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Infant Crying Acoustic Characteristics Evoking Unpleasant Emotions in Mothers

This study examines the infant crying acoustic characteristics likely to arouse negative emotions and distress in mothers. We used samples of infant crying from three situations (hunger, pain, and the mother's absence) in six healthy infants over six months. We played the recordings of infants crying to 90 mothers in the care of infants and had them self-evaluate emotions and feelings. In addition, the sounds were analyzed acoustically through a CSL4400 to analyze frequency, energy, total expiratory time, and the number of the expirations. In this study, cries due to pain and the absence of the mother caused more unpleasant emotions and irritation in comparison to the infant sounds of hunger. In particular, crying from the absence of the mother caused the most distress. An analysis of these sounds showed that crying in the situations of pain and the absence of the mother were strong in frequency, high energy, and prolonged. These results suggest a relation between infant crying acoustical characteristics and the feelings of distress by the mother.

We all have personal notions about the meanings of various cries at different age levels. The cries of young infants are an especially compelling stimulus and there is an urgency associated with an infant cry that makes our response obligatory (Ostwald, 1963). Crying by neonates and infants are the primary mode of expressing and communicating basic needs and events (Lester, 1985; Murry, 1979). It is a social behavior that has a powerful effect on the parent-infant relationship and often elicits strong emotions in parents (Lester, 1985; Murry, 1979). Ostwald stated that the cries of infants can evoke strong feelings of concern and protectiveness; however, they can also evoke hostility (Ostwald, 1963; Kim & Miyamoto, 2009). Infant crying may cause aggression as well as a desire to nurture.

When a mother is faced with persistent crying, she experiences emotional unrest in the form of strong feelings of anxiety, frustration/irritation and shaken confidence in her abilities as a mother (Okamoto, 2006). According to a report from the Ministry of Health, Labor and Welfare in Japan 2008, 44% of the deaths caused by child abuse in Japan involved infants under the age of one. In 29% of the abuse cases, the main factor that triggered the parents' violent actions was the incessant crying of the child (Ministry of Health, Labor and Welfare in Japan, 2008). In addition, in the study on the factors of parenting stresses of mothers who have an infant, the psychological stress on mothers became too much if they suffered from babies' crying plus a lack of sleep; subsequently, Hotta and Yamaguchi (2005) argue the necessity of foster aid for mothers.

Researchers have examined the factors that influence adult responses to infant crying. Many approaches that focus on the acoustic characteristics of cries have shown that the variations in the fundamental frequencies of the cries might be an important source of information concerning the perception of the cries. High pitch cries usually tend

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to evoke aversive, annoying, and urgent feelings that tend to be more informative compared to cries with lower basic pitches (e.g., Adachi *et al*., 1985; LaGasse, Neal & Lester, 2005; Zeskind, 1983; Zeskind & Lester, 1978; Zeskind & Shingler, 1991; Zeifman, 2001; Wasz-Hockert *et al*., 1968). However, not all studies have concluded that the frequency is the most important acoustic variable to initiate parental responses. The duration of cries (the length of expiration) and the duration of pauses between cries are among the acoustic variables shown to influence the perception and reaction to cries (Cuisinier *et al*., 1998; Wood & Gustafson, 2001; Zeskind *et al*., 1992). Gustafson and Green (1989) found increased duration, amount of dysphonation and energy in low and high frequencies were related to aversive adult ratings and not fundamental frequency (Porter *et al*., 1986; Gustafson, Green, & Tomic, 1984).

Researchers examined cry types with different acoustic features that reflected the changing states of the infants. (Fuller & Horii, 1988; Porter *et al*., 1986). Fuller and Horii, (1988) found that the Fo and the energy distribution (tenseness) of cries differ between situations. In addition, infant cries change with age, partly due to the maturation of the larynx, its neural control systems, and partly to the increasing psychological sophistication of the infant (Lester & Boukydis, 1992; Zeifman, 2001; Zeskind & Lester, 2001). For example, developmental changes in the musculature of the ribcage lead to a reduction in the respiratory rate during crying (LaGasse, Neal & Lester, 2005) and the increased tension of the laryngeal muscles stiffens the vocal folds thus resulting in more energy in higher frequencies and higher Fo (Protopapas & Eimas, 1997). Leger *et al* (1996) found that the cries of 6-month-olds were rated as significantly more emotionally intense than the cries of 1-month-olds when heard by parents and adults. Recent research suggests that the cry is better characterized as a graded acoustic signal that changes as a function of the level of infant distress (Boero *et al*., 1998; Gustafson & Harris, 1990; Murry, 1979).

