The impact of home musical activities on language development in infants born prematurely

A thesis submitted to Middlesex University in partial fulfilment of the requirements for the degree of Master of Science by Research

Student: Maria Chifa, M00575168

DoS: Dr Fabia Franco

Department of Psychology

Middlesex University London

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Abstract

Fast-growing evidence supports that musical activities positively impact children`s overall development, especially language development. However, little research has been conducted regarding the relationship between the home musical environment and language development in infants born prematurely, a population at risk for language delays and impairments. The present study investigated the influence of early musical experience (including parental singing) measured by the Music@Home questionnaire (Politimou et al., 2018), while controlling for general enrichment at home (STIMQ, Dreyer et al., 1996) as well as perinatal PTSD (PPQ) (Callahan et al., 2006), on language development measured by CDI-UK (Alcock et al., 2020). A sample of 145 infants between 8 and 18 months (corrected age) was divided into two groups: [1] main sample (n=117) – infants without any suspected or identified areas of difficulty; [2] sub-sample (n=28) – infants with suspected or identified areas of difficulties, to avoid the introduction of a confound which might have affected the language scores either because of prematurity or other neurological conditions. Based on the main sample, unexpectedly, results revealed that infants did not experience language delays. As hypothesised, results showed that home musical environment significantly predicted infants` comprehension and gestural communication, independently from infants` corrected age. Additionally, gestural communication was predicted by infants` gestational age, which emphasises that prematurity impacts language development. Interestingly, even in the group with suspected disability, music at home facilitated language development. These findings constitute the first demonstration that an enriched musical environment can enhance development of communication skills in a population at risk for language delays, namely infants born prematurely, opening the path for future intervention research and offering encouragement to families of preterm infants. The participants in this study were representative of middle/upper class, highly educated parents, hence future research must specifically focus on lower class, less educated families.

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I finally extend my gratitude, and dedicate a poem, to all the participants that took some time and kindly completed this survey, particularly to the parents of children with suspected or identified difficulties as they gave me the opportunity to have an insight into an approach that can support their infants` language development!

Unspoken words

Sweet, sweet child,
How could you talk,
When instead of words
You've been surrounded by noise?

How would you know what I say
When things happened the wrong way?
I didn't have the chance to whisper to you,
Except rarely, during Kangaroo...

I did not sing you 'goodnight songs',
Nor did I say early morning words.
You seldom heard me saying something
And that made me feel I'm crushing.

But if you cannot say a word,
Smile to me, and I'll have the world.
Smile and laugh,
And that will be more than enough.

There is time for us to start over,
To say what wasn't said just yet,
To get to each other closer
Like we, for the first time, just met.

Preface

The academic work conducted during my MSc by Research has comprised two parts: [i] refining the analyses and writing up as a paper the research conducted for my undergraduate dissertation on the caregivers' perception of the Neonatal Intensive Care Unit soundscape, which is now published in the open access cross-disciplinary journal Children[1] and is attached here at the end of the Appendix section; [ii] new research on one particular aspect of the sound experience in the post-discharge life of prematurely born infants, i.e., home musical interactions and their impact on early language development, which is a developmental area in which preterm children are typically delayed – this is reported in the main body of this dissertation, and will be written up for publication as a new paper.

[1] Chifa, M., Hadar, T., Politimou, N., Reynolds, G., & Franco, F. (2021). The soundscape of neonatal intensive care: a mixed-methods study of the parents' experience. *Children*, *8*(8), 644.

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1. Introduction

This study aims to investigate whether language development is affected by musical activities that prematurely born infants are exposed to in their home settings while controlling for other factors, such as different types of play activities at home and parental stress. It is important to explore factors underlying language acquisition in preterm infants because it is generally reported that this infant population often experience language delays (Nguyen et al., 2018). For instance, Cusson (2003) investigated 43 mother-infant dyads (infants born <36 week gestation and < 2kg birthweight) assessing neonatal behaviour using the Neonatal Behavioural Assessment Scale – NBAS (Als et al., 1977), maternal sensitivity during face-to-face mother-infant interaction videotaped at 7 months, and general development and language outcomes at 26 months, corrected age, using Bayley Scales of Infant Development (Bayley, 2006); and Reynell Developmental Language Scales (Edwards et al., 1999). The results showed that factors such as length of hospital stay, birth weight, Apgar scores, infant irritability and state regulation at hospital discharge all had an influence on language delays. The present study will therefore focus on early language developmental outcomes in function of concurrent music and play interactions at home and individual differences in birth variables and parental stress.

1.1. Early language development in neurotypical infants

Since hearing is well developed in the last three months of pre-natal life, it has been suggested that language starts developing in utero by sound differentiation. More specifically by discrimination of speech sounds; melody perception and voice recognition (Lecanuet et al., 1993; Vouloumanos et al., 2010). This continues throughout infancy when infants are able to discriminate the phonetic contrasts of language as well as mother`s versus stranger`s voices (Beauchemin et al., 2011; Lee & Kisilevsky, 2014; Sato et al., 2012; Vouloumanos et al., 2010). Moreover, the melody of infant crying at birth reflects the prosody of the native language (Mampe et al., 2009).

