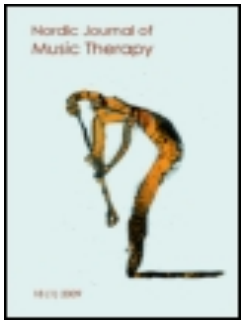

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Live music therapy with lullaby singing as affective support during painful procedures: A case study with microanalysis

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ABSTRACT

During the most vulnerable period in a child's life, preterm and sick infants are exposed to a high number of painful procedures, sometimes without the comfort and affection of their parents. Since repeated pain and frequent use of analgesic drugs may have consequences for the neurological and behaviour-oriented development of the infant, it is vital to identify effective non-pharmacological interventions with regard to procedural pain. This paper reviews the use of live lullaby singing as an adjuvant to the control of premature infant pain. The objectives of this case study were to analyse the live lullaby singing for two premature infants during venipuncture in comparison to standard care only, and the infants' physiological and affective responses emerging before, during and after this procedure. The empirical data stem from a quantitative clinical study. From this larger study, two premature infants were selected. Through microanalysis, with in-depth analysis of video footage, and pain assessment with Behavioral Indicators of Infant Pain (BIIP), painful standard care procedures with and without live lullaby singing, were analysed. The results show that live lullaby singing with premature infants is a communicative interaction which may optimize the homeostatic mechanisms of the infant during painful procedures. This case study shows the importance of predictability of the affective support, right from the start of the live singing intervention. It is important in a painful context that vocal interactions provide regular and comforting intensity, shape and temporal structures.

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KEYWORDS Pain management; premature infants; music therapy; infant directed singing; lullaby; microanalysis

Introduction

The soothing and emotional regulating properties of a lullaby are well-known cross-culturally (Fernald, 1989; Papoušek & Hwang, 1991; M. Papoušek, H. Papoušek, & Symmes, 1991; Rock, Trainor, & Addison, 1999; Trainor, Austin, & Desjardins, 2000; Trehub, Unyk, & Trainor, 1993a, 1993b; Werker, Pegg, &

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McLeod, 1994). Singing to infants in the course of caregiving to regulate the infants' state and lull them to sleep goes way back in human history (Patel, 2008; Rock et al., 1999).

Emotional regulation is a central feature of music therapy (Mondanaro & Sara, 2013; Robarts, 2009; Trondalen & Skårderud, 2007), and regulating the intensity of a premature infant's affects during a stressful and painful experience is a challenge. The academic and clinical field of music therapy has for the last 70 years documented the effects of music in alleviating stress, pain and anxiety (Bradt, 2010, 2013; Dileo, 1997; Edwards, 1999; Loewy, 1997; Mazer, 2010; Mondanaro & Sara, 2013; Standley, 2012; Turry, 1997; Wigram, Nygaard Pedersen, & Bonde, 2002). The effects of music interventions in neonatal intensive care units (NICU) have been researched (in music therapy and medicine) for the last 20 years (Bieleninik & Gold, 2014; Haslbeck, 2012a; Loewy, 1997, 2000).

Treatment of premature infants with music therapy has shown reduced symptoms of stress (Haslbeck, 2012a; Lai et al., 2006; Schwilling et al., 2015; Whipple, 2008), reduced inconsolable crying behaviour (Keith, Russell, & Weaver, 2009), improved vital signs (Arnon et al., 2006; Cassidy & Standley, 1995; Filippa, Devouche, Arioni, Imberty, & Gratier, 2013; Johnston, Filion, & Nuyt, 2007; Loewy, Stewart, Dassler, Telsey, & Homel, 2013; Rand & Lahav, 2014; Standley & Moore, 1995; Teckenberg-Jansson, Huotilainen, Pölkki, Lipsanen, & Järvenpää, 2011), improved feeding behaviours and sucking patterns (Standley, 2012), deeper sleep (Arnon et al., 2006; Garunkstiene, Buinauskiene, Uloziene, & Markuniene, 2014) and faster weight gain (Standley, 1998). Music interventions have shown positive effects on behavioural pain indicators and on pain scores (Bo & Callaghan, 2000; Butt & Kisilevsky, 2000; Chou, Wang, Chen, & Pai, 2003; Ghetti, 2012; Pölkki & Korhonen, 2014; Tramo et al., 2011; Yinger & Gooding, 2015), shorter hospital stay (Standley, 1998), enhanced bonding and reduced parental stress and anxiety (Arnon et al., 2014; Lai et al., 2006; Schlez et al., 2011; Teckenberg-Jansson et al., 2011). Comparing live infant-directed singing with recorded lullabies, live singing has found to have physiologically and behaviourally more impact on the preterm and term infant (Arnon et al., 2006; de L'Etoile, 2006¸ Garunkstiene et al., 2014). Live singing has also shown to encourage social interaction between the parent and the preterm infant (Filippa et al., 2013; Pölkki & Korhonen, 2014). Infants' responsiveness to parental singing is well documented (Nöcker-Ribaupierre, 2004), but live infant-directed singing by a female stranger is still more effective than listening to recorded music (de L'Etoile, 2006; Filippa et al., 2013; O'Neill, Trainor, & Trehub, 2001), and a capella singing has found to be more preferable to infants than accompanied singing (Ilari & Sundara, 2009). Because of its possibilities to interact with and entrain to the infant, live singing has greater potential than recorded music in addressing neonatal pain (Loewy, MacGregor, Richards, & Rodriguez, 1997; Pölkki & Korhonen, 2014; Turry, 1997).

Music is a biopsychosocial phenomenon experienced within a physical, psychological and social context (Dileo, 1997; Mazer, 2010). Like music, pain is a subjectively biopsychosocial experience (Bernatzky, Presch, Anderson, & Panksepp, 2011; Loewy, 1997). Even extremely premature born infants have functioning pain pathways (Nöcker-Ribaupierre, 2004). Many of the brain regions that encode pain in adults have also been found to be active in infants, suggesting

that newborn infants, like adults, are able to experience both sensory and affective aspects of pain (Goksan et al., 2015). Though infants are unable to express pain verbally, they communicate their experiences of pain through their physiology and behaviour (Anand, Stevens, & McGrath, 2007; Brazelton & Als, 1979; Franck, Greenberg, & Stevens, 2000).

Adding live lullaby singing to provide affective procedural support in a noisy, stressful and painful situation poses particular challenges (Ghetti, 2012). Overstimulation of the premature infant is a risk with auditory interventions (Bieleninik & Gold, 2014; Loewy et al., 2013). Preterm infants have problems with regulating endogenous physiological disturbances in combination with external stimulation (Lester, Boukydis, & LaGasse, 1996). They need 1–2 minutes to adapt to new sensory stimuli in the environment and self-regulate, to calm and organize their physiological and behavioural state, back to homeostasis (Axelin, Eriksson & Gradin, 2013). Preterm infants are also more sensitive to pain and stress than full term infants (Grunau, 2013). Acute pain is a negative stressor and may result in immediate consequences like decreased oxygen saturation levels, as well as irregular and rapidly increased or decreased heart rate (Franck et al., 2000; Neal & Lindeke, 2008). When the infant is stressed and overwhelmed, the sympathetic nervous system is stimulated, which produces the fight, flight or freeze response (Wennerberg, 2010). Simultaneously, the parasympathetic nervous system is deactivated, which affects the stability in the cardiovascular and respiratory systems (Franck et al., 2000; Lester et al., 1996). Acute pain has also long-term negative impact on infants' neurological development (Brummelte et al., 2012) and their future behaviour (Doesburg et al., 2013). Recently, also the use of analgesic drugs has been linked to impaired development (de Graaf et al., 2011), which emphasizes the need for complementary and alternative approaches to pain management.