Of importance is that some acoustic characteristics of infant cries have evoked the negative emotion of caregivers. We believe that the negative emotions of caregivers are a key factor leading to infant abuse. This study will deal with how a mother perceives the crying of a baby and the acoustic characteristics of infant crying causing a mothers unpleasant emotions.

METHOD

Participants

The survey targeted 92 mothers who participated in the Childrearing Aid Program at the Childrearing Support Center in Tsukuba, Japan and gave their consented to this study. The ages of the participants ranged from 19 to 44 (19 yrs: 2.2%, 20-29 yrs: 30%, 30-39 yrs: 63.3%, and 40-44 yrs: 4.4%). A total of 36 mothers (39% of the subjects) have one child, 51 mothers (56%) have two children, and five mothers (5%) have three children. Their children's age group is as follows: 35 children under 12 months (39%); 50 children from 12 months to 18 months (56%); and 5 children over 18 months (5.6%). For this study (in the case of a mother with two children) the second child became the standard for sex and age. All the subjects were dysphonation Japanese and full-time housewives. Data from 2 additional participants were eliminated due to an error in data collection. This study was conducted in the quite room of the Childrearing Support Center in January 2008.

Cry Stimuli

The setting conditions for crying referred to advanced research (Arakawa *et al*., 2000) and was established based on the opinions of the children's mother. The status of the voice record is shown in Table 1. Prior to obtaining cry samples permission was obtained from the mothers and from the family pediatrician in regards to pain stimulation. Cries of three girls and three boys were sampled in three types of situations: hunger, pain, and the mother's absence. The infants were all six months old and full-term, normal, and healthy. The reason for the 6 months of age period is based on the theories of Piaget (1968) and Bowlby (1977) that refer to Piaget's process of thinking and Bowlby's social behavior development.

All sampling cries were recorded with a Sony ICD-MX5 with a microphone positioned about 15 cm from the infant's mouth and the recording time

was 20 seconds. This record method referred to the advanced research (Adachi *et al*., 1985; Arakawa, 2000). Hunger cries were sampled before scheduled infant feeding times and pain stimulation cries were recorded during vaccinations. Cries due to the mother's absence were sampled when mothers were temporarily separated. Cries from hunger and the mother's absence were recorded in the babies' homes. The 15-second recordings of these samples were later converted into samples with a frequency of 44.1kH-16bits for CD-R. A total of 18 cry stimuli were obtained from these procedures.

Procedure

Cry stimuli were played back with the Sanyo PH-PR81 recorder. Subjects were seated 1 m from the speakers and requested to answer questions about their own emotional state when they listened to the cry stimuli. Answers were on a five-point Likert scale. A cry considered "pleasant" was 0 points, "slightly pleasant" 1 point, "neither pleasant nor unpleasant" was 2 points, "slightly unpleasant" was 3 points, and "unpleasant" was 4 points. All subjects were given no information about the causes for the crying or about the infants.

Acoustic Analyses

Acoustical elements are selected based on advanced research (LaGasse, Neal & Lester, 2005) (see Table 2). The acoustical characteristics of cry stimuli were analyzed through a CSL4400 (KayPENTAX Computerized speech Lab, Model 4400). The acoustical elements analyzed were fundamental frequency, maximum frequency, average energy, maximum energy, total expiratory time, and the number of the expirations. The fundamental frequency and the maximum frequency were measured within the range of 200Hz to 700Hz and the average energy and the maximum energy were measured within the range of 30dB to 90dB. The number of the expirations is the number of vocalizations during crying and the total expiratory time of the cry was measured as the duration of the expiratory phase of the cry. Recorded samples were edited to remove unnecessary breathing noises or pauses (based on 25 msec of signal) (see Table 2).

