

Singing, sharing, soothing – biopsychosocial rationales for parental infant-directed singing in neonatal pain management: A theoretical approach

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Abstract

Infant-directed singing is a medium for parents and infants to communicate in a mutual relationship. Parental infant-directed singing is a multisensory, biopsychosocial communication that applies to ill and vulnerable hospitalised infants. The primary musical features of infant-directed singing are ideal for emotional coordination and sharing between parent and infant without the risk of over-stimulation. In this article, we suggest that parental infant-directed singing is regarded as a nonpharmacological emotion regulation intervention, which may modify the painful experience for both the infant and the parent before, during and after painful procedures in the neonatal intensive care context. Parents have the biopsychosocial resources to alleviate their infant's pain through infant-directed singing, if they are empowered to do so and coached in this process. A music therapist specialised in neonatal music therapy methods can mentor parents in how to use entrained and attuned live lullaby singing in connection to painful procedures. Pain and the vast amount of painful procedures early in infancy, combined with early parent–infant separation and lack of parental participation in the care of the infant during neonatal intensive care, place arduous strain on the new family's attachment process and on the infant's and parents' mental health, both from a short and long-term perspective. Therefore, we argue with biopsychosocial rationales, that live parental infant-directed singing should be promoted in neonatal pain care worldwide. Consequently, parents should be welcomed round the clock and invited as prescribed pain management for their infant.

Keywords

Affect attunement, biopsychosocial, infant, infant-directed singing, music therapy, pain management, parent, vitality affects

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If a community values its children, it must cherish their parents. (Bowlby, 1951, p. 84)

An ongoing global paradigm shift in neonatal care is the concept of family-centred care (Fellman, 2017). Neonatal care in the Nordic countries is on the front line of welcoming and including both parents in the everyday care of their infant as well as providing facilities for the parents to stay overnight (Nordhov et al., 2010; Olsson et al., 2012; Örtengstrand et al., 2010; Pallás-Alonso et al., 2012; Raiskila, Axelin, Rapeli, Vasko, & Lehtonen, 2014; Raiskila et al., 2017). However, in neonatal pain care the caregiving culture in many neonatal intensive care units (NICU) today, even in the Nordic context, still restricts parental

participation in pain relief, which may result in inadequate pain management (Axelin et al., 2015; Courtois et al., 2016; Palomaa, Korhonen, & Pölkki, 2016). When born prematurely (before 37 full weeks of gestation), or when critically

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ill at birth, an infant will be cared for in the NICU. Continuous advancements in neonatal care allow infants to survive outside the womb at younger gestational ages with increased survival of the extremely preterm, born from 22 weeks of gestation (Moore, Lemyre, Barrowman, & Daboval, 2013). Yet, the increased survival might also require intense, stressful and painful medical treatments (Zimmerman & Bauersachs, 2012). In most countries worldwide, NICUs are not welcoming parents to partake in their infant's care around the clock (Greisen et al., 2009). Infants are therefore separated from their parents for long periods of time, causing a relational traumatising (Feldman, Weller, Leckman, Kuint, & Eidelman, 1999; Shaw et al., 2009). Repeated, cumulative and inadequately treated procedural pain in addition to separation from the parent, will not just harm the infant physically and psychologically in the short term, including increasing the risk for abnormally heightened sensitivity to pain (Taddio, Shah, Atenafu, & Katz, 2009), but might also jeopardise the new family's attachment process and mental health in the long term and for generations to come (Cirulli et al., 2010).

Infants cared for in the NICU experience on average between 7 and 17 painful procedures per day (Cruz, Fernandes, & Oliveira, 2016). Only very few infants receive appropriate pharmacological and nonpharmacological analgesic therapy (Carbajal et al., 2015; Cruz et al., 2016; Roofthoof, Simons, Anand, Tibboel, & van Dijk, 2014). Due to the difficulty in understanding pain in a population that does not verbalise pain, observations of pain behaviour, e.g., facial activity and cry, form the basis of the assessment of neonatal pain. There is still no gold standard for pain assessment in infants and there are at least 29 available pain scales, both one-dimensional and multidimensional, used in preterm and full-term infants in situations of acute and prolonged pain (de Melo et al., 2014; Stevens et al., 2014; van Dijk et al., 2006). Pain has a long-term negative impact on infant's development and future behaviour (Verriotis, Chang, Fitzgerald, & Fabrizi, 2016), but so do analgesic drugs, which also have negative developmental side effects (de Graaf et al., 2011). Research shows that for the most common procedure in the NICU, skin puncture, topical anaesthetics are not effective, nor is morphine or paracetamol (Fernandes, Campbell-Yeo, & Johnston, 2011). The limited choice of pharmacological agents and the high frequency of painful procedures in NICUs, emphasise the need for nonpharmacological approaches to pain management such as oral sweet solutions, non-nutritive sucking, skin-to-skin contact and facilitated tucking (Fernandes et al., 2011). Among the nonpharmacological approaches, the biopsychosocial perspective strongly supports parent-driven interventions (Campbell-Yeo, Fernandes, & Johnston, 2011). Coaching parents to better meet their infant's attachment needs during times of pain may lead to more efficacious interventions (Pillai Riddell et al., 2012). Research clearly shows that parents should be empowered to use parental

interventions including their presence and use of their voice to positively impact their infants as well as themselves (O'Toole, Francis, Pugsley, & Gephart, 2017).