Infant-directed singing sustains infant attention without overstimulation in contrast to infant-directed speech or motherese, which may result in cycles of heightened arousal and re-engagement with its greater variability characteristics; bell-shaped contours, high fundamental frequency, approving rising contours with wide pitch range (Nakata & Trehub, 2004; Shenfield, Trehub, & Nakata, 2003: Stern, 2000). Lullaby singing, which is one of the principal infant-directed song genres (the other one is play songs), is easily anticipated. The repetitiveness of lullaby singing is more effective than infant-directed speech in regulating and comforting the infant's stimulation and affect levels (Corbeil, Trehub, & Peretz, 2015; Nakata & Trehub, 2004). Lullabies are generally sung by caregivers with falling pitch contours, narrow and low pitch range and with a slower, less rhythmic tempo than play songs (Fernald, 1989; O'Neill et al., 2001; Rock et al., 1999; Trainor, Clark, Huntley, & Adams, 1997; Tsang & Conrad, 2010). Interactive live lullaby singing and "song of kin" interventions with parent-selected songs (Loewy, 2015), entrained to the infant's breath and observed vital signs, are supportive for the premature infant's behavioural development and has no known side effects (Loewy et al., 2013). Music entrainment facilitates infants' self-regulation to homeostasis by the application of live, moment-by-moment musical elements, tuned to the infant's vital signs (Loewy et al., 2013).

Infants are sensitive to vocal performance style (Rock et al., 1999), and experience the caregiver's affective intention through the prosody (Fernald, 1989). The regular

pulse of singing is also ideal for emotional coordination between caregiver and infant (Bergeson & Trehub, 2002; Nakata & Trehub, 2004). Affects are contagious, and affect contagion refers to the induction of an affect in one person from seeing or hearing someone else's affect display (Stern, 2000). In the interpersonal world of the infant, affects help the infant to cope with the surroundings both psychologically and biologically (Stern, 2000).

Infants are sophisticated communicative music listeners (Ilari & Sundara, 2009; Trevarthen, 2008). Empirical findings show that newborn infants have an auditory primitive intelligence already present at birth (Carral et al., 2005). Infants are able to adapt to and predict future auditory events through their capacity to identify acoustic uniformities, and they react neurophysiologically to alterations of such consistencies and to oddballs in an auditory signal (Carral et al., 2005; Stern, 2005; Winkler, Háden, Ladinig, Sziller, & Honing, 2009). Infants have an innate capacity to perceive the coherence of temporal, shape and intensity structures (Stern, 2000; Zentner & Eerola, 2010). Tones repeated in a certain pattern leave traces in the infant's sensory memory, lasting for up to 8–10 seconds (Leppänen, Eklund, & Lyytinen, 1997). Stern (2005), labels these traces present moments. Newborn infants perceive and sense surrounding stimuli in sequential present moments, which last between 1 and 10 seconds (Stern, 2005). Through amodal perception, which is the ability to integrate information from various senses, infants are able to embody information perceived in one sensory modality and transpose it into another sensory modality, and variations in the intensity gradient of one modality (e.g. sound) generally match the gradations in the intensity in another behaviour (e.g. motion), (Stern, 2000). Trevarthen (2008) writes about a sense of time in movement, which enables the infant to synchronize in dance-like body gestures with the variations in intensity, shape and temporal structures of the caretaker's voice and gestures, seeking to create a synrhythmic proto-conversation. A communicative musicality (Malloch et al., 2012) or proto-musicality (Volgsten, 2012) may take place within this shared sense of time.

The positive outcomes of live infant-directed singing are well researched. However, the use of live lullaby singing as an adjuvant to the control of premature infant pain is yet to be evaluated. The objectives of this case study were to analyse the live lullaby singing for two premature infants during venepuncture in comparison to standard care only, and the infants' physiological and affective responses emerging before, during and after this procedure.

Method

Participants

The participants of this case study were two premature newborn infants of the same gestational age; a girl, Estelle (pseudonym) and a boy, Carl (pseudonym) (Table 1), going through two venepuncture procedures; one with standard care only and one in addition with live lullaby singing. The infants were part of a larger study (N = 38) conducted in a level 2 neonatal ward, providing special but not intensive neonatal care (Stark, 2004), in Sweden. This clinical study, with randomisation of the order of the interventions, was performed so that each infant acted as their own control. Infants with known congenital malformations, severe illness, respiratory support or ongoing treatment with sedatives or analgesics were excluded. Estelle, Carl and their parents were of Swedish descent. Both infants received the same lullaby, but in random order (Table 1).

Table 1. Background data of the premature infants in the case study, Estelle and Carl.

	Estelle, premature Swedish-born girl 35 + 4 weeks of gestation birth-weight 1870 grams		Carl, premature Swedish-born boy 34 + 5 weeks of gestation birth-weight 2535 grams	
	First intervention	Second intervention	First intervention	Second intervention
Intervention	Standard care	Live lullaby singing	Live lullaby singing	Standard care
Song		Vyssa lulla litet barn (trad. Sweden) F sharp major/minor 58 bpm, 3/4 time	Vyssa lulla litet barn (trad. Sweden) F major/minor 55 bpm, 3/4 time	
Age at intervention	2 days	4 days	4 days	5 days
Parental presence	Mother	Both parents	Both parents	No parent
Duration of intervention	21 min and 42 sec	10 min and 52 sec	11 min and 40 sec	18 min and 16 sec
Number of skin punctions	2	1	1	2

Intervention

Standard care included facilitated tucking, done by the assistant nurse or the parent, oral glucose (30%) and the opportunity to suck on a pacifier or on a parent's or nurse's plastic gloved finger (Axelin et al., 2013). The parents were invited to attend both venepuncture procedures. To standardize the interventions, the live lullaby singing was performed for the infants by a music therapy student according to a protocol designed by the research team, inspired by the "song of kin" intervention (Loewy, 2015), the musical sedation procedure (Loewy, 2009, 2013) and by further previous research (Ghetti, 2012; Haslbeck, 2012a, 2012b; Loewy et al., 2013; Pölkki & Korhonen, 2014; Standley, 2012; Tramo et al., 2011; Whipple, 2008). The songs used in the clinical study were parent-preferred lullabies. In the cases where the parents did not identify a favourite lullaby, the music therapy student chose a traditional Swedish lullaby. The protocol stated that the singing should maintain a constant sound level between recommended ≤55–65 dB on the A-scale (Neal & Lindeke, 2008; Philbin, 2000). It should continue before venepuncture in order to lull the infants, during the blood sampling to support and provide a holding environment (Wigram et al., 2002; Winnicott, 1960) and after the venepuncture procedure to soothe and facilitate self-regulation (Figure 1). Estelle and Carl experienced in total two venepuncture procedures during the study period with no previous experience of procedural pain, except the mandatory vitamin K-injection at birth.