RESULTS

Ratings

Average evaluations ranged from 1.6 to 3.0 points (rounded up to two decimal points). Cries evaluated higher than the mean score of 2.24 were included in the "severely unpleasant group." Eight cry samples were grouped in the "severely unpleasant" Group A: one was from hunger, three resulted from pain (from vaccination), and four from the mother's absence (see Table 3).

Acoustic Characteristics

The acoustical analysis compared data in two groups: Group A "unpleasant" and Group B "not unpleasant."

Frequency

The basic frequency of Group A ranged from 367 to 490Hz, and a cluster (seven in eight cries) were of about 400Hz; the average group frequency was 406 Hz (SD=38.67). Seven cries from Group B had a basic frequency of about 350Hz, one was from 400

Table 1. *Voice Stimulating Situations and Its Conditions*

Situation		Condition
Pain Crying	When an Infant Feels Pain.	Sound after an Infant Vaccination That Is Recognized as a Crying Sound by Mothers and Observers
Hunger Crying	When an Infant Feels Hungry.	After 3 To 3.5 Hours of Having Breast Milk or Formula. The Crying Stopped as Soon as Breast Milk or Formula was Provided. After Crying, Infants Had The Same Usual Amount of Breast Milk or Formula. It is the Crying Sound Recognized by Mothers and Observers.
Mothers Absence Crying	When Infants Realize the Absence of The Mother.	When a Mother's Voice Can be Heard but not Seen. Infants Stop Crying as Soon as Their Mothers Came Back. It is the Crying Sound Recognized by Mothers and Observers.

Table 2. *Acoustic Measurement of Crying Sound*

Sound used in the Analysis	
Fundamental Frequency (Hz)	Average Record in the Basic Frequency with Vocalization Per 15 Sec
Maximum Frequency (Max Hz)	Highest Record in The Frequency
Average Energy (dB)	Average in Basic Acoustic Pressure With 15 Sec
Maximum Energy (Max dB)	Highest Record of Acoustic Pressure
Number of Expirations	Numbers of Severed Phrase Like Vowels and Consonants
Total Expiratory Time	Overall Time of Vocalization from the Start to the end of a Voiced Sound

Table 3. *Mother's Discomfort Rating*

N=90			M (SD)=2.24(.65)		
Crying					
h-1	1.56(.72)	p-1	2.12(.56)	M/a-1	2.20(.56)
h-2	2.11(.64)	p-2	2.07(.57)	M/a-2	2.38(.63)
h-3	1.77(.69)	p-3	3.00(.83)	M/a-3	2.35(.62)
h-4	2.36(.77)	p-4	2.10(.85)	M/a-4	2.33(.60)
h-5	2.00(.64)	p-5	2.90(.75)	M/a-5	2.30(.71)
h-6	2.02(.58)	p-6	2.59(.73)	M/a-6	2.13(.69)

h: hunger crying p: pain crying m/a: mothers absence crying ( ): standard deviation

to 450Hz, and two samples reached 450Hz or more. The average of this group was 391.4Hz (SD=54.80). There was no significant difference in the fundamental frequency between the two groups. ($t(16)=-.53$, $p<.60$. NS). However, the maximum frequency of Group A was significant higher than Group B ($t(16)=-2.72$ $p<.015$). The maximum of frequency of Group A ranged from 474 to 604Hz and the average group frequency was 555Hz (SD=53.9); Group B ranged from 428 to 551Hz and the average of this group was 494Hz (SD=41.8).

Energy

There were no significant differences in the average energy ($t(16)=-2.06$, $p<.064$) and maximum energy ($t(16)=-2.05$, $p<.057$) between the two groups. The average energy of Group A was 73dB (SD=2.3) and of Group B was 70dB(SD=4.10). The maximum energy of Group A was 83(SD=2.5) and of Group B was 80(SD=2.6).