Affects provide the basic neurological foundation for the formation of emotions and feelings. Affects are often followed by bodily responses. Both unpleasant and pleasant affects trigger neurotransmitters and hormones in the infant's body and brain (Hart, 2008). The network of brain regions that encodes both the affective and sensory aspects of the pain experience have been well described in adults but not sufficiently in infants, though we know that the immature infant is more sensitive to pain than adults (Goksan et al., 2015). New research shows that almost all regions of the brain that are activated during acute pain in adults, are also activated in healthy full-term newborn infants (Goksan et al., 2015). However, noxious stimulation in infants does not evoke activity in the amygdala or orbitofrontal cortex. It is therefore plausible that infants do not experience the full range of aversive qualities that adults associate with pain (Goksan et al., 2015). On the other hand, Goksan et al. (2015) showed that the anterior cingulate cortex, which is a brain region involved in affective processing, is activated in infants following noxious stimulation. The cingulate gyrus directs the infant's attention towards outside stimuli, but also registers the infant's internal emotional states in relation to other people as well as to painful and other somatosensory signals arising inside the body. The cingulate gyrus interacts with the insula area where the sensory aspects of pain are processed. The insula receives pain signals from the internal organs and from the skin. The cingulate gyrus processes the affective aspects of pain and is activated both when a person feels pain him/herself (including social rejection pain), and when he/she feels someone else's pain, regardless of whether this pain is physical or psychological (Hart, 2008). The cingulate gyrus has a high concentration of opioid receptors. Activation of this region offers the infant a sense of safety and relatedness. The anterior cingulate gyrus also contains cells that are rich in receptors for the neurotransmitter dopamine. The cingulate gyrus is believed to develop during the first months of life (Hart, 2011), but as Goksan et al. (2015) have shown, it is active in affective pain processing from birth. This suggests that infants have the capacity to experience an emotionally relevant context related to incoming sensory input. It is therefore plausible that infants are responsive to affective pain-alleviating interventions from birth. Music, and especially singing, is commonly used to successfully modulate infant affect (Trehub, Ghazban, & Corbeil, 2015).

Music interventions, both live and recorded, have a measurable short-term physiological and behavioural impact on hospitalised preterm and term infants and on their parents, with reduced infant stress responses and inconsolable crying behaviour, reduced parental stress and anxiety, and improved parent–infant interaction and bonding (Anderson & Patel, 2018; Arnon et al., 2014; Bieleninik, Ghetti, &

Gold, 2016; Ullsten et al., 2017). Music interventions have improved infant's vital signs, increased levels of quiet alert or quiet sleep states (Loewy, Stewart, Dassler, Telsey, & Homel, 2013), improved weight gain and reduced length of hospitalisation compared to a control group (Garunkstiene, Buinauskiene, Uloziene, & Markuniene, 2014; Saliba, Esseily, Filippa, Kuhn, & Gratier, 2017; Standley, 2012; van Der Heijden et al., 2016). The long-term effects have so far been insufficiently studied (Bieleninik et al., 2016; Haslbeck, 2012). In procedural pain management, recorded lullabies and recorded maternal voice have been shown to have certain positive effects on infant's behavioural pain indicators (Azarmnejad, Sarhangi, Javadi, & Rejeh, 2015; Bergomi et al., 2014; Bo & Callaghan, 2000; Butt & Kisilevsky, 2000; Chirico et al., 2017; Chou, Wang, Chen, & Pai, 2003; Pölkki & Korhonen, 2014; Qiu et al., 2017; Shabani, Nayeri, Karimi, Zarei, & Chehrazai, 2016; Tramo et al., 2011). To our knowledge, no study has so far assessed the pain-alleviating effects of infant-directed *live* singing performed by a parent during acutely painful procedures. Based on what we know, our research (Ullsten et al., 2017) was the first clinical trial to measure the pain-relieving effects of live lullaby singing on behavioural and physiological pain responses during venipuncture in preterm and term neonates; though the live lullaby singing was not performed by a parent but by a music therapy student under training. The results on the physiological and behavioural variables we could assess, did not show any significant pain-alleviating effects of live lullaby singing on preterm and term infant's pain responses during venipuncture, nor did they indicate that live lullaby singing was harmful or stressful. Still, the lullaby singing significantly calmed the infant's respiration before venipuncture and there were non-significant trends with fewer and shorter skin punctures during lullaby singing (Ullsten et al., 2017). These results indicate the potential efficacy of live infant-directed singing in neonatal pain management, given that one vital factor for not reaching significant results might quite plausibly have been the absence of parental participation in the study design.