In early infancy, language patterns are fundamentally perceived as melodies and reflected in infants` initial sound utterances (D'Odorico et al., 1985; Locke & Bogin, 2006;), while mastering melodic contours, durational features and amplitude will be reflected in the coupled advancement of phonation and articulation required for successful speech production and associated with the communication of pragmatic meanings (D'Odorico & Franco, 1991; Snow, 2006; Wermke & Mende, 2006). At 3 months, non-native language-specific sounds are produced, while from 6 months the language-specific perceptual reorganisation begins starting with vowels (Kuhl, 2004). During this period, social interactions, if delivered contingently, with infant vocalisations can increase babbling and vocalisation (Goldstein et al., 2003).

The next stage of speech and language acquisition includes phonating, with jaw movements, and eventually organised syllables (reduplicated and variegated babbling) reflecting prior exposure to speech (Locke & Bogin, 2006), in the sense that native language begins to be recognisable (Boysson-Bardies, 1991). Furthermore, important developments of cortical areas responsible for improvements of working memory and pattern recognition occurs (Kuhl et al., 2003; McMahon et al., 2012). During the second year of life, language acquisition is influenced by the multiplication of associations between different cortical processing areas, reflected in a rapid increase in the number of words a child understands and produces (Chorna et al., 2017). Parental input plays a critical role, with the amount of speech exposure being associated with superior language development outcomes (Fernald et al., 2013; Romeo et al., 2021; Weisleder & Fernald, 2013).

1.2. Language delays in preterm infants

Unlike most infants, premature infants have a more challenging journey with their language development. This introductory review will present the challeges of premature birth for language development and the influence of other factors, such as perinatal stress in parents or how enriching activities influence this process.

Every year, approximately 15 million infants are born before term worldwide (WHO, 2015) with around 60,000 in the UK (Bliss, 2019). An infant is considered premature, if s/he is born earlier than 37-week gestation (extremely preterm: <28 weeks; very preterm: 28–32 weeks; and moderately to late preterm: 32–37 weeks). The average length of the stay in Neonatal Intensive Care Units (NICU) for infants born under and up to 27-week gestation is 92 days, compared to 4 days of hospitalisation for infants born at full-term (over 37-week gestation) (Bliss, 2019). Risks of delays or impairments in cognitive and language development are more prevalent in preterm than full-term births (Hirvonen et al., 2018; Stolt et al., 2007). Even a small loss of hearing or difficulty with attention can have a profound effect on learning, communication and emotional bonding (Kuhn et al., 2017; Moon, 2017; Vohr, 2016). The aetiology of these weaknesses is likely to be multifactorial (Stipdonk et al., 2016), with risk factors being related to preterm birth and the iatrogenic effects of neonatal intensive care (Zimmerman & Lahav, 2013).

For various reasons, prematurity, particularly if associated with very low birth weight, is linked to poor language development outcomes in the early years (Zimmerman, 2018). The last trimester of gestation is crucial for foetal brain development, with rapid development of neurons and wiring, however, the interruption caused by premature birth slows down this process. This link had been found to be inverse linear, in that the earlier a foetus is born, the poorer language skills s/he might have and the higher risk for language delays (Boyle et al., 2012; Quigley et al., 2012). François et al. (2021) found attenuated brain responses to speech sounds in moderate prematurely born infants. Additionally, and importantly, the environment that preterm infants are exposed to after birth is different compared to full-term infants, by lacking high exposure to human voice, which is essential for language development (Filippa et al., 2017; Moon, 2017; Saliba et al., 2018; Webb et al., 2015) and by being immersed in an acoustically aversive soundscape of medical machines (Chifa et al., 2021). In the NICU, the voices, when present, are masked by electronic, non-biological sounds which may occur 24-hours a day, making it difficult to distinguish foreground from background sounds at 60Db or to filter out and process noxious stimuli (Gray & Philbin, 2004; (Smith et al., 2018). Voices can positively affect also cardiorespiratory stability (M. Scala et al., 2018), as well as feeding and growth factors (M. L. Scala et al., 2020) and reduce pain thresholds (Filippa et al., 2021), yet, despite being so important they might even be excluded by the incubator (Lester et al., 2016),

A large body of research has been researching the frequency of language delays in preterm children. For example, D'Odorico et al., (2011) analysed two groups of participants: 24 preterm and 15 full-term Italian children. At 12 and 18 months, participants` verbal production in play sessions was recorded and at 24 months, the MacArthur-Bates CDI parental report was administered (Italian: PVB) (Caselli & Casadio, 1995). By comparing the data from the two groups, the results showed that premature infants` had reduced involvement in the language process and poorer receptive and productive vocabularies compared to their full-term peers. Additionally, Gayraud and Kern (2007) further stressed that preterm children significantly differ from full-term children in vocabulary size and composition. The study used the French MacArthur-Bates CDI parental report to collect data from 323 preterm and 166 full- term children at 24 months. Results showed that preterm children produced fewer words and their vocabulary included phonetically simpler words than their full-term peers at 24 months (Gayraud & Kern, 2007).