Number of the Expirations

The number of expirations in Group A ranged with a frequency value of expirations 7 per 15 seconds, and Group B was with a frequency value of 6 per 15 seconds. The difference between Groups was analyzed with Wilcoxon signed-rank test. Therefore, a significant difference was not obtained between the two groups. (w=78.00 N.S) (see Table 4)

Total Expiration Time(s)

When total expiration times of each group were compared, Group A's average expiration time was 10039 ms (SD=.90), and five of eight cries from Group A had a total expiration time of 10 seconds or more. For Group B, the average was 8150 ms (SD=1.43). Therefore, the cries of Group A were significantly longer than Group B ($t(16)=-3.23$, $p<.005$) (see Table 4).

Comparing the Elements Within the Unpleasant Group

We evaluated the unpleasantness of the cries caused to mothers. Of the total 18 cries analyzed, we included the cries reaching a point higher than the average evaluation point in the "severely unpleasant group" (Group A); however, there were three cries with a higher average evaluation point from the other five and the sound features of these two subgroups were compared. Three cries showed high points (average points: 2.8) and were classified as Group AH and the other five cries were grouped in

Table 4. *Number of Expirations and Total Expiratory Times of the Two Groups*

Acoustic Variable					
Group A (crying)	Number of Expirations (N)	Total Expiratory Time (ms)	Group B (Crying)	Number of Expirations (N)	Total Expiratory Time (ms)
1	6	8314	1	6	7914
2	7	10185	2	6	10002
3	9	10112	3	7	7589
4	7	11242	4	5	8208
5	5	9800	5	5	6881
6	7	10217	6	6	10163
7	6	9490	7	5	7803
8	6	10956	8	5	5546
			9	7	7883
			10	6	10511

Table 5. *Acoustic Variable of the Group AH and Group AL*

	Acoustic Variable					
	F0 (Hz)	Maximum (Hz)	Average Energy (dB)	Maximum Energy (dB)	N / Expirations (N)	T / Expiratory Time (ms)
Group AH						
1	387(79.2)	595(89)	71(6.1)	84(6.1)	7	10185
2	367(56.8)	604(74)	75(5.7)	84(6.1)	9	10112
3	387(48.6)	595(109)	73(7.1)	86(7.1)	7	11242
Group AL						
1	428(52.8)	551(64)	73(6.7)	83(6.7)	6	8314
2	406(67.0)	474(65)	74(4.6)	79(4.7)	5	9800
3	381(33.7)	474(73)	69(4.9)	79(5.0)	7	10217
4	403(88.8)	551(60)	73(5.1)	81(5.2)	6	9490
5	490(76.1)	595(52)	76(3.2)	85(3.2)	6	10956

( ) standard Deviation

group AL (average points: 2.3). As a result, a significant result was not obtained through all the sound features (fundamental frequency (t(6)=-1.28 N.S), higher maximum frequency (t(6)=2.16, p<.10), average energy (t(6)=1.88 N.S), maximum energy (t(6)=1.88 N.S), total expiratory time (t(6)=-.25 N.S). However, there was a significant difference in the deviation values of frequencies (t(6)=3.289 p<.05) and number of expirations (W=16.00 .05) between Group AH and AL. (See Table 5).

DISCUSSION

Rating of Cries

A mother is in contact with various baby sounds through daily childcare that result in a theory that mothers make judgments and act appropriately depending on infant's sounds. Therefore, for the mother, crying is stimulation for childcare and an infant's cries might be sometimes considered as unpleasant by mothers. Concerning what kinds of cries evoke negative feeling, in this study eight cries received high unpleasant scores from the mothers: hunger = 1; pain = 3; and mother's absence = 4. Subjects were given no information about the sound and the samples were played at random. The three sounds of crying under the pain stimulation received the most unpleasant appraisal among the sounds of crying. It is also argued in the advanced study (Protopapas & Eimas, 1997; Zeskind & Marshall, 1988) that the crying sound under the pain situation causes tension and displeasure that result in attention. It might seem that this study is also the result of supporting an advanced study; however, four crying sounds under the absence of mothers received higher records than the total unpleasant average. These results were consistent with the study of Kim and Miyamoto (2009) that argue the relatedness between crying sounds due to the absence of mothers and the unpleasant emotions of mothers.