In this theoretical article we present and discuss the biopsychosocial rationales for ratifying parents' presence in neonatal pain management in combination with live parental infant-directed singing (PIDS) and the concept of affect as the principal link between the infant's experienced pain and clinical interventions. Our aim is to synthesise concepts, theories and previous interdisciplinary research to better form the expectations and safety of PIDS as pain management. Before studying the PIDS intervention in vivo it is essential to hypothetically map the underlying analgesic aspects of this unexplored intervention, including the role of the music therapist in neonatal pain management. As a biopsychosocial framework for this article we refer to neuroaffective developmental psychology as defined by psychologist Susan Hart (2008, 2011). Neuroaffective developmental psychology integrates the

theoretical fields of modern neuroscience and developmental psychology in order to gain a deeper understanding of the complexities of infant development that take place in close interaction with the infant's caregivers. In our article, we will also expand on the neuroaffective developmental psychology synthesis by including research from neonatal music therapy.

Pain modulation is influenced by neurochemical processes

Pain arises from a distributed network of brain activity, none of which is unique to pain. When this network is synchronised it results in the sensory, emotional, motivational, and cognitive experience that constitutes pain (Verriortis et al., 2016). Dopamine, oxytocin, the endogenous opioid system, the anterior cingulate cortex and the insula, may all contribute to the emotional modulation of pain (Roy, Piché, Chen, Peretz, & Rainville, 2009; Swain et al., 2014; Uvnäs-Moberg, 2009). Emotions can have strong effects on pain perception; negative emotions increase pain, whereas positive emotions decrease pain (Roy et al., 2009). The neurochemical systems are innate and biological, but at the same time also dependent on and responsive to environmental stimulation. Nature and nurture are intertwined in neonatal pain experiences. Research has identified several hormonal and other physiological mechanisms mediating the effects of parent–infant proximity on attachment and pain (Rilling, 2013; Swain et al., 2014), such as dopamine and oxytocin. Affects seem to influence the transmission of pain information to somatosensory regions and modulate spinal pain processes and pain perception (Hsieh et al., 2014; Roy, Lebus, Hugueville, Peretz, & Rainville, 2012; Roy et al., 2009). When regulating interactions with the infant, the parent acts as the external regulator of the neurochemistry in the infant's brain as well as in the infant's endocrine and nervous system (Ham & Tronick, 2009; Pasiali, 2014).

Positive interactions with the infant, such as infant-directed singing, trigger, for example, activation of the neurotransmitter dopamine, which stimulates the reward centres in the infant's brain through the opioid system and inhibits cortisol receptors (Swain et al., 2014). Loving and enjoyable parent–infant interactions are important for the release of dopamine, which enhances curiosity and exercises the infant's nervous system to handle increasing levels of arousal. Pleasurable dopamine activation early in infancy, such as when parents sing and appreciate their infant, is important for the development of the infant's nervous system, for protecting the infant's brain from consequences of early-life stress and pain and for promoting attachment formation (Swain et al., 2014). Social affective interactions such as PIDS, with parents' positive facial and vocal expressions, also trigger the infant's endogenous opioid system, the body's internal morphine system, which releases anti-stress responses and has a generally calming

influence on negative arousal. Opioids are involved in regulating pain, joy and reward responses. High opioid levels lead to a sense of safety. Opioids, which are released in case of fear and of pain, have a calming effect and may reduce pain and stress, acting to modify the infant's mood and pain perception.