Furthermore, Nguyen et al. (2018) longitudinally investigated the language acquisition trajectory in 224 preterm and 77 full-term children, from 2 years old to 13 years old, assessing the participants at 2, 5, 7 and 13 years, using an age suitable measure at every period. The results demonstrated that prematurely born children had lower functioning across all components of language, even at the age of 13. Despite the literature showing that it is expected that preterm children`s language development will catch up in time to a certain degree (Luu et al., 2011; Luu et al., 2009), early severe delays, which are more common in the lowest gestational age group, predict a higher risk for persistent language delays throughout the preschool years, and these delays are linked further to academic struggles as well as socioemotional and behavioural issues (Zambrana et al., 2021).

1.3. Parental stress and background affect language development in preterm infants

Parental involvement is crucial for language acquisition, especially in the first years of an infant`s life (Neuhauser et al., 2018). The quality of children`s interaction with parents during the daily routines, such as nursing and other caregiving tasks represents a source of learning and connecting to each other. Thus, the interaction behaviour can be grouped into two main components; sensitivity and stimulation (Linberg et al., 2020; Vallotton et al., 2017). Sensitivity is described by the warm, accepting, prompt and contingent responses which parents use to provide their children with affective, vocal and gestural cues (Ainsworth et al., 1974; Shin et al., 2008). Stimulation is described by the activities that parents and children perform together and that stimulate and nourish children`s cognitive skills (Bradley et al., 2003).

Overall, there is solid evidence to suggest that mother-child verbal interactions enhance language skills, with the amount of speech directed to infants being positively linked to vocabulary at 18 months (Fernald et al., 2013; Weisleder & Fernald, 2013) 30, 38 and 40 months (Wade et al., 2018) and child-directed conversational turns predicting language ability in older children later (Romeo et al., 2021). However, in the context of the preterm birth, parent-child interaction can be drastically damaged in that caregivers might not have the opportunity to notice and respond to infant`s cues while also being impeded by the medical equipment or clinical state of the infant preventing the ability to provide the quality and quantity of experiences that a full-term infant might benefit from. Furthermore, having a child born prematurely can cause stress and impaired role adaptation to the parents, and parents of preterm infants are at risk of developing PTSD symptoms (Suttora et al., 2014). For instance, Chifa et al., (2021) revealed that parents who spent some time in NICU with their infants reported PTSD symptomatology also in association with the aversive NICU sounds, and that their communication with the baby was affected by such noises. Thus, parental mental health is an important variable to consider when investigating environmental factors that may impact on children`s language development.

It is widely accepted that parental mental health, such as anxiety, depression and PTSD, are linked to infant development (Mensah & Kiernan, 2010). For instance, maternal depression, especially when chronic and prolonged, has been previously linked to poor child cognitive, language and social skills (Goodman et al., 2011). Moreover, it has been suggested that the caregiving environment is even more influential on infants born preterm than their full-term peers. This could be explained, on one hand, by the fact that preterm infants may suffer from brain abnormalities which may lead to difficulties in biological and behavioural regulation (Inder et al., 2005). Thus, they might need more support from the caregivers to regulate their behaviour and might be negatively affected by their caregiver`s emotional state. On the other hand, it is possible that parents, being aware of their preterm infants vulnerability, might put extra effort into providing suitable stimulation, hoping to compensate the initial difficulties, which might lead to infant`s higher than expected cognitive functioning (Gueron-Sela et al., 2015). These two alternative scenarios may interact with socio-

economic status (SES) and educational levels of the caregivers. For instance, Wild et al. (2013) investigated the impact that SES has on language development in preterm children born below 32 weeks gestation in US. The participants were two groups of families (65 children in each group): one with Private insurance (P-Ins) *vs*. one with Medicaid-type insurance (M-Ins) whose infants had been administered with the Bayley Scales of Infant Development III (BSID-III) at 22 months. The results showed that the BSID-III Language Composite scores were lower in M-Ins than P-Ins (87.9 ± 11.3 vs. 101.9 ± 13.6). Moreover, Patra et al. (2016) suggested that maternal education is the most powerful predictor for language development, motor and cognitive skills in infants born preterm at the age of 20 months. Indeed, Sentenac et al., (2020) investigated the correlation between maternal education and language development in children born below 32 weeks gestations. Children`s language skills were assessed using CDI at 2 years of corrected age, focusing on expressive language. The results suggested that low maternal education significantly increased the risk of expressive language delay, which reference to children`s incapability of combining words and forming multi-word utterances and very poor expressive vocabulary (Sentenac et al., 2020).

1.4. Music – an aid for language development?

Given the numerous factors that negatively impact language acquisition, it is essential to consider factors that have been shown to positively affect early communication and language, as they may have important implications for the support of premature infants and their caregivers. One such factor is music - a broad term which can be expressed in various forms. Numerous studies suggest that even informal musical experience in infancy and childhood is associated with better communication and language development outcomes (Francois & Schön, 2011; Politimou et al., 2019; Schaal et al., 2020; Schön et al., 2008). Although it is not clear yet why and how music may support language, one hypothesis is that musical interactions support attention via the music regular beat, which increases predictability (Schön et al., 2008). It is also possible that phonetic alterations associated with singing (e.g., vowel expansion) would also contribute to more easily discriminable stimuli (Falk, 2009; Falk et al., 2021). Could it then be possible that premature infants supported by an enriched musical home environment could show a significantly smaller delay compared to their peers from less musically active families? Based on the above literature, this is the hypothesis of the present study.