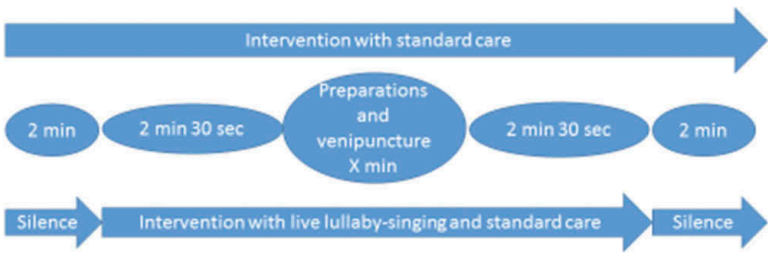

Figure 1. Overview of the two randomized procedures in the study. Venepuncture with standard care only and with standard care and live lullaby singing.

Data collection

The complete procedures were videotaped with a digital video camera (JVC GR-DVL 9600, Tokyo, Japan). The sound of the lullaby and environmental sounds were recorded with the built in camera microphone. The sound levels of the lullaby were measured 10 cm from the infant's ear with a sound level meter (CIM390, Taipei, Taiwan) on dBA slow, A scale. Saturation data were collected from each infant through a saturation probe on the hand or the foot (LNOP®, Masimo Set, Infiniti Medical) and the data for heart rate and respiratory rate through three electrodes on the infant's chest (NEOTRODE®, ConMed, New York, USA), connected to a Dash 3000-monitor (General Electric, Canada), the same monitor for all infants and all procedures. The patient monitor was connected to a research computer (Toshiba, server iCentral, software Datex S/5 collect 2004), which stored the physiological information from the monitor with an interval of 10 seconds. Due to practical schedule reasons, different specialist nurses and midwives performed the venepunctures.

Data analysis

There is a long tradition within developmental psychology research to use video recordings and microanalysis to study parent-infant moment-to-moment communication (Beebe, 2014). Music therapy research and practice define microanalysis as a detailed method investigating "minimal changes in relationships or interactions between people or minimal changes in music and dynamic forces" (Wosch & Wigram, 2007, p. 14). Micro processes are studied by combining qualitative and quantitative methods. This case study follows the tradition with hand-coded second-by-second microanalysis of the videotapes that was differentiated into four levels.

At level 1, thorough descriptions were made of the four videotaped procedures performed on Estelle and Carl, in total 62 minutes and 30 seconds. Each video description included different layers over the same timescale, presented in tables using Excel software as a basic structure. In the procedures with lullaby singing, 12 different layers were discerned, and in the standard care 10 layers:

(1) Heart rate (HR).
(2) Oxygen saturation (SaO_2).
(3) Respiratory rate (RR).
(4) Behavioural responses of the infants.
(5) Assessment of total pain responses of the infants according to BIIP.
(6) Behavioural responses from the nurses/midwives.
(7) Behavioural responses from the assistant nurses.
(8) Responses and actions from the parents who were present.
(9) Behaviour of and interactions in the singing performed by the music therapy student.
(10) Environmental circumstances (noise).
(11) Quality of the picture in the video.
(12) Sound levels measured in dB.

At level 2, detailed transcriptions of the two lullaby episodes (Appendix 1 and 2) into conventional music notation were made by the first author with the notation software Finale 2014 (MakeMusic Inc, Boulder, USA), and peer reviewed by two university teachers in music and composition, which resulted in some minor changes. The selection of a conventional notation system for transcription was inspired by Friederike Haslbeck (2014a, 2014b) and her microanalysis of creative music therapy with premature infants.

At level 3, analysis involved a comparison and evaluation of all layers, including the musical layers. This comparison of layers was conducted within each videotaped procedure, as well as between the procedures.

At level 4, Estelle's and Carl's responses were assessed from the video films by the first author with Behavioral Indicators of Infant Pain (BIIP). BIIP is a validated tool for assessing pain in preterm and term infants (Holsti & Grunau, 2007). The BIIP evaluates the state, level of arousal, five face actions and two hand actions (Figure 2 and Appendix 3). The highest possible score in BIIP is 9, and the scoring range is: 0–2 minimal or no pain, 3–6 moderate pain and 7–9 significant pain (Holsti & Grunau, 2010). In this case study, behavioural responses on pain were assessed for the first blood test in each intervention, from the skin puncture and 60 seconds onward (Holsti & Grunau, 2010). HR, RR and SaO_2 were also taken in consideration during the pain assessment.

Ethics of the entire study was approved by the Regional Ethical Review Board (2012/1097-31/2; 2012/1754-32). Written informed consent was acquired from both parents of the infants.

Figure 2. Illustration of five facial actions and two hand actions indicating pain in the Behavioral Indicators of Infant Pain (BIIP), a tool for assessing pain in preterm and term infants. Illustration by Isabell Pettersson.

Results

The lullaby performance for Estelle and Carl

The transcriptions of the two versions of the lullaby [Vyssa lulla litet barn] are shown in Appendix 1 for Estelle and Appendix 2 for Carl.

The prelude

The transcriptions disclosed an improvised introduction like a prelude to the lullaby melody, which was improvised by the music therapy student in irregular bell-shaped contours with narrow falling intervals. The preludes were performed in a major key, which changed into a minor key when the lullaby melody began. The preludes varied in length.

The prelude for Estelle was hummed in F sharp major with a tempo of 58 bpm in 3/4 time, in a wordless tone on an M-sound with closed mouth between 40 and 50 dB on the A scale (measured 10 cm from her ear) for 49 seconds (Appendix 1). In the prelude, approximately the same tone sequences were repeated twice with rests in between. After 49 seconds the original lullaby melody [Vyssa lulla litet barn] began, sung in the same tempo as the prelude, but in F sharp minor and with a regular and structured rhythm and melody.

The improvised prelude for Carl was hummed in F major with a tempo of 55 bpm in 3/4 time, in a wordless tone on an M-sound with closed mouth between 30 and 50 dB on the A scale (measured 10 cm from his ear). The prelude continued for 1 minute and 12 seconds (Appendix 2). After the improvised prelude, the singing altered into the original lullaby melody sung in F minor in a more rhythmical and structured style.

During venepuncture

The first time the lullaby was presented for Estelle, the melody was in its original structure. When the lullaby was repeated for the second time during the nurse's preparations, the melody was ornamented with some extra notes in the melody (bar 53 and 62, Appendix 1). Twelve seconds after the skin puncture, Estelle moaned twice for 2 seconds and the lullaby singing was interrupted and replaced with 14 seconds of comforting infant-directed speech in sliding prosody with glissandi (bar 72–74, Appendix 1). The lullaby melody resumed on an M-sound with closed mouth.

The lullaby melody was performed for Carl with a plain melody with no ornamentations during the first 2.5 minutes. When the nurse started stroking Carl's head with a wet compress looking for a vein, the humming changed character. The singer opened her mouth and started humming on an A-vowel (bar 56, Appendix 2), and the melody was enriched with extra notes in between the regular ones (bar 60, 71 and 76–77). After the skin puncture Carl cried for 7 seconds, and the lullaby was replaced with infant-directed speech in a comforting downward prosody (bar 71–75). The lullaby melody returned to a regular pulse (bar 79).