The neuropeptide hormone oxytocin is also a calming hormone which is a well-known component of a complex biobehavioural system and plays a crucial role in the infant's and parent's central nervous systems in establishing parental–infant attachment (Gerhardt, 2015; Pasiali, 2014; Seltzer, Ziegler, & Pollak, 2010; Swain et al., 2014). Oxytocin and the opioid system are closely related. Oxytocin may alleviate pain and reduce stress through increasing the sensitivity of the opioid system and enhancing the release of dopamine and endorphins (Uvnäs-Moberg, 2009). Parents' interactions with the infant enhance oxytocin and dopamine release in parents and promote the maintenance of positive parental behaviours such as attentiveness and sensitive caregiving (Rilling, 2013; Swain et al., 2014; Uvnäs-Moberg, 2009). Through soothing and comforting PIDS, the parent is regulating both his/her own oxytocin level and the infant's, because the oxytocin is released as a result of sensory stimuli such as vocalisation and facial expressions that express safety. Research with older children has shown that a mother's comforting vocalisations alone, can release oxytocin in the child after a stressful event, without involving direct physical or other types of somatosensory (perception of sensory stimuli from the skin and internal organs) contact (Seltzer et al., 2010). Both direct, interpersonal contact and vocal contact alone were effective at reducing the children's stress, although the condition involving touch resulted in a more rapid reduction and the effect in both conditions was maintained up to one hour post stressor (Seltzer et al., 2010).

A parent's sensitive care, helping the infant to self-regulate and attain homeostasis, seems to prevent hyperactivation of the stress response system, hypothalamic–pituitary–adrenal axis of the endocrine system (HPA). Research has shown that infant's and older children's distress during painful medical procedures is strongly influenced by the parents' sensitive behaviour such as the parents' facial expression and tone of voice during the procedures (Franck, Greenberg, & Stevens, 2000; McMurtry, Chambers, McGrath, & Asp, 2010; Pillai Riddell et al., 2011; Pillai Riddell & Racine, 2009). If a parent says, "it doesn't hurt", using a reassuring tone of voice while the child is hurting, the parent does not communicate a shared affect of the painful experience. Parents' vague and inauthentic attuned commands, like reassurance, might even increase child distress (McMurtry et al., 2010). If the parent turns to the infant saying, "it hurts but I am here for you", a different tone of voice is probably used. It is the latter that could be considered attuned to the experience of an infant in pain (McMurtry et al., 2010; Zwimpfer, 2017). When the infant and the parent experience a high

degree of control in a challenging or stressful situation, the event is not always experienced as distressing. It is the perception of the stressful experience that determines the amount of stress hormone cortisol that is released. Coping strategies or a sense of control reduce the negative experience of stress and therefore quickly bring the cortisol level back to normal (Gerhardt, 2015). What seems to be most crucial for an infant before, during and after a painful situation as well as for forthcoming painful experiences, is the extent to which the parent is emotionally available and stable, capable of noticing signals and able to regulate and share the infant's states (Pillai Riddell et al., 2011).

Sometimes it is not the parents' absence that is the problem for the hospitalised infant, but the quality of the parents' presence (Gerhardt, 2015). Since infants use their parents to regulate their own affective states and behaviours, they may both be the source of each other's stress. When infants and parents share affects, parents are also hurt when their infant is in pain. Prolonged early separation in the NICU and lack of parental involvement in the infant's pain management cause distress in the relationship between parents and infant and may lead to parental stress and depression, which impairs parents' capacity for parenting (Ahlqvist-Björkroth, Boukydis, Axelín, & Lehtonen, 2017; Flacking et al., 2012). Research has also documented an enhanced risk for post-partum depressions in mothers after caesarean sections, which per se delays and impairs the early mother–infant interaction (Velandia, Matthisen, Uvnäs-Moberg, & Nissen, 2010). Stress and depression raise the cortisol levels in the infant and the parent respectively, and raised levels increase the intensity of anxiety reactions, which in turn may increase the painful experience (Gerhardt, 2015). Cortisol also activates the HPA system, preparing the body for fight, flight or freeze response (Anderson & Patel, 2018; Ullsten, Eriksson, Klässbo, & Volgsten, 2016). Cortisol has a long-lasting effect on the organs and both deficient and excessive levels of activity in the HPA system can be harmful for the infant's developing nervous system and can divert energy from crucial brain development (Anderson & Patel, 2018; Hart, 2008).

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). There might be a risk of affect contagion if anxious parents, during the painful procedure, transfer their anxiety to their infant. Parents who are under stress, as they usually are during their infant's hospitalisation, are likely to have more difficulty in regulating their infants well (Gerhardt, 2015). Furthermore, some parents are overwhelmed by their infant's distress or have a depressive symptomatology or other mental health problems and are therefore less able to engage their own executive prefrontal cortex during infant crying and pain and may thus struggle to regulate their infant's negative reactions (Rilling, 2013; Swain et al., 2014). Parenting styles in humans are also likely to be passed down through generations, which explains in part why the neural and

behavioural variations of parenting are associated with a parent's own parental care experiences (Swain et al., 2014).