Perhaps, the most interesting and easiest type of music to engage infants with is within the infant-directed (ID- henceforth) register, which characterizes daily interactions with babies in their home settings. ID-Speech is defined by high pitch, lower tempo, repetition of short sequences, sustained pauses (Fernald & Kuhl, 1987; Fernald et al., 1989) and represents a key component of responsive parent-infant communication (Lam-Cassettari & Kohlhoff, 2020). It has been suggested that its characteristics may be described as more 'musical' (Papoušek & Papoušek, 1995), and it has been shown that infants prefer ID-Speech, listening to it significantly longer compared to adult-directed speech (Fernald, 1985; Pegg et al., 1992; Thiessen et al., 2005). These aspects make infants` language acquisition easier (Golinkoff et al., 2015). Consistent adaptations have been found in ID-music, particularly singing (Trehub, 2003; Trainor & Zacharias, 1998), with infants even displaying a strong preference for ID-Song over ID-Speech (Tsang et al., 2017). In turn, recent studies have found that neurotypical language development is indeed positively associated with early language outcomes (Falk et al., 2021; Franco et al., 2020; François et al., 2017; Gerry et al., 2012; Papadimitriou et al., 2021; Zhao & Kuhl, 2016).

There is evidence suggesting that parental mental health may impact not only on parenting skills in general, but also specifically on the set of communicative adaptations pertaining to the ID-register, thus potentially hampering infants' language development. For instance, Lam-Cassettari and Kohlhoff (2020) found that depressed mothers used less frequently IDS compared to non-depressed mothers,

and D'Odorico and Jacob (2006) showed an attenuated ID-register in the speech of mothers of infants identified as 'late talkers'. Consistently, various studies demonstrated that infants who experienced less IDS input showed poorer language development by their second year of life (Ramírez et al., 2020; Ramírez-Esparza et al., 2017). Although premature infants show the same preferences as infants born at full-term for the ID-register (Filippa et al., 2018), they might spend the first weeks or months in hospital, hence their exposure to infant-directed speech and song can be dramatically reduced by the

1.5. Controlling for other stimulative activities

However, not only music can positively impact language development, but so too can other various activities and interactions within families. For instance, object exploration, both oral (i.e., mouthing) and manual (i.e., turn, rotate, transfer, fingering), are considered key abilities that predict subsequent achievements. Zuccarini et al. (2017) investigated whether object exploration in linked to language skills and concluded that the amount of time a preterm infant spends exploring an object at 6 months contributes to predicting hearing, language and cognitive skills at 24 months. That might be explained by object exploration providing infants, the opportunity to practice skills that are critically shared with language, allowing them to experience changes in the relationship with the object, as well as with the people who are relevant for communicative development and language acquisition(Iverson, 2010). Another study revealed that infants, both at the age of 6 and 9 months, vocalised more often and produced vocalisation with consonants during mouthing (Fagan & Iverson, 2007). Parents can therefore encourage object exploration in infants by providing suitable and age-appropriate toys.

Book reading or nursery rhymes are activities that can begin pre-birth, continue in the NICU and at home, after discharge. Of these activities, shared picture book reading is one of the most explored aspects and has been found to support language development (Bus et al., 1995; Flack et al., 2018; Mol et al., 2008). Although the majority of parents report that they start to read to their infants when they are approximately 6 months (Niklas et al., 2016), in the case of preterm birth, there are various programs, such as the Newborn Individualized Developmental Care and Assessment Program (NIDCAP), that encourage parents to read to their infants soon after birth. Book reading facilitates infants` exposure to live voice and encourages parents to produce words for their preterm infants (which can be difficult in NICU).

The benefits of book reading on language development has been largely investigated in full-term infants (Canfield et al., 2020; Duursma, 2014). For instance, Karrass and Braungart-Rieker (2005) implemented an interventional study with n= 87, 8-month-old babies, in which reading picture books was found to predict laboratory language measures at the age of 12 and 16 months. Reading books at 4 months did not predict language. Less attention has been devoted to exploring this topic with preterm infants. Recently, Neri et al. (2021) investigated possible advantages of book reading while in NICU. Fifty-five infants were in the reading group and 45 infants were in the control group. Infants language and hearing skills were assessed using the Griffith Mental Development Scale (Griffiths, 1996) and the results showed that the reading groups performed significantly better than the control group. More precisely, in both groups, the hearing and language mean decreased between 9-18 months, however, in the reading group, the decrease was significantly lower than in the control group.