The coda

After the needle was removed, the lullaby was repeated a third time for Estelle (bar 80, Appendix 1). This time with more ornamentations of the melody (bar 89, 93 and 106) and in a more intense vocal style where the humming varied between closed and

open mouth. The lullaby melody returned a fourth time but was concluded after two phrases in an improvisational coda in six bars with descending minor thirds and long extended final notes.

The lullaby coda for Carl included an improvisational cadence, where the last phrase in the lullaby was repeated three times (bar 121–141, Appendix 2). The cadence dissolved in a descending perfect fifth and a minor sixth, performed with glissandi and finally a descending minor third.

Physiological results

During the interventions with live infant-directed singing (including prelude and lullaby), both Estelle and Carl showed a more stable and regular physiological pattern throughout the procedures (Figure 3). Both lullaby interventions included just one skin puncture to achieve the required amount of blood and were therefore shorter in duration, compared to two punctures during the procedures with standard care only (Table 1).

Physiological responses from Estelle

During the standard care intervention, Estelle showed a physiological sensitivity for noise and sound in the environment. Large and fast fluctuations in HR and RR were visible for this procedure after venepunctures and stressful or noisy episodes, though the SaO_2 was stable.

Estelle's physiology during the intervention with lullaby singing showed the same sensitivity for environmental noise as in standard care only. During baseline, Estelle responded to the random noisy sounds in the room with an irregular RR and HR, though the SaO_2 was still stable (Figure 3). After baseline, when the humming prelude started, Estelle needed 30 seconds to become stable. This stable state with normal pulse variations, steady SaO_2 and a slowly stabilizing RR, continued until the preparations for the skin puncture started. During handling and venepuncture, the physiological variations were stressed, with an increase in HR and decrease in RR but the SaO_2 continued to be stable. After the venepuncture, in the recovery episode, Estelle was quickly self-regulating back to homeostasis with a smoother pattern in the RR and HR and with a stable SaO_2 until the end (Figure 3).

Physiological responses from Carl

The physiological values for Carl in standard care only (Figure 3), showed signs of stress with a lot of activity and intense fluctuations. The pattern that appeared showed that Carl's HR rose rapidly and his RR decreased promptly during handling and holding, but stabilized each time the nurses removed their hands from him. His SaO_2 remained stable. Carl's parents were not present during standard care, only during the lullaby intervention.

The physiological responses during the prelude are shown in Figure 6. Carl's SaO_2 stayed stable during the prelude. His HR was sensitive to the intensity of the music and followed the contour of the melody. His RR followed the HR but inverted, and was also sensitive to the tension and release in the singing. A more regularly repetitive lullaby singing started after the prelude, which resulted in rapidly stabilized physiological values for Carl. During handling and skin puncture his HR and RR

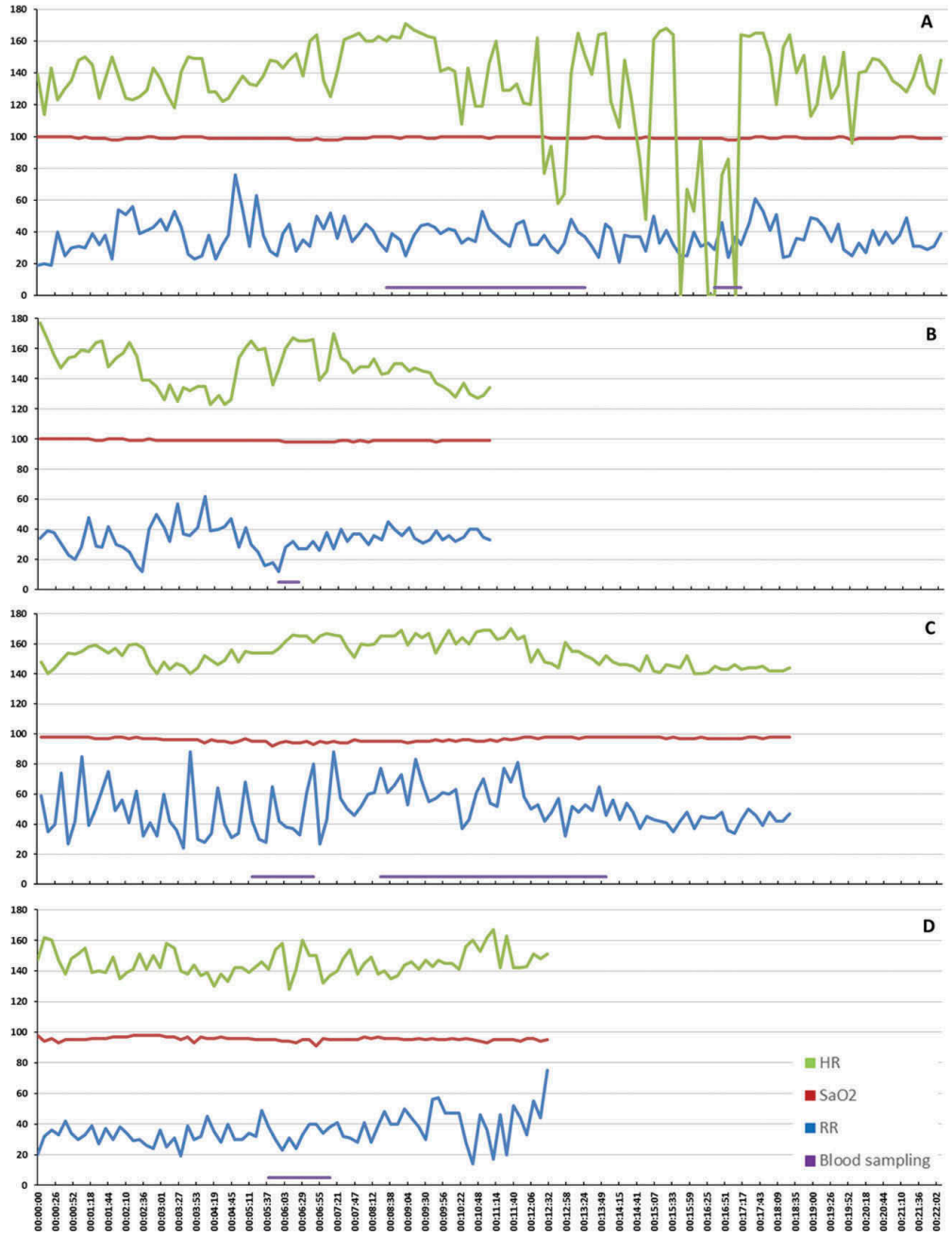

Figure 3. Physiological responses for (A) Estelle during standard care only, (B) Estelle during lullaby intervention, (C) Carl during standard care only and (D) Carl during lullaby intervention. From the top and down on the *y*-axis: (■) heart rate (min^{-1}), (■) saturation (%), (■) respiration rate (min^{-1}), (■) blood sampling episodes. The duration of the procedures, (h: m: s), is shown on the *x*-axis. The procedures with standard care only are longer than the procedures with lullaby intervention. In graph A, there are a few measurement errors with a sequence of zero values probably caused by unattached electrodes.

were affected and unbalanced (Figure 3). When the needle was extracted, Carl's HR and slowly his RR were stabilised again through the recovery episode with lullaby singing. Twenty seconds after the singing ended, Carl's HR increased and his RR dropped rapidly. Carl needed exactly 1 minute to self-regulate and return to stable levels.