Affective sharing may modify the experience of pain

A shared secure base (Bowlby, 1969) may modify the experience of a painful procedure. A newborn infant has an innate capacity to communicate and share affects, which develops through the close relationship with the parents (Trevvarthen & Malloch, 2000). Communication takes place through the intentions and affects carried by the music-like qualities of the infant–parent joint vocalisation in combination with the joint dance-like gestures of their bodies and facial movements within a shared sense of time or a present moment (Malloch et al., 2012; Stern, 2005; Ullsten et al., 2016). This communicative musicality is essential for companionable parent and infant communication (Malloch, 2000). Trevvarthen speaks of an *intersubjective* ability to have and share purposes and emotions with other persons. The sharing of purposes is rewarding to the self (Trevvarthen, 2008; Trevvarthen & Malloch, 2000). Infants, as well as adults, need to share experiences in order to help make sense of them (Trevvarthen & Malloch, 2000).

Trevvarthen's description of intersubjectivity corresponds to Stern's concept of *affect attunement*, which is central in interpersonal relatedness and encompasses the sense of parental emphatic responsiveness (Ammaniti & Ferrari, 2013; see also Ainsworth, 1979). According to Stern (2000), the largest single reason for attuning to their infant, according to parents, is simply *interpersonal communion*; "to be with" the infant, "to share", "to participate in" and "to join in". More specifically, affect attunement enables sharing an experience of an inner state between the infant and the parent. This process begins when the parent matches the inner state of the infant without complete imitation of the exact behaviour (Stern, 2000). Infants have an innate general capacity to receive information derived from one sensory modality (e.g., hearing) and translate it into another sensory modality (e.g., motion). Such *amodal perception* (Stern, 2000), involving the audiovisual mirror neurons (Fogassi et al., 2005; Keysers et al., 2003), plays a key role in affect attunement whereby the intention, through the characteristics of intensity, timing and shape in the interaction, can be perceived by the infant and caregiver on an implicit level and evoke an interpersonal reciprocally related response from both parties. This creates an experience of emotional connectedness and a subjective experience of "I feel that you feel that I feel" (Stern, 2005, p. 91).

Dyadic regulation thus takes place through affect attunement, when the parent shares, soothes and consolidates the infant's inner state. The infant develops self-regulatory systems when his or her physiobiological rhythms interact with an emotionally available and stable parent in a predictable environment (Ham & Tronick, 2009; Sander,

1988; Tronick, 1989; Tronick et al., 1998). Most of the affective states involved in affect attunement are innate *vitality affects* (Køppe, Harder, & Væver, 2008). Vitality affects are connected to vital body rhythms and synchronies such as blood pressure, heartbeat and breathing, and to vital life processes such as becoming hungry or falling asleep (Køppe et al., 2008). The basis of parental attunement and of vitality affects is formed by *protomusical* elements such as intensity, contour, timing, temporal beat, rhythm, duration and shape, performed in infant-directed speech and infant-directed singing (Stern, 2000; Ullsten et al., 2016; Volgsten, 2012). The intensity profile in interpersonal interactions, that is, the change in intensity over time and the dynamic movement in this communication, is the foundation of vitality affects (Køppe, Harder, & Væver, 2008; Smeijsters, 2012; Stern, 2000). Vitality affects are present continuously in the background of all interactions and are sensed by subtle changes in, for example, the parent's vocalisations (Ammaniti & Ferrari, 2013; Dimitriadis & Smeijsters, 2011). Vitality affects are stabilised through regulatory protomusical affect attunement in parent–infant interactions (Ammaniti & Ferrari, 2013). This crucial early relationship can only take place when both parties are in a relatively calm and secure state and when the infant is ready for contact (Stern, 2000). An unpredictable environment, premature birth, illness and parental deprivation can hamper the infant's self-regulatory development (Verriotis et al., 2016).

Sharing is part of human life from the start. Social behaviour such as attachment and communication may even be established before birth through auditory experience (Moon, 2011). In the womb, the foetus grows familiar with the interior sounds of the mother, continuously enriched by the multimodal sensory environment; the steady rhythm of the mother's heart and breathing, her bloodstream's swoosh and the music of her prosody where the musical qualities of the voice are salient in the perinatal experience of speech (Moon, 2011, 2017; Moon, Lagercrantz, & Kuhl, 2013). From about three months before birth the foetus can hear a variety of sounds from the extrauterine world. This enables the developing foetus to share and acquire preferences for the family's music, culture and voices (Moon, 2011). The mother's behaviour, the way she moves and acts, also becomes familiar to the foetus and is reflected in her voice (Moon, 2011). The mother's voice is an element of connection, guaranteeing the continuity of prenatal and postnatal life (Nöcker-Ribaupierre, 2004). For the newborn infant, the mother's voice – along with other developmentally appropriate sensory events such as touch, light, smell and movement – is a predominant source of multimodal stimulation and regulation (Fancourt & Perkins, 2018; Krueger, 2010; Lickliter, 2011). Prosody, or the emotional expressions in the parent's voice together with his or her gestures and touch, may well be the most multisensory part of our language; the primary form of communication for infants and parents across cultures (Fernald, 1989;

Huotilainen, 2013; Rock, Trainor, & Addison, 1999). The soothing and comforting emotion regulation properties of a lullaby are well known cross-culturally and historically (Fernald, 1989; Rock et al., 1999; Shenfield, Trehub, & Nakata, 2003). The newborn infant enters a multisensory field of affective resonance with the parent via prosody, facial expressions, eye contact, body movements and timing, and through this resonance, infant and parent share and engage in each other's nervous systems (Ham & Tronick, 2009; Tronick et al., 1998).