1.6. Summary and hypothesis of the current study

The research outlined above demonstrates the importance of a nurturing environment to support language development in preterm infants. Although there is abundant literature investigating the causes underlying delayed language development in preterm infants compared with full-term infants, the literature is scant when considering the ways in which parents of preterm infants may support

their language development at home, in everyday settings post-discharge from NICU. Therefore, this study aims to:

1) investigate the effects of two types of self-reported enrichment [i] level of home musical activities and [ii] level of book readings and play stimulation. The main hypothesis is that high scores in caregivers' musical activities with infants will predict language development over and above general stimulation. Language development will be measured using the most commonly adopted parental report, MacArthur-Bates Communicative Development Inventories: CDI-UK adaptation (Alcock et al., 2020) Words & Gestures form, suitable for the first phase of language acquisition

2) model the relative impact of parental variables, such as perinatal stress measured with the PPQ (Callahan et al., 2006) and education, while including crucial infant demographic information, such as gestational age and weight at birth, as well as the corrected age[2] at the time when completing the survey. In general, gestational age and corrected age are expected to be positively correlated and birthweight negatively correlated with language development. Based on the literature reviewed above, parental education is expected to be positively correlated with infant language outcomes. The effects of perinatal stress could be either negatively (Goodman et al., 2011) or positively (Gueron-Sela et al., 2015) associated with the dependant measures.

Given that ID-music has been shown to facilitate language acquisition in infants born at term, the main hypothesis of this study is that premature infants exposed to higher levels of home musical interactions will display superior language outcomes than infants exposed to lower levels of home ID-music. Should this hypothesis be supported by the research results, this study could help providing recommendations that will contribute to closing the gap between preterm infants` language acquisition and their full-term peers.

In order to control for the influence of other (non-musical) forms of enrichment on language development in premature infants, we also included measures of general enrichment (e.g., toys) and book reading. Based on previous findings with full-term infants (Papadimitriou et al., 2021), the present study hypothesises that musical interactions will support language development independently and over general enrichment also in this preterm sample.

2. Method

2.1. Participants

Native English-speaking participants from English-speaking and other countries were recruited via social media such as Facebook and Instagram, as well as via the researchers' personal and professional networks (e.g., Whittington Baby Charity, London). Inclusion criteria were that participants had to be native English speakers/have English as the home language, their child being born < 37-week gestation, and who was, at the time of completion, between 8-18 months corrected age. From the total number of individuals who accessed the survey initially, the following were excluded due to : [i] not completing all the questions of the survey (N=383), completing rate being between 14% - 77%, [ii] having children outside the range reported above (N=10), [iii] not being native English speakers (N=2). A total of N=145 were included in the analyses with a complete response set. Respondents were only

[2] Corrected age, or adjusted age, is premature baby's chronological age minus the number of weeks or months s/he was born early.

female (100%) and they were the premature infants' mothers, with a mean age of 31.14 years (*SD*=5.66). Detailed information about the sample is reported in Tables 1, 2 and 3. The 74.5 % of the parents that completed the survey had at least a bachelor's degree or another degree/diploma of equivalent and 62.1% were in professional or managerial jobs. With respect to the siblings, 60% of infants were the only child in the family, while 40 % had one or more siblings.

Table 1

Descriptive statistics of the sample (parents and infants) (N=145)

	M	SD	Min	Max
Maternal age (years)	31.14	5.66	20	44
Gestational age at birth of the children (weeks)	30.59	3.68	22	37
Days spent in NICU (N)	51.54	51.77	0	242
Infant birth weight (g)	1537.97	672.07	368	3203
Corrected age of the infants when the survey was completed (months)	13.41	3.47	8	18

Table 2

Infant`s sample characteristics (N=145)

Gender of the children	Siblings	Identified or suspected areas of difficulty	Categories of prematurity	Categories of weight	Status
69 (47.6 %)	58 (40 %)	35 (24.1 %)	41 (28.3%)	42 (29.0 %)	118 (81.4 %)
Female	Yes	Yes[3]	Extremely preterm[4]	ELBW[5]	Singleton
76 (52.4)	87 (60 %)	110 (75.9 %)	44 (30.3)	32 (22.1)	25 (17.2 %)
Male	No	No	Very preterm[6]	Very low birth weight[8]	Twins
			60 (41.4)	62 (42.8)	1 (.7 %)
			Moderate to late preterm[7]	Low birth weight[9]	Triplets
				9 (6.2)	1 (.7 %)
				Normal birth weight	Other

[3] Sensory processing disorder, cerebral palsy, chronic lung disease, motor delay, blindness, speech delays, unsafe swallow, global development delay, brain injury, Dandy Walker malformation, VACTERL Association, ASD, Hydrocephalus, spina bifida.
[4] Extremely preterm – infant born below 28 weeks gestation.
[5] Extremely low birth weight – less than 1000 g.
[6] Very preterm – infant born between 28-32 weeks gestation.
[7] Moderate to late preterm – infant born between 32-37 weeks gestation.
[8] Very low birthweight – less than 1500 gr.
[9] Low birth weight – less than 2500 gr.