Pain score and behavioural responses of Estelle and Carl

The results from the pain assessment with BIIP during venepuncture with standard care only and with lullaby intervention with standard care are displayed in Table 2.

Behavioural responses from Estelle

Estelle showed signs of constant distress before, during and after the two blood sampling procedures in standard care only. Her BIIP score was 8, indicating significant pain (Table 2). Loud conversations were going on in the background during the entire standard care procedure, as well as high pitched sounds from the monitors and a phone ringing intensely. Estelle was reacting strongly to the environmental noise with restless body movements. During the first 4.5 minutes of the intervention, her behaviour showed recurring finger splay and fisting, restless head moves from side to side, grunting sounds, kicking legs, startles, eye squeeze, brow bulge, taut tongue, naso-labial furrow, horizontal mouth, hands on face and hands and arms extended in a halt-position or salute (extension of the arms into mid-air in front of the body), (Figure 4).

The first blood sampling was then initiated and lasted about 5 minutes. During the last minute of this first blood sampling when the nurse had difficulties in collecting enough blood, the nurse and Estelle's mother, who sat next to the crib, were engaged in brief dialogues in a light tone of voice. The environment was temporarily moderately silent and Estelle began to suck on the assistant nurse's gloved finger, which seemed to calm her behaviour as well as her physiology. Transcription of the next episode on the video (Figure 5), disclosed how the nurse spontaneously turned to Estelle saying—in a descending tone of voice ranging a minor third—that she had to take another blood sample from Estelle. After that remark, Estelle immediately stopped sucking on the assistant nurse's gloved finger and showed signs of a freeze response in her face and body, which turned dull and limp, followed by a radically

Table 2. Pain assessment with BIIP (Behavioral Indicators of Infant Pain) for Estelle and Carl, during venepuncture (from skin puncture and 60 seconds onward) in standard care only and in lullaby intervention with standard care.

		Estelle		Carl	
Score	State	Standard care only	Lullaby intervention	Standard care only	Lullaby intervention
0	Deep sleep		0		0
0	Active sleep				
0	Drowsy			0	
0	Quiet awake				
1	Active awake				
2	Agitated/Crying	2			2
	Face				
1	Brow bulge	1	1		1
1	Eye squeeze	1	1		1
1	Naso-labial furrow	1			1
1	Horizontal mouth stretch	1		1	1
1	Taut tongue	1			1
	Hand				
1	Finger splay			1	1
1	Fisting	1			
	Total score	**8**	**2**	**2**	**8**

The bold values in Table 2 indicate the total score for the pain assessment according to the method.

Figure 4. Halt or salute position before the venepuncture during Estelle's standard care only.

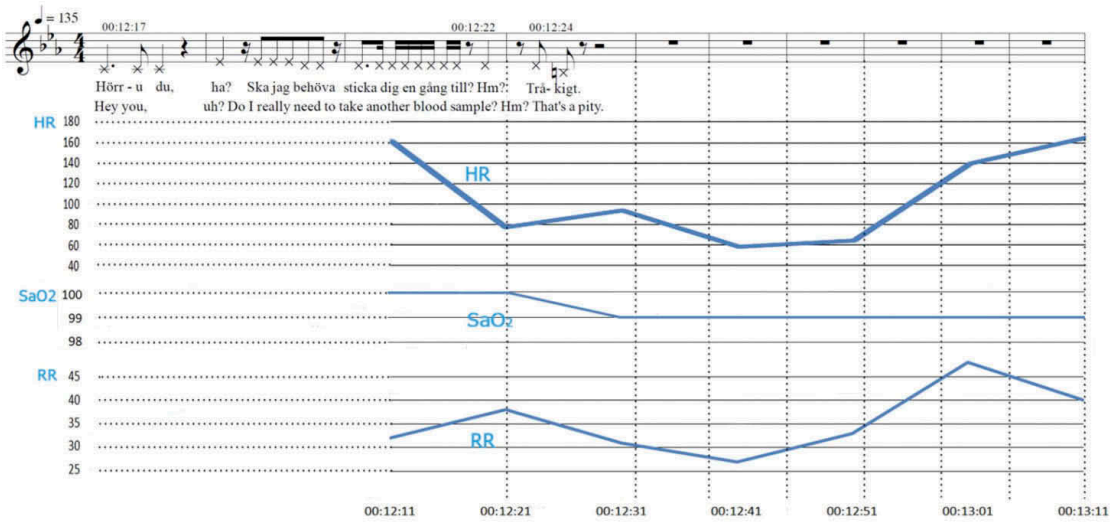

Figure 5. Transcription of Estelle's physiological reactions when the nurse impulsively addressed Estelle with a descending prosody ranging a minor third, saying that she had to take another blood sample. The *y*-axis shows heart rate (min^{-1}), saturation (%) and respiration rate (min^{-1}). The duration of the physiological responses (h: m: s) is shown on the *x*-axis and corresponds to the melody and the video time.

drop in HR as well as in RR (Figure 5). The assistant nurse who noticed Estelle's reaction, instantly started to gently shake Estelle, but Estelle did not respond to the handling. After 30 motionless seconds Estelle started crying and kicking her legs again and her HR and RR increased promptly.

In the beginning of the lullaby intervention, the background was noisy with loud talking and laughing, beeping monitors and slamming doors. Estelle sucked her pacifier intensely during these sounds. When the singing started with the prelude, Estelle turned her head and face towards the sound on her right side. Synchronous with the elongated glissando in bar 6 (Appendix 1), she turned her head in the exact

same tempo as the falling tones, back to her original resting position on her left side. Ten seconds after the singing started, Estelle sucked her pacifier once and became calm after that. When the nurse started preparing for the blood sampling, she responded to the handling with a single rotating movement with her left hand, which turned into a finger splay. Despite that, her body and face kept calm until the needle punctured the skin. Estelle moaned for 2 seconds but was easily comforted. The blood sampling sustained for 30 seconds. Her BIIP score was 2, indicating minimal pain (Table 2). Estelle's behavioural responses continued to be calm during the recovery period. Five seconds after the lullaby ended, Estelle appeared to react to the silence by sucking her pacifier intensely. She managed to self-regulate and kept calm in body and face until the procedure was over.

Behavioural responses from Carl

Carl displayed a pronounced sucking behaviour throughout the whole standard care only procedure. He reacted to all sounds in the room with startles, twitchy body movements, rapid eye movements behind closed lids and raised eyebrows. When the needle punctured the skin, Carl moaned, grunted, sighed and sucked intensely. After 2 minutes and 13 seconds the nurse extracted the needle without managing to get blood, and Carl continued sucking intensely on his pacifier. His BIIP score was here 2, indicating minimal pain (Table 2).The second blood test continued for 7 minutes and 17 seconds. Carl became gradually more motionless during this handling and stopped sucking his pacifier. He showed signs of exhaustion with a 2-minute long time-out period at the end of the second blood sampling, where his face turned pale and his body was limp.

Carl's behavioural responses during the prelude are illustrated in Figure 6, where his responses are shown in the pictures parallel to the melody, parallel to his physiological responses regarding HR, RR and SaO_2.