Parental singing as social affective pain alleviation

Both pain and music are complex phenomena, described as subjective, multidimensional, perceptual, contextual, biopsychosocial experiences. A biopsychosocial model of pain requires acknowledgement of sociality (Williams & Craig, 2016). In a painful context, it is important to recognise the reciprocal relationship between the infant and the parent. The infant will be sensitive to the parent's behaviours, which will influence the infant's pain expression (Pillai Riddell & Racine, 2009). Multimodal interventions applied by a parent have been shown to alleviate procedural pain in infants (Bellieni et al., 2007). A combination of maternal soothing behaviours has shown to decrease infant reactivity in a painful situation (Jahromi, Putnam, & Stifter, 2004). The combination that was most used among the mothers and most effective at reducing all levels of infant distress, was holding/rocking together with soothing vocalising behaviours (Jahromi et al., 2004). Singing with an infant is a social and often multimodal action, which includes rhythmically organised auditory, visual, olfactory, tactile, kinaesthetic and vestibular modalities (Longhi, 2009; MacKinlay & Baker, 2005; Trehub et al., 2015). Infants prefer infant-directed singing and infant-directed speech to adult-directed speech (Fernald, 1989). Infants prefer music to speech (Edwards, 2011). Good-enough singing is better for maintaining emotional regulation than using infant-directed speech during painful procedures (Zwimpfer, 2017). Infant-directed singing sustains infant attention without over-stimulation in contrast to infant-directed speech or motherese, which may result in cycles of heightened arousal and re-engagement (Nakata & Trehub, 2004; Ullsten et al., 2016). Lullaby singing is one of the principal infant-directed song genres (the other one is play songs), and its repetitiveness 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). The regular pulse of a lullaby soothes not just the infant, but also the parent (Fancourt & Perkins, 2018; Ham & Tronick, 2009; MacKinlay & Baker, 2005).

Parents have reported that being in the NICU with their infant is like being spectators of their own lives, like attending a parent school and being constantly evaluated by the

staff (Edwards, 2011). To use the voice and sing in this situation is a challenge to many parents. Parents might feel shy and inhibited about singing, especially in a multibed NICU design where the environment includes loud ambient noise, stress and unfamiliar situations (Edwards, 2011; Shoemark & Arnup, 2014). A family-friendly NICU with family rooms for couplet care, or beds and privacy within the given design as well as a nurturing unit culture, which removes all restrictions with regard to parents, may enhance parent–infant closeness around the clock (Flacking et al., 2012). However, research by Shoemark & Arnup (2014) shows that most of the mothers in the NICU (60%) sing spontaneously to their infants. Despite feelings of inadequacy, parents can imagine themselves singing to their infants even during a painful procedure, knowing it will calm the infant and help both themselves and their infant to cope with the pain:

The blood sampling procedure is horrible but the singing created a warmer and cosier atmosphere in the room, helping us to focus on our baby's feelings... if the staff would support us and encourage us to sing during the procedure, then I would absolutely do it, but I would like some hands-on information in advance about how to sing. (Father, personal communication after a lullaby intervention during venipuncture, February 9, 2013)

Surveys show that both nurses and parents are positive toward using music and singing in the NICU (Arnon et al., 2006; Loewy et al., 2013; Pölkki et al., 2012a, 2012b; Shoemark & Arnup, 2014). Parents have described that parent-preferred music, both recorded familiar songs and interactive infant-directed singing, increases the feeling of security and decreases crying, stress and pain in their infants (Pölkki et al., 2012a).