Table 3

Parents` sample characteristics (N=145)

Gender of the respondents	Nationality of participants	Highest level of education achieved	Years spent in education	Occupational groups of respondents
145 (100 %)	71 (49 %)	78 (53.8 %)	62 (42.8 %)	42 (29 %)
Female	British	College or University	14-18	Intermediate managerial/ professional
	23 (15.9 %)	30 (20.7 %)	33 (22 %)	37 (25.5 %)
	American	Post-graduate (Master`s degree or equivalent)	Over 18	Supervisory or clerical/ junior managerial
	51 (35.1 %)	24 (16.6 %)	24 (16.6 %)	22 (15.2 %)
	Other	Higher or secondary education	12-14	Skilled manual worker
		10 (6.9 %)	21 (14.5 %)	11 (7.6 %)
		Secondary school up to 16 years of age	9-12	Higher managerial/ administrative
		3 (2.1 %)	4 (2.8 %)	18 (12.4 %)
		Post-graduate (PhD or doctorate)	6-9	Homemaker
				15 (10.3 %)
				Other

As can be seen in Table 2, some parents reported their children to have identified or suspected areas of difficulty. Hence, it was decided to analyse this sample (N=28) separately in order to avoid the introduction of a confounding as their language development scores may be different either because of their prematurity or because of other neurological conditions.

Therefore, the main analyses include results for the sample without areas of difficulty (N=117) – for this group, infants` ages at the time of data collection was distributed as shown in Figure 1. From the sample of N=28 with areas of difficulty/impairments ages at the time of data collection was distributed as shown in Figure 2.

Figure 1

Histogram showing the age distribution for the participants without reported identified or suspected areas of difficulty (N=117)

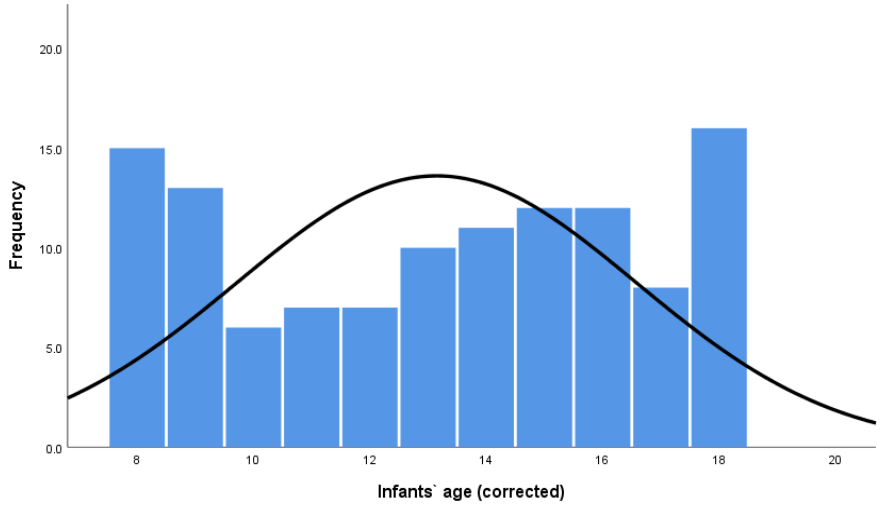
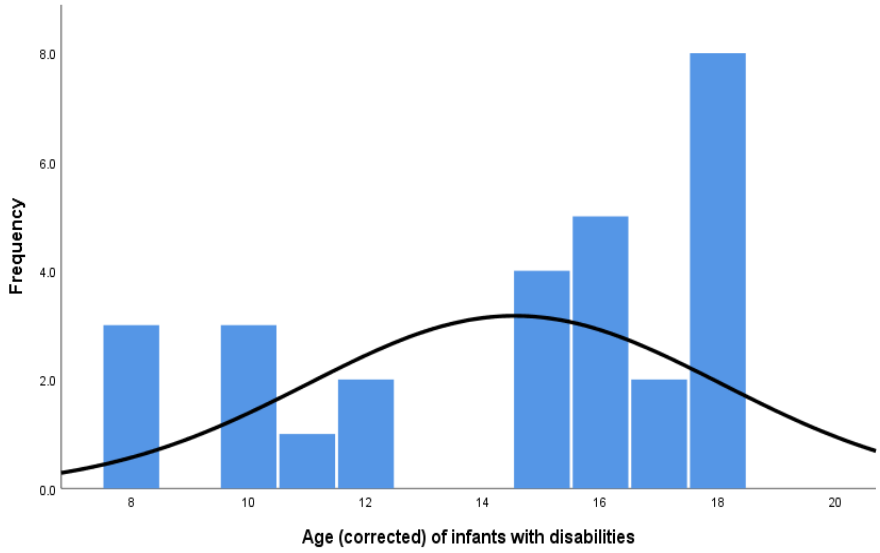


Figure 2

Histogram showing the age distribution for the participants with reported identified or suspected areas of difficulty (N=28)



2.2. Materials

Participants completed a demographic section giving information about their child (gestational age, birthweight, corrected age, days spent in NICU, if they have siblings and if they have identified or suspected areas of difficulty) and themselves (relation to the child, age, nationality, educational level by years in FT education leading to a qualification and qualification type, and socio-economic/professional class). After the demographic section, the next questionnaires to be completed were:

i) MacArthur-Bates CDI Questionnaire – This questionnaire was used in its recent adaptation to British English (Alcock et al., 2020), specifically the Words & Gestures Form, valid between 8-18 months. Understanding of first words and phrases was divided into `First signs of understanding` (3 Yes/No questions) and `Phrases understood` (28 questions). For the word list (395 words), each word`s score is 1 or 0 on two variables: 'Understand only' and 'Understand and say'. Gesture wise, there were 75 examples, comprising first communicative gestures, games and routines, actions with objects, pretending to be a parent, imitating other adult actions. This questionnaire can be found in Appendix 1.