The first 24 seconds of the prelude, or the first eight bars of humming (Figure 6), Carl lay down quietly on his right side on the examination bed, with his hands relaxed next to his face and with his mother's hand on his chest. During the rest in bar 8, Carl startled and his arms moved away out from his face and down. Simultaneously with the ascending ornamentation, a major second (M2) in bar 10, his left hand which was relaxed, followed the M2 in a rotating movement with the arm and hand (Figure 6). In bar 11, Carl relaxed and opened both his hands exactly when the humming landed on the A tone. During the silence in bar 12, he returned to his original position with hands next to his face and chest. The same pattern was repeated when the next phrase in the prelude started, where body movements were synchronous with the melody. In bar 16, on the first note during the ascending melody, Carl placed his right hand loosely over his eyes and face. When the M2 occurred, he rotated his body on the ascending and descending movement in the music, and his hands stretched out and rotated in chorus with the M2 ornament. During the silence in bar 18, Carl's body and hands relaxed again next to his face. In bar 19, Carl gently opened his left hand as if he was conducting the first tone, the G. The right hand, near his face, opened softly synchronous with the ascending M2 in bar 20. On the descending major third (M3), Carl kept his hands open until the tone ended. Synchronous with the rest in bar 22, his left hand relaxed back to his face, but the right hand stayed open

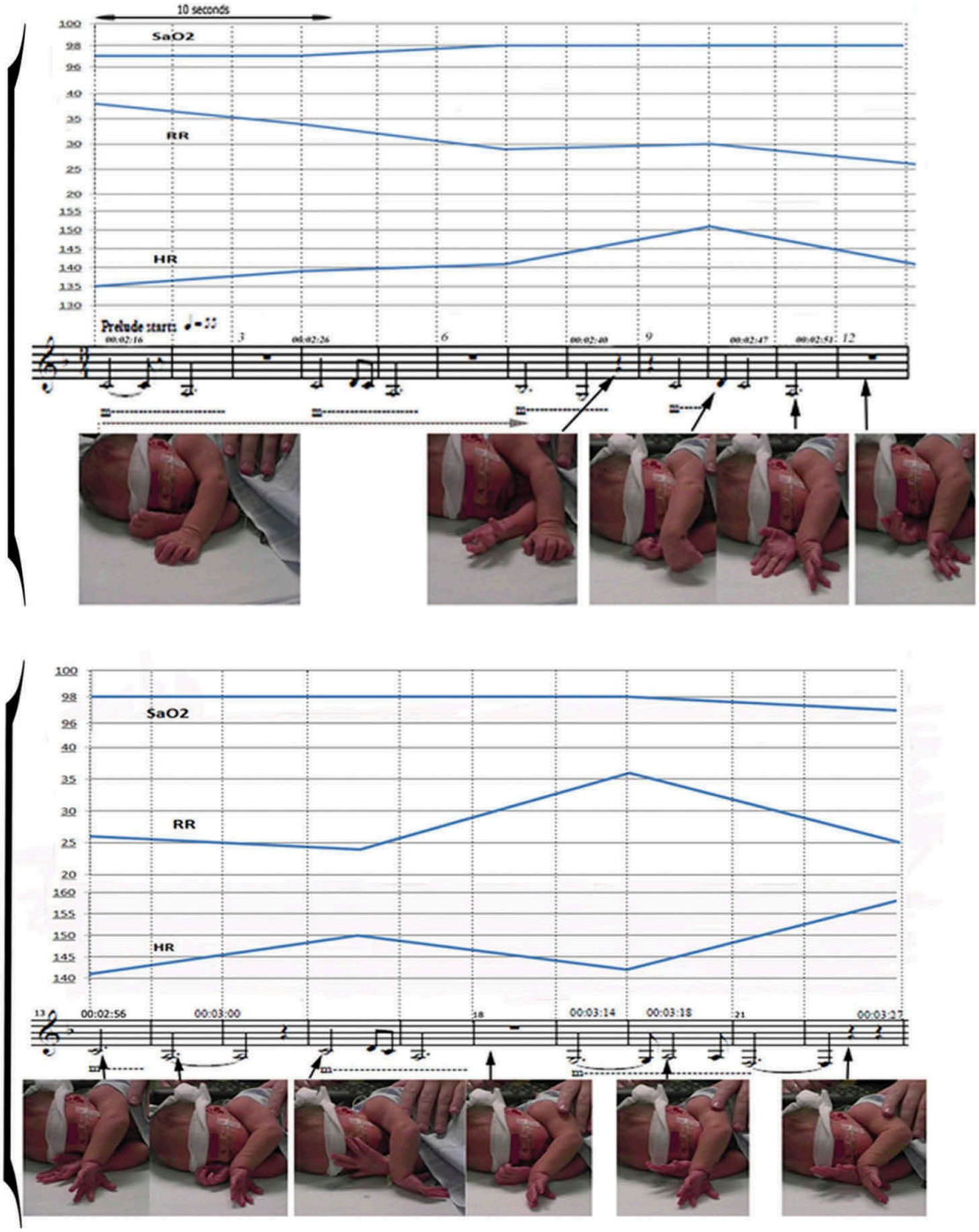

Figure 6. Parallel presentation of behavioural and physiological responses of Carl during the prelude in the lullaby intervention.

during the rest and all through the first bar of the following lullaby melody. Carl's right hand gradually relaxed during the first four bars of the lullaby melody.

Carl's BIIP score during skin break, was 8, indicating significant pain (Table 2), despite a rather stable HR, RR and SaO_2 throughout the lullaby intervention. In the silent recovery period, 7 seconds after the singing stopped, Carl reacted to the silence. During the first minute of absence of singing he displayed finger splay, fisting, sucking movements, tongue protrusion, rotating body and arm movements, red

face, grunting, moving his hands near the mouth. Precisely 1 minute after the lullaby finished, Carl's behaviour was relaxed again with no movements in hands or body, and with his hands close to his mouth.

Discussion

The transcriptions of the live lullaby singing identified an improvised prelude to the regular lullaby melody, including a key change from major to minor key, ending with a coda. During the interventions with live singing, both Estelle and Carl showed, through microanalysis of physiological and behavioural responses, more stable and regular patterns throughout the procedures compared to the procedures with standard care only. Since the nurses needed less time to achieve the required amount of blood, both venepuncture procedures with lullaby interventions included just one skin puncture and were shorter in duration. The procedures with standard care only, which required two skin punctures, were about twice as long. Across studies, it has been found that live infant-directed singing may optimise the homeostatic mechanisms of the infant during painful procedures, helping the neonate to regulate the affective state, findings corroborated by the present case study.