Bowbly (1977) points out that the first 6 months of life is a critical period for infant attachment development. Infants under 6 months age begin an emotional exchange with a select group of intimate people and show social behaviors near certain people as part of their attachment behavior. These results are of interest because the subjects for the crying sound analysis were 6-month-old infants.

Crying is an innate behavior for infant childcare and social development. As infant situations become unpleasant, infants express their feelings with sound to attract attention and to eliminate displeasure. The absence of mothers is the most unpleasant situation for infants (as much as physical displeasure), thus a caregiver's rapid intervention is needed. This study is the first study that found this result in the research on infant crying sounds. The 'isolation call' (or separation distress call) is widely seen in animals (Michelsson *et al*., 1996; Hofer & Shair, 1989; Newman, 2007). However, we cannot tell if this is the same call used by animals since no other study has examined cries due to the absence of a mother. Further studies are required to examine this issue.

Cry Characteristics

Fundamental frequency and Energy A significant difference in the fundamental frequency of the crying voices was not obtained between the cries in Group A (evoking a more unpleasant feeling) and Group B (not evoking an unpleasant feeling). However, we found a significant difference in the maximum frequency between the two groups. The relation between unpleasant emotions in the listeners and cries with high frequency has been reported in other studies. In these studies, a neonate or young infant with pain stimulation averaged a fundamental frequency of more than 500 Hz (Adachi, *et al*., 1985; Protopapas & Eimas, 1997; Zeskind & Marshall, 1988). The average maximum frequency of Group A was 555Hz. Our findings support previous research results that cries with a high frequency (500Hz or more) may evoke unpleasant feelings in mothers.

Infant cries change with age due to the emotional development and to the physical maturation of the larynx that alter the expressive functions of the cry (Gustafson & Green, 1991; Lester & Boukydis, 1992). Leger *et al*., (1996) verified that older infants have more powerful energy than younger infants that strongly influence the feelings of the mother. We did not find a significant difference in the average energy and maximum energy between the two groups. However, energy measures comparing Group B and Group A showed that the unpleasant crying group was more powerful. We could verify it as a more effective signal to attract the attention, sentiment and emotion of the listener (Gustafson , Green & Tomic, 1984).

Three pain cries from Group A had a higher average evaluation point compared with the other five. However, a significant result was not obtained through all the sound features noting they had the largest deviation value. That is, the cry of Group AH was larger than the cry of Group AL with more extreme vocal changes in the fifteen seconds. Michelsson *et al*., (1996) also noticed that the pain cry is often characterized by a shift in an abrupt change in fundamental frequency. In addition, Zeskind and Marshall (1988), found high positive correlations between fundamental frequency and ratings at an average fundamental frequency of 695Hz with a standard deviation of 249Hz. Music therapy also confirms that a sudden change in sound frequency during a fixed time influences the emotions of the listener (Maeda, 2008). We agree that a high correlation between fundamental frequency and cry ratings is increased by the inclusion of stimuli with a wide range of fundamental frequencies (Gustafson & Green, 1989). Furthermore, we suggest that there was a characteristic sudden change from a basic frequency to high frequency to rouse the attention of the caregiver that was interpreted as negative.

Number of expirations and total expiratory times When the number of expirations was compared a significant difference was not obtained between the two groups. However, Group A total expiration time was significantly longer than Group B. That is, one utterance of the crying of the group A is long.

Several studies have examined how adults rate

the duration of the cries (Porter *et al*., 1986: Zeskind *et al*., 1992: Protopapas & Eimas, 1997). Gustafson and Green (1989) found that cry segments with longer expiratory sounds were perceived by parent and nonparent adults as aversive, unpleasant, and sharp sounding than cries with relatively shorter expiratory components.