ii) Music@Home Questionnaire Infant version (Politimou et al., 2018) – This psychometrically robust questionnaire was used for the assessment of the home musical environment, comprising 18 questions in total, scored on a 7-point scale (1-Completely disagree; 7-Completeley agree). The questionnaire yields an Overall Music@Home score that can range from 18 to 126, with higher scores indicating higher musicality. Furthermore, the subscale `Parent initiation of singing` was explored to gain an insight into singing activities that parents engage their children with. Scores for the Parent Initiation of Singing scale can range from 5 to 35. This questionnaire can be found in Appendix 2.

iii) STIM-Q Infant version (Dreyer et al., 1996) was used to measure families` cognitive environment. Specifically, two scales were used: the `Reading` scale (12 questions) referring to reading activities in the home environment, and `Parental Involvement in Developmental Advance` (PIDA: 7 questions) measuring the number of different interactional activities occurring between the caregiver and the infant, which may promote cognitive development. This questionnaire can be found in Appendix 3.

iv) The Perinatal PTSD Questionnaire (PPQ: Callahan et al., 2006) - This questionnaire was used to investigate the level of stress and the presence of PTSD symptoms in the parents. PPQ comprises 14 Items scored on a five-point scale, ranging from 0 = not at all, to 4 = often, more than a month (e.g., Did you have bad dreams of giving birth or of your baby's hospital stay?). Higher scores are indicative of higher levels of PTSD symptomatology. There are three subscales measuring intrusion, avoidance and hyperarousal symptoms. This questionnaire can be found in Appendix 4.

v) Qualitative: At the end of the survey, participants were asked if they wanted to share any comments about their home environment in relation to interacting with their baby or suggestions regarding the survey. The question was formulated as follows:

"Is there anything you would like to add regarding your home environment/child? This can concern any of the topics addressed before. Please write in the box below."

The comments from the open questions can be found in Appendix 5.

2.3.Procedure

The survey about early communication in children born prematurely was constructed and distributed using the Qualtrics survey tool (Qualtrics, 2017). Parents were invited to complete the survey by clicking an online link, which was posted on social media and parent networks. Following the information section, participants were first required to give their informed consent and then complete the survey. The completion of the survey took around 60 minutes, depending on the amount of details that the respondents reported in the open question. However, the participants were informed that they had the opportunity to take short breaks during the completion of the survey, with their answers being saved. Respondents did not receive any compensation for completing the survey.

2.4. Data analysis

Data was analysed using SPSS version 23.0 (Kirkpatrick, 2015). Inspection of the UK-CDI scores (Comprehension, Gesture, Production) revealed that most infants were mostly pre-verbal due to their age, thus analyses investigating the relationship between musical home environment and CDI-UK focused on Comprehension and Gesture. Thus, in order to better understand the scores of the measures used in this survey, descriptive statistics presented in the following tables and figures were performed. Since this research did not receive external funding and was conducted within a given timeframe, which happened to be during the Covid19 pandemic, rather than a-priori, a post-hoc sensitivity power analysis was carried out before starting the statistical analyses. In order to determine if the sample of collected responses was large enough to detect reliable results, G*Power (Kang, 2021) was used to calculate a reliable medium effect size, with alpha ≤.05 and power = .80 obtainable with sample N=117. Based on the smallest partial eta squared achieved for the Music@Home: General Factor effect in relation to the variable CDI-UK Comprehension in the present sample of infants without neurological complications (N=117), the significant results in the CDI-UK Comprehension analysis showed power = .83, while the significant results in the CDI-UK Gesture analysis achieved power = .98. Thus, the sample for the present study can be considered sufficiently powered to detect reliable results (Suresh & Chandrashekara, 2012).

From the qualitative aspect of the study, n=32 parents answered the open question and some of the most common aspects encountered in parents` comments were outlined. Unfortunately, due to the question being very open, the data was not very strong to support a full thematic analysis. However, it was very important to hear any suggestions from caregivers as it opens up future areas for research.

2.5. Ethics

The research proposal was approved by the Psychology Research Ethics Committee of Middlesex University (# 15225) as conforming to the ethical principles of the British Psychological Society and the WMA Helsinki Declaration. Participants received information about the study before participating, explicitly consented to take part in the survey and were provided with a full debrief at the end of the survey. All data were anonymised on collection and respondents were informed that they could withdraw from the study at any time by closing their browser.

3. Results

The results are presented in two sections: (i) quantitative analyses for both groups: without suspected or identified areas of difficulty and with suspected or identifies areas of difficulty; (ii) qualitative data analysis (open question).

3.1. Quantitative data analysis for the main sample (without suspected or identified areas of difficulty)

With the aim of inspecting the data and finding the most suitable type of analysis, a summary of the scores from the questionnaires used and the relevant variables was explored, as seen in Table 4.