An asset with this study was that the results are consistent with the fact that differences in infants' physiology, biochemical and psychological factors influence perception of pain, making it a unique experience for each individual. Estelle's pain responses, analysed with BIIP, were more robust and coherent compared to Carl's. However, the problem with assessment of behavioural observations like the BIIP is to discriminate between stress from causes other than pain, for example environmental noise. Background noise was an issue in all situations in this case study. Another scale that measured the global behavioural distress might have been a better indicator of the overall effect of the painful experience and more responsive to the influence of the live lullaby intervention, than would the attempt to assess pain intensity with tools like the BIIP. The microanalysis of the infants' overall pain experience in this case study revealed that the BIIP did not capture long time-out periods or signs of exhaustion. Lack of visible pain-related responses does not necessarily imply absence of experienced pain. This was the case in Carl's intervention with standard care only, with no parents present, where his BIIP score indicated minimal pain. At the same time, the physiological measurements displayed stressed vital signs, as well as behavioural signs of exhaustion, with a 2-minute long time-out period at the end of the second blood sampling. Carl's physiology also indicated stress caused by handling during standard care only. A pain exposed infant in constant hyperactive state becomes exhausted, passive and oversensitive to all handling trying to preserve energy with less crying, weaker grimace and limp posturing (Franck et al., 2000). These manifestations are not included in BIIP assessments. In the procedure with lullaby singing Carl's responses were vice versa, despite his mother's support through facilitated tucking, with a more stable HR, RR and SaO_2 but a high BIIP score during skin break.

One deficit of this study was the confounders emanating from the larger quantitative clinical study with various specialist nurses conducting the blood tests, parents present during one intervention but not in the other, and different environmental circumstances for the infants during the procedures. The infants in this case study were already given standard pain management with facilitated tucking and oral

glucose, hence only additive effects of the live lullaby singing could be assessed. Future studies may find it useful to eliminate background noise (cf. e.g. Lasky & Williams, 2009), to minimise the infants' environmental stress and emphasise the live singing. The latter would presumably have been more audible and soothing if performed with elongated breathy vowels instead of a closed humming (cf. Loewy, 2013; cf. Turry, 1997).

Affect contagion refers to the induction of an affect in one person from seeing or hearing someone else's affect display. This might have occurred in Estelle's standard care only, when the nurse impulsively addressed Estelle with a descending prosody ranging a minor third, which was immediately followed by a frozen body and face response with a radical drop in Estelle's HR and RR. A plausible explanation is that, within a "present moment" (Stern, 2005), Estelle with her innate auditive sensitivity was able to perceive the discouraging prosody and in her sensory memory store the nurse's affective sense of no hope (Carral et al., 2005; Ruusuvirta, Huotilainen, Fellman, & Näätänen, 2003; Winkler et al., 2003). In traumatic situations which are fear-provoking, a freeze response might automatically get activated, which involve behavioural immobility and marked drop in HR and RR (Ursin, Endresen, Lund, & Mjellem, 1994; Wennerberg, 2010). Infant-directed speech must be practiced cautiously within a pain context.

A corresponding result was Carl's behaviour during the prelude. The performance features in Carl's prelude were irregular in rhythm and pitch contour with a bell-shaped melody contour, similar to the shape, intensity and temporal structures of infant-directed speech, which is more engaging than soothing. The communicative message in the first 10 seconds in the prelude, about three and a half improvised bars, was fragmentary, possibly without an intentional narrative (cf. Trevarthen, 2008). This compared to the start of the traditional lullaby melody, where 10 seconds were equivalent to a complete coherent melody message (Appendix 2). Carl's rotating hand movements, finger splays and hand covering face responses could be interpreted as signs of an infant trying to self-regulate from an over stimulating interaction with infant-directed speech. The prelude for Estelle was 24 seconds shorter and performed with more repetitive and regular pitch contour (Appendix 1), which might be an answer to why she responded with less pronounced behavioural reactions and needed less time to self-regulate during her prelude. Estelle seemed to perceive the common modalities in her prelude in just 10 seconds, within the time frame of the sensory memory and a present moment. In the prelude Estelle responded instantly, turning her head towards the sound, showing a neurologically mature interest in the singing (Standley & Walworth, 2010; Tsang & Conrad, 2010). However, a relaxed infant responds to new stimuli with smooth moving conducting hands (Haslbeck, 2014a), indicating a participation in affective communication with synrhythmic proto-conversation. Through amodal perception Carl perceived common temporal, shape and intensity levels in the prelude performance and, across modalities, transferred these into a kinetic hand-dance. With his sense of time in movement, Carl's hand gestures were synchronised with the impulses in the actions of the singer's voice in the prelude, and with her alterations of the regularity in the prelude. Carl's coping self-regulatory behaviours prompted him to shift his possibly negative affective state, likely overwhelmed by the irregularities in the prelude, to a state where he could pursue social proto-conversation (cf. Tronick, 1989). Estelle displayed similar

cross-modal pattern but shorter. In the beginning of her prelude, she transferred the shape of the glissandi into a synchronous turning of the head. According to previous research (Carral et al., 2005; Stern, 2000), both infants seemed to perceive the total structure of the prelude by connecting their amodal perceptions, Estelle faster than Carl.

This case study showed the reciprocity of physiological and behavioural activity linked to live infant-directed singing and infant-directed speech during painful procedures. For both infants, the live singing appeared to offer affective support, which decreased stress before the skin break and after, and facilitated recovery and homeostasis. Estelle seemed to benefit from the live lullaby singing even during the skin puncture. A research area of great future interest is the parental perspective in the live lullaby singing with the pain alleviating potential of parental singing and the importance of empowering parents to become more involved in affective procedural support through live singing. More research is also needed to expand healthcare staff's awareness of multimodal and multidisciplinary approaches to pain management, since pain involves the interaction of biopsychosocial and situational factors.

Conclusion

In a painful setting, music therapists, staff and caregivers must think carefully about when and how to communicate and interact with vulnerable preterm infants to promote a context of safety. In addition to providing a caring and quiet environment throughout the entire procedure, the infant's regulatory style and responses must be observed before the painful procedure is carried out. The infant is then constantly assessed during singing, in order to refocus the affective support within the present moment, to maintain emotional regulation. Live singing with premature infants is a communicative interaction, which may optimise the homeostatic mechanisms of the infant during painful procedures, provided that the vocal performance is predictable, fosters safety and ensures regular comforting temporal, shape and intensity structures from the start of the live singing intervention.

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No potential conflict of interest was reported by the authors.

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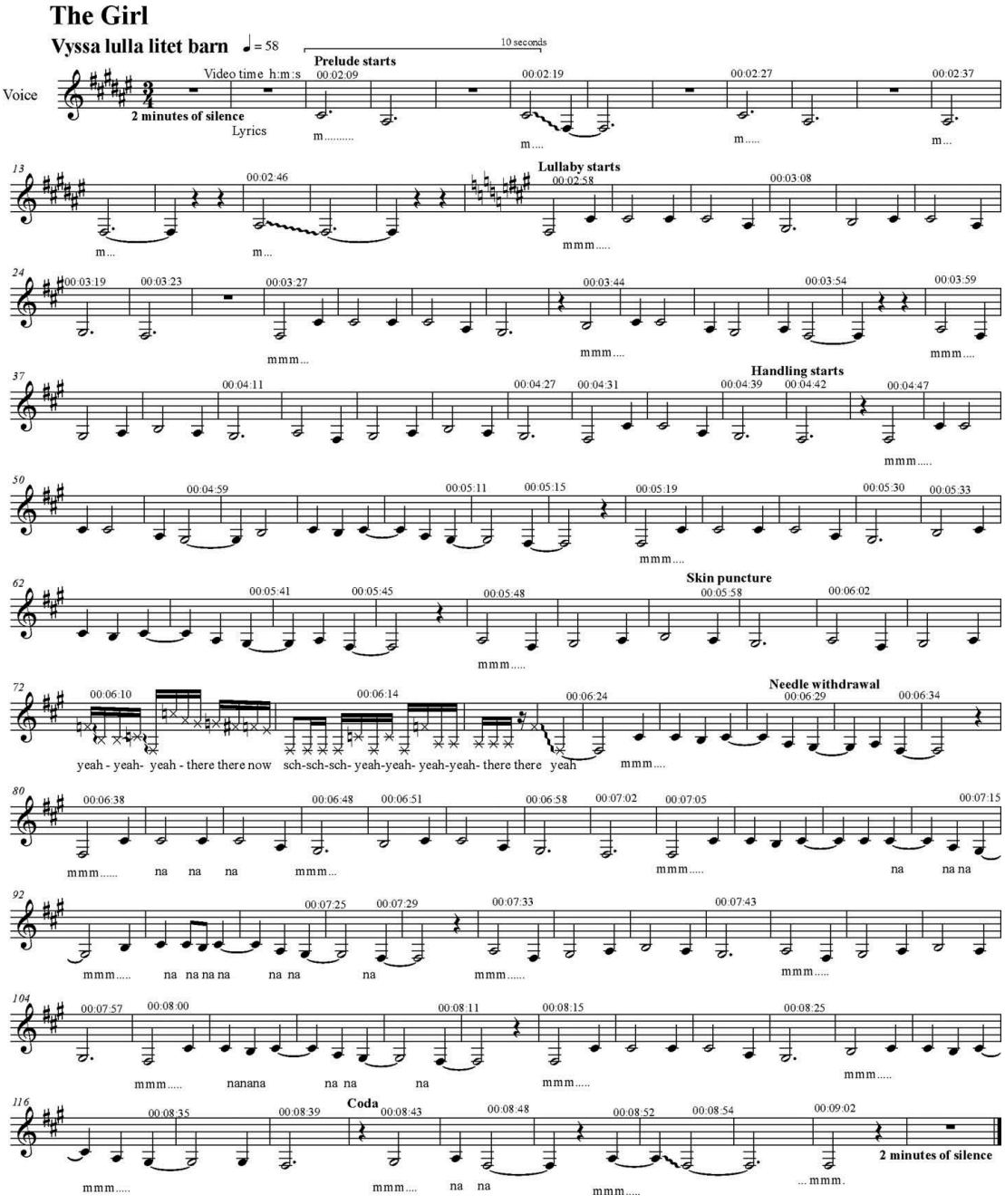
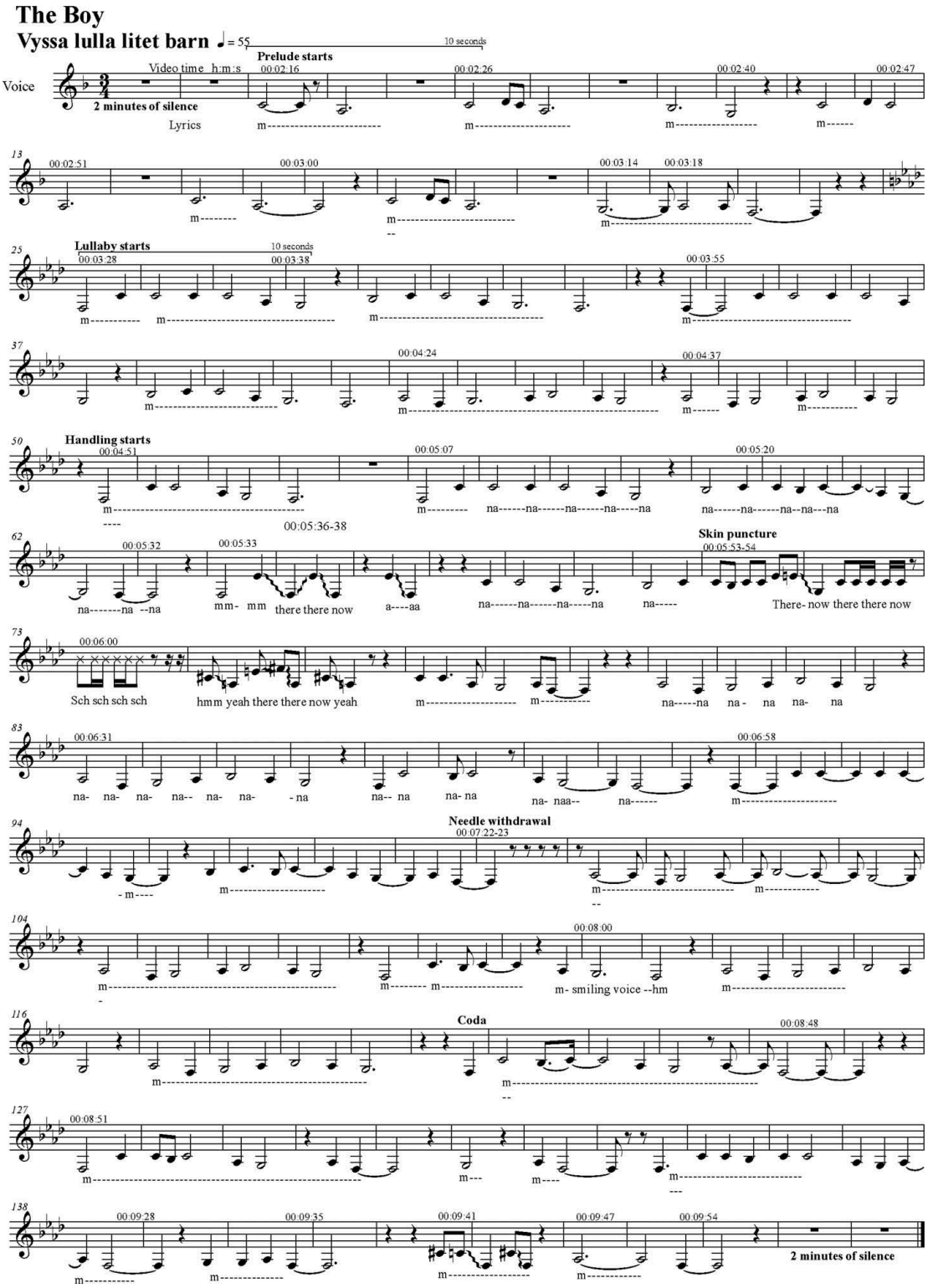
Appendix 1. Transcription of Estelle's lullaby intervention



Appendix 2. Transcription of Carl's lullaby intervention



Appendix 3. Video coding observation form of Behavioral Indicators of Infant Pain (BIIP). (Holsti & Grunau, 2010).

	Coding #				
	DVD #				
	Sequence #				
	Video Start Time				
	Video End Time				
SCORE	STATE				
0	Deep Sleep				
0	Active Sleep				
0	Drowsy				
0	Quiet Awake				
1	Active Awake				
2	Agitated/Crying				
	FACE				
1	Brow bulge				
1	Eye squeeze				
1	Naso-labial furrow				
1	Horizontal mouth stretch				
1	Taut tongue				
	HAND				
1	Finger splay				
1	Fisting				
	TOTAL SCORE				
	NOTES				