An impediment to parental-driven nonpharmacological pain management, including PIDS, might be a risk for classical conditioning, also called Pavlovian conditioning. According to the behaviourist psychological approach and the stimulus-response theory, animals can associate stimuli with each other (Parncutt, 2009). Parncutt (2009) suggests that this also applies to the human foetus, who can associate patterns of sounds with emotions. This should imply that an infant might learn to associate the parent as a person and/or the parent's voice and singing with pain, if the parent routinely sings or plays music to the infant prior to skin puncture. The stimulus-response principle is not applicable in PIDS, since the vocal communication in PIDS is live and constantly attuned to the infant's inner state. PIDS is a multisensory dialogue responsive to the infant's expressions of pain, distress or pleasure (Fellman, 2017). If an emotionally available parent is constantly altering the timing, intensity and shape of the singing and the actions according to the infant's affective behaviour, the parent's vocalisation and the parent as a person will not become a conditioned stimulus associated with pain. The risk of

classical conditioning is probably more pronounced if the skin puncture is accompanied by recorded music or a parent's recorded voice. In neonatal pain research, recorded music during skin puncture is considered to be a simple, convenient, inexpensive and complication-free intervention (Azarmnejad et al., 2015; Kurdahi Badr et al., 2017). The main author of this article has elsewhere argued against superficial use of music in neonatal pain management (Ullsten, 2017). Infant-directed communication, both speech and singing, can be simulated in recording sessions, but this are not interactive and contingent on the infant's responses (Filippa et al., 2017) and the voice is auditory only, not multimodal (Moon, 2017). The parent's prosody cannot be reduced to an acoustic signal. A parent's positive and soothing voice and touch is powerful. Love and joy are important elements to provide a secure, safe and shared emotional base. Painful and noxious stimuli will be overpowered by the parent's positive, soothing affect and attuned sharing, and the infant will learn that security and comfort will come from the parent, not pain (L Franck, personal communication, March 28, 2017).

Implications for music therapy in neonatal pain practice

Music is an expected part of parenting in most cultures of the world (Shoemark, 2013). Research shows that bonding, interacting, communicating, comforting, encouraging family togetherness, so-called social caregiving (Custodero & Johnson-Green, 2008), is the main reason for parents to sing to their hospitalised infants (Shoemark & Arnup, 2014). In order to feel comfortable in singing and "musicking" with their infants, most parents have stated that they need more guidance from staff and role models on the unit (Pölkki et al., 2012a). To achieve the benefits that PIDS can offer, a music therapist specialised in neonatal music therapy methods may function as a guide and a mentor for the parents to use their voices in the NICU (Edwards, 2011; Shoemark, 2017; Shoemark, Hanson-Abromeit, & Stewart, 2015; Whipple, 2000). The notion that humming is as meaningful as singing is a relief for many parents, who feel overwhelmed by the idea of singing in the seemingly public space of the NICU (Edwards, 2011).

Crying is the most evident signal of infant distress. Infant crying prompts caregiving interactions aimed at relieving the situation. When newborn infants cry, they cry with a melody and with intensity contours that are prosodically typical for their native languages (Mampe, Friederici, Christophe, & Wermke, 2009). This research shows that infants can memorise and reproduce the main intonation patterns of their mother tongue. Infant's innate tendency to entrain to sounds, voices and affects, is a principle that may be used by the parent to regulate the infant's cry in a painful situation. Tonal vocal holding (Loewy, 1995, 2004) is an intervention that uses purposeful

breathing and the voice to match the tone and the timbre of the infant's cry or vocal expressions (Bradt, 2013; Loewy, 2013). The parent's voice may assist the infant in regulating and transitioning from negative behavioural states, e.g., inconsolable crying, enabling a conservation of resources. Infants who are in pain might withdraw from interaction, but the musical framing of the infant's cry opens the potential for interaction and provides comfort, support, release of tension and a shared feeling of being heard during painful procedures (Bradt, 2013; Loewy, 2013). Instinctively, parents might want to calm a distressed infant without first matching the infant's distress, indirectly leaving the infant to calm down on his/her own (Hart, 2011). If the parent in connection with the infant's painful procedure first shares the infant's affective state and adapts to the infant's rhythm, before trying to calm the infant, the infant will feel supported by the parent in a shared attuned down-regulating process. The synchronisation and control of a physiological rhythm by an external stimulus requires *entrainment* (Loewy, 2015; Sander, 1988). The parent should use the singing to match the level of the infant's emotional intensity, gaining an emotional connection, before he or she gradually modifies and fine-tunes the style of singing to encourage parent–infant intimacy, calmness and sleep (MacKinlay & Baker, 2005). The parent alters this biopsychosocial attunement gradually, following the iso principle (Wigram, Nygaard Pedersen, & Bonde, 2002), leading the infant into a new but safer affective state, regulating the infant through social biofeedback and signalling to the infant that he/she understands (Gerhardt, 2015).

