cry, and are shared by monozygotic infants since early developmental ages. The fact that single twins can be individually discriminated within their groups, however, suggests that intrauterine experience might influence the temperamental characteristics of monozygotic twins (SEGAL 1999). In conclusion, we believe that cry investigation in monozygotic twins is of interest in taking apart fixed and variable components of acoustics structure of the infant cry, in addition, the investigation of the same subjects at different developmental ages, is useful for monitoring possible relative changes between fixed and variable components.

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Tabel 1: Number of twins in each group are indicated in parentheses. As can be seen, variables in discriminant functions are different for all groups. Percentage of wails successfully discriminated are shown in parentheses.

	Twin group (n. of twins)				Number of wails	Variables in the discriminant function
		And.	Bo.	Leo.		
Discrimination at term of three severe premature groups 71.58% cries correctly classified	And. (4)	45 (91.8%)	4 (8.2%)	0 (0%)	49	Max. freq. on F°
	Bo. (3)	6 (20.7%)	23 (79.3%)	0 (0%)	29	
	Leo. (2)	10 (58.8%)	7 (41.2%)	0 (0%)	17	
Discrimination at 33 weeks of three severe premature groups 65.0% cries	And. (4)	14 (56.0%)	5 (20.0%)	6 (24.0%)	25	Peak freq. (all cry) Dynamic gamma End freq. on F° correctly classified Time for max. freq.
	Bo. (3)	3 (9.7%)	23 (74.2%)	5 (16.1%)	31	
	Leo. (2)	4 (16.7%)	5 (20.8%)	15 (62.5%)	24	
		Dim.	Mag.			
Discrimination at term of two groups of moderate premature 78.8% cries correctly classified	Dim. (2)	11 (64.7%)	6 (35.3%)		17	Lenght of all wails
	Mag. (2)	5 (14.3%)	30 (85.7%)		35	

Tabel 2: Sex of twins in each group is indicated in parentheses. As in tab. 1, discriminant functions are different for all groups. Percentage of wails successfully discriminated are shown in parentheses.

	Individual twins (sex)					**Number of wails**	**Variables in the discriminant function**
		And.e (M)	**And.m (M)**	**And.s (F)**	**And.v (F)**		
Discrimination at term of individual twins of And. (severe premature) group 61.22% correctly classified	And.e (M)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2	End freq. on F° Starting freq. on F° Time for max. freq.
	And.m (M)	0 (0%)	10 (83.3%)	0 (0%)	2 (16.7%)	12	
	And.s (F)	0 (0%)	0 (0%)	3 (18.8%)	13 (81.3%)	16	
	And.v (F)	0 (0%)	1 (5.3%)	3 (15.8%)	15 (78.9%)	19	
Discrimination at 33 weeks of individual twins of And. (severe premature) group 66.7% correctly classified	And.m (M)		15 (100%)	0 (0%)	0 (0%)	15	Peak freq. (all cry)
	And.s (F)		5 (50%)	1 (10%)	4 (40%)	10	
	And.v (F)		4 (28.4%)	0 (0%)	10 (71.4%)	14	
		Bo.e (M)	**Bo.a (M)**	**Bo.c (M)**			
Discrimination at term of individual twins of Bo. (severe premature) group 75.86% correctly classified	Bo.e (M)	7 (87.5%)	0 (0%)	1 (12.5%)		8	Lenght of all wails Peak freq. (all cry) Min. freq. on F°
	Bo.a (M)	1 (9.1%)	9 (81.8%)	1 (9.1%)		11	
	Bo.c (M)	2 (20.0%)	2 (20.0%)	6 (60.0%)		10	
Discrimination at 33 weeks of individual twins of Bo. (severe premature) group 61.29% correctly classified	Bo.e (M)	12 (85.7%)	0 (0%)	2 (14.3%)		14	Lenght of wails Dynamic gamma
	Bo.a (M)	3 (42.9%)	0 (0%)	4 (57.1%)		7	
	Bo.c (M)	1 (10.0%)	2 (20.0%)	7 (70.0%)		10	
		Leo.e (M)	**Leo.l (M)**				
Discrimination at term of individual twins of Leo. (severe premature) group correctly classified	Leo.e (M)	7 (77.8%)	2 (22.2%)			9	End freq. on F°
	Leo.l (M)	4 (50.0%)	4 (50.0%)			8	
Discrimination at 33 weeks of individual twins of Leo. (severe premature) group none correctly classified	Leo.e (M)					2	No variable qualified for the analysis
	Leo.l (M)					22	
Discrimination at term of individual twins of Dim. (moderate premature) group none correctly classified	Dim.a					6	No variable qualified for the analysis
	Dim.f					9	
		Mag.g	Mag.s				
Discrimination at term of individual twins of Mag. (moderate premature) group 83.33% correctly classified	Mag.g	3 (75.0%)	1 (25.0%)			4	Starting freq. on F°
	Mag.s	1 (12.5%)	7 (87.5%)			8	
						216	