Table 4

Descriptive statistics (means, medians, standard deviations and range) for all the relevant variables (N=117)

	Mean	Median	Std. Dev	Range	Skewness	Kurtosis
CDI-UK Comprehension	162.18	129.00	123.11	2.00-429.00	.60	-.78
CDI-UK Gesture	32.18	32.00	19.03	2.00-75.00	.37	-.79
CDI-UK Production	39.35	10.50	72.99	0-397.00	2.89	8.62
Music@Home: General Factor	98.77	99.00	15.10	66.00-126.00	-.30	-.70
Music@Home: Parental Initiation of Singing	27.84	29.00	5.40	16.00-35.00	.32	-1.07
STIMQ: Reading scores	12.31	12.00	2.81	3.00-19.00	-.16	.11
STIMQ: PIDA scores	5.52	6.00	1.41	1.00-7.00	-1.00	1.02
PPQ: Overall scores	25.71	28.00	12.18	0-50.00	-.12	-.79
PPQ: Intrusiveness	5.68	5.00	3.29	0-12.00	.41	.72
PPQ: Avoidance	9.06	9.00	4.86	0-19.00	-.09	-.93
PPQ: Arousal	10.96	11.00	5.77	0-20.00	-.10	-1.06
Gestational age (weeks)	30.60	31.00	3.54	22.00-36.00	-.58	-.67
Birth weight (grams)	1542.85	1559.00	639.60	368.00-3040.00	.09	-.93
Days spent in NICU	47.71	30.00	49.89	0-242.00	1.87	.22
Maternal Education	4.69	5.00	1.14	1.00-6.00	-.85	.22
Infants` age (corrected)	13.15	14.00	3.43	8.00-18.00	-.12	- 1.32

Regarding Skewness and Kurtosis, the variables that did not meet the expected values of -/+ 3, being negatively skewed, according to Maindonald and Braun (2006), are: Days spent in NICU (zSkewness = 8.38, p<.001; zKurtosis = 9.70, p<.001), CDI-UK Productive vocabulary (zSkewness = 12.09, p<.001; zKurtosis = 19.41, p<.001), STIMQ: PIDA (zSkewness = 4.48, p<.001) and Maternal Education (zSkewness =-3.83, p<.001). Therefore, these variables will not be included in further analyses requiring a normal distribution.

For the remaining variables, the distributions of Music@Home: General Factor and Music@Home: Parental initiation of singing subscale are presented in Figures 3 and 4; for CDI-UK comprehension and CDI-UK Gesture see Figures 5 and 6, PPQ-Overall scores (Figure 7) as well as Infants` age (Figure 8). More in-depth summaries of scores are presented in the Appendix 6 and Appendix 7. The normative scales based on the mean scores for CDI-UK Comprehension, Gesture and Productive, are reported in Appendix 8 and Appendix 9. A first interesting result is that infants from the present sample scored within the normative profile for language development of their age groups.

Figure 3

Histogram that shows the distribution of scores for Music@Home: General Factor

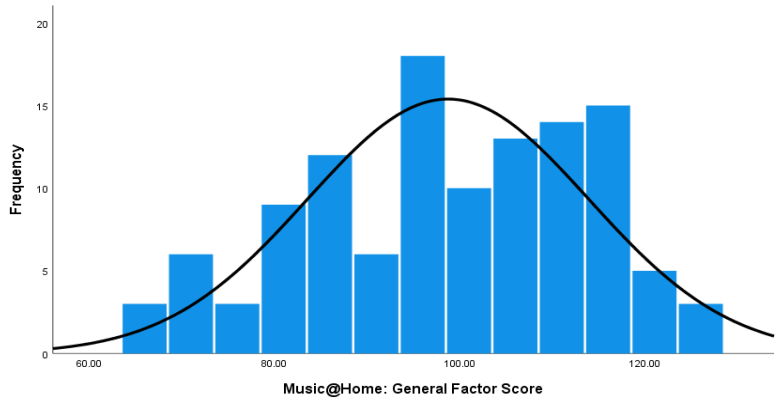


Figure 4

Histogram that shows the distribution of scores for Music@Home: Parental Initiation of Singing

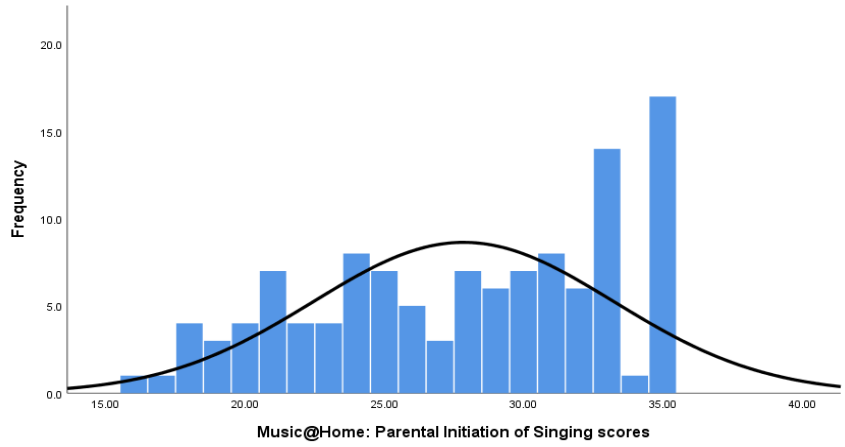


Figure 5

Histogram that shows the distribution of scores for CDI-UK Comprehension