As Murry stated (1979), continued exposure to the sounds of the cry with the attendant involuntary experiencing a high level of emotional arousal in the parent tips the parent's motivation from altruistic to egoistic. The motivation is no longer to alleviate infant distress but to alleviate parental distress at having to listen to the sound of crying for a prolonged period. In addition, studies by Zeifman (2004) of acoustic features of infant crying related to intended caregiver intervention has yielded interesting results. The point of intervention was not marked stimulated by a change in frequency, but by the length of the expiration. We do not understand at what point in length the expirations stimulated nurturing from the caregiver; however, longer expirations awaken concern and negative emotion in the listener as well as influence caregiving.

Many mammalian infants make characteristic sounds when distressed. Aside from the contextual similarities, structural similarities between the cries of human infants and mammalian infants can be added (Newman, 2007). Other non-human mammalian infants as well call the caregiver with utterances of a long duration. Our finding suggests that cries with substantial vocalization may also generate concern of human caregivers. In addition, the relevance of unpleasant emotional response do not solely depend on the psychosocial characteristics of the individual listeners.

REFERENCES

Adachi, T., Murai, N., Okada, H., & Nihei, Y. (1985). Maternal perception of infant cries. *Tohoko Psychol Folia*, *33*, 146-151.

Arakawa, A., Tanaka, D., & Iikura, Y. (2000). A method of classifying baby cries using frequency analyses Proc. Society conference IEICE; D-14-6.

Boero, D. L., Volpe, C., Marcello, A., Bianchi, C., & Lenti, C. (1998). *Newborns crying in different contexts*: Discrete or graded signals? Perceptual and Mortal Skills, *86*, 1123-1140.

Bowlby, J. (1977). Attachment. Tokyo: Iwasaki-sa.

Brewster, A. L., Nelson, J. P., & Hymel, K. P. (1998). Victim, perpetrator, family, and incident characteristics of 32 infant maltreatment deaths in the United States Air Force. *Child Abuse and Neglect, 22(2)*, 91-101.

Cuisinier, M., Janssen, H., & de Graauw K, *et al*. (1998). *Predictors of maternal reactions to excessive crying of newborns*: Findings from a prospective study in naturalistic situation. *Early Development Parent*, *7*, 41-49.

Frodi, A. (1985). When empathy fails: Aversive infant crying and child abuse. In: Lester, B.M., Boukydis CFZ, editors. *Infant crying*: Theoretical and research perspectives. New York: Plenum Press. 59-82.

Fuller, B., & Horii, Y. (1988). Spectral energy distribution in four types of infant vocalization. *Communication Disorders*, *19*, 441-447.

Gustafson, G. E., & Green, J. A. (1991). On the importance of fundamental frequency and other acoustic features in cry perception and infant development. *Child Development, 60*, 772-780.

Gustafson, G. E., & Harris, K. L. (1990). Women's responses to young infants' cries. *Developmental Psychology, 26,* 144-152.

Gustafson, G. E., & Green, J. A. (1989). On the importance of fundamental frequency and other acoustic features in cry perception and infant development. *Child Development, 60*, 772-780.

Gustafson, G. E., Green, J. A., & Tamara Tomic (1984). Acoustic correlates of individuality in the cries of human infants. *Developmental Psychobiology, 17(3),* 311-324.

Hofer, M., Shair, H., & Murowchick, E. (1989). Isolation distress and maternal comfort response of two-week-old rats. *Developmental Psychobiology, 22*(5), 553-566.

Hotta, N., & Yamaguchi, T. (2005). A study on the

mental state of mothers with 6-month-old child (part 1). *Japanese Society of child Health, 64,* 3-10.

Kim, Y., & Miyamoto, S. (2009). The research for the sound of infant and the infant-care stress of mother. *Psychiatria et Neurologia Peadiarica Japoonica, 49*, 61-70.

LaGasse, L. L., Neal, A. R., & Lester, B. M. (2005). Assessment of infant cry: Acoustic cry analysis and parental perception, *Mental Retardation and Development disabilities research reviews, 11*, 83-93.

Leger, D. W., Thompson, R. A. & Merritt, J. A. & Benz, J. J. (1996). Adult perception of emotion Intensity in human infant cries: Effects of infant age and cry acoustics. *Child Development, 67*, 3238-3249.