A central focus of both neonatal music therapy research and neonatal music therapy practice is the family-centred approach, where the parent and infant are considered to hold the primary relationship, while the music therapist holds a supportive external role. A music therapist works through partnership to support parents to understand and be sensitive to their infant's cues and encourages the parents' own potency to parent a sick infant and to find strategies they can use to interact with their infant (Edwards, 2011). Familiarity is a key component of music, which can provide comfort in a painful situation (Thompson, 2013). The neonatal music therapist recognises the family's pre-existing musical preferences and parent's preferred songs in the therapy and can coach parents how to use entrained and attuned live lullaby singing and infant-directed *songs of kin* (Loewy, 2015; Loewy et al., 2013). The song of kin is a melody that is identified by the parent and has been used within a family's history or is representative of the culture of that family's community (Loewy et al., 2013). A song of kin may be a religious song, a nursery rhyme, a lullaby, or a self-composed melody. Songs of kin are implemented as lullabies in the attuned moment-to-moment changes of the infant–parent relationship. Psychotherapeutic music sessions just for the parents, which offer potent non-confrontational support, are also part of the NICU model Rhythm, Breath, Lullaby (RBL), where the parents are

encouraged to use their voices with their infants (Loewy, 2015). When parents are coached to entrain to their infant's breathing rate or activity level, the parents attune to their infant's needs better as well as enhancing the infant's behaviour and physiology (Loewy et al., 2013). Parental stress significantly decreases when parents are encouraged to use their own voices to soothe their infants with a song or a lullaby of their own choice (Loewy et al., 2013).

Parents have found it helpful to use PIDS to communicate with their vulnerable infants and they feel empowered in their new parental role (MacKinlay & Baker, 2005; Vuong, 2013; Whipple, 2000). Parents have described (MacKinlay & Baker, 2005) how lullaby singing helped them to keep in control because they felt as though they were doing something to help their infants. Lullabies provided a tool up their sleeve that the parents knew would work to calm down their infants (MacKinlay & Baker, 2005), as well as providing the parents with a tool they could use beyond the NICU, at home (Shoemark et al., 2015).

Conclusions

Music engages social human beings in reciprocal communication, bringing to mind the original sense of the word *communicare*, signifying sharing and partaking (Volgsten, 2015). Music is a social-cultural phenomenon that shares the same elementary properties as infant-directed communication (Volgsten, 2012). The protomusical elements intensity, contour, tempo, rhythm, timbre, dynamic and shape, bear resemblance to the structure of human affects without being confined to a particular emotion. Singing thus affords easily repeatable and recognisable affective patterns to which the parent–infant dyad may attune (Longhi, 2009; Volgsten, 2012; Volgsten & Pripp, 2016). Vitality affects help the infant to orient him/herself in the environment. Everything that an infant experiences, including pain, has its own vitality affect. Vitality affects are interwoven on a physiological, psychological and social level. As we have presented in this article, pain is influenced by physiological, emotional and social experiences. Pain induces vitality affects, which vary between each individual in terms of timing, intensity and shape. By means of these biopsychosocial protomusical features, that PIDS also comprises, an emotionally available and well-informed parent may use the infant-directed singing to entrain to the infant's affective state and gradually modify and fine-tune the style of singing to match, share and modulate the intense dynamic vitality affects of the painful experience.

Regardless of physical restrictions, vocal interaction is a means of social communication and affective and physiological regulation, a readily available platform for parent–infant interactions, which offers an affective relation between the parent and infant. We have in this article presented rationales that explain how and why neonatal music

therapy may offer safe parental-driven interventions, which may improve procedural pain care for both infants and their parents. Biopsychosocial interventions do not just help the infant to cope with procedural pain, they literally reduce pain. PIDS can serve as an important nonpharmacological affective regulation intervention, where the music therapist, specialised in neonatal music therapy methods, can mentor parents to use entrained and attuned live infant-directed singing in connection to painful procedures. Along with many other parental-driven nonpharmacological interventions, the multimodal PIDS offers the parent–infant dyad experiences of pleasure, happiness, love and joy instead of pain, worry and fear. Shared pleasure has the capacity to dissolve a negative painful affective spiral. Shared positive affects and healthy parent–infant interactions enhance the release of endogenous pain-alleviating hormones and opioids in both infants and parents, which promotes pain relief and attachment formation. A research area of great future interest would of course be to assess the pain-alleviating potential of the multimodal parental infant-directed singing in vivo, where parents, coached in PIDS by the music therapist, use amodal perception to soothe and regulate the infant as a preparation before the painful procedure, share and comfort the infant during the procedure, and offer recovery after the skin puncture in an attuned down-regulating process. The theoretical biopsychosocial rationales give opportunities for PIDS and neonatal music therapy to be included in the gold standard for nonpharmacological neonatal pain management.

Contributorship

AU researched literature, conceived of the study and wrote the first draft of the manuscript. AU and UV conducted the analyses. All authors contributed to the article, reviewed and edited the manuscript and approved the final version of the manuscript.

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