Lester, B. M., & Boukydis, C. F. Z. (1985). *Infant Crying*: Theoretical and Research Perspectives. New York: Plenum.

Lester, B. M., Boukydis, C. F. Z., Garcia-Coll, C. T., Hole, W., & Peucker, M. (1992). Infantile colic: Acoustic cry characteristics, maternal perception of cry and temperament. *Infant Behavior and Development, 15*, 15-26.

Maeda, K. (2008). Research on emotion to music. Retrieved 5 August 2008 From http://www.art.hyogo-u.ac.jp. (in Japanese)

Michelsson et, al., Christenssion, K., Rothganger, H., & Winberg, J. (1996). Crying in separated and non-separated newborns: sound spectrographic analysis. *Acta Paediatr, 85*, 471-475.

Ministry of Health, Labor and Welfare in Japan, (2008). Retrieved 20 June 2008 From http://www.mhlw.go.jp/bunya/kodomo/dv31/index.

Murray, A. D. (1979). Infant crying as an elicitor of parental behavior: An examination of two models. *Psychological bulletin, 86*, 191-215.

Newman, J. D., (2007). Neural circuits underlying crying and cry responding in mammals. *Behavioural Brain Research, 182*, 155-165.

Okamoto, M., & Matsuoka, M. (2006). Causal model structure analysis of emotional unrest in first time mothers faced with persistent infant crying 6-7 weeks postpartum. *Asian Nursing Research, 3(1),* 1-14.

Ostwald, P. (1963). *Sound Making:* The acoustic communication of emotion. Springfield, Ill.: Charles C Thomas.

Piaget (1968). Child Psychology: Revolve the development process of thing. Tokyo: Takizawa-sa.

Porter, F. L., Miller, R. H., & Marshall, R. E. (1986). Neonatal pains cries: Effect of circumcision on acoustic features and perceived urgency. *Child Development, 57*, 790-802.

Protopapas, A., & Eimas, P. D. (1997). Perceptual differences in infant cries revealed by modifications of acoustic features. *Acoustical Society of America, 102(6),* 3723-3734.

Zeifman, D. M. (2001). An ethological analysis of human infant crying: answering Tinbergen's four questions. *Developmental Psychobiology. 39*, 265-285.

Zeifman, D. M. (2004). Acoustic features of infant crying related to intended caregiving intervention. *Infant and child development, 13*, 111-122.

Zeskind, P. S. (1983). Cross-cultural differences in maternal perceptions of cries of low- and high- risk infants. *Child Development, 54*, 1119-1128.

Zeskind, P. S., Klein, L., & Marshall, T.R. (1992). Adults' perceptions of experimental modifications of durations of pauses and expiratory sounds in infant crying. *Developmental psychology,* 28(6), 1153-1162.

Zeskind, P. S., & Lester, B. M. (1978). Acoustic features and auditory perceptions of the cries of newborns with prenatal and perinatal complications. *Child Development, 49*, 580-589.

Zeskind, P. S., & Lester, B. M. (2001). *Analysis of infant crying*. In: Singer LT, Zeskind PS, editors. Biobehavioral assessment of the infant. New York: Guilford Publications Inc. p 149-166.

Zeskind, P. S., & Marshall, T. R. (1988). The relation between variations in pitch and maternal perceptions of infant crying. *Child Development, 59*, 193-196.

Zeskind, P. S., & Shingler, E. A. (1991). Child abusers' perceptual responses to newborn infant cries varying in pitch. *Infant behavior & Development, 14*, 335-347.

Wasz-Hockert, O., Lind, J., Vuorenkoski, V., Partanen, T., & Valanne., E. (1968). *The infant cry*: A spectrographic and auditory analysis. Clinics in Developmental Medicine, (Vol 29). London: Spastics International Medical Publication.

Wood R. M. & Gustafson G. E. (2001). Infant crying and adults' anticipated caregiving responses: acoustic and contextual influences. *Child Development, 72(5),* 1287-1300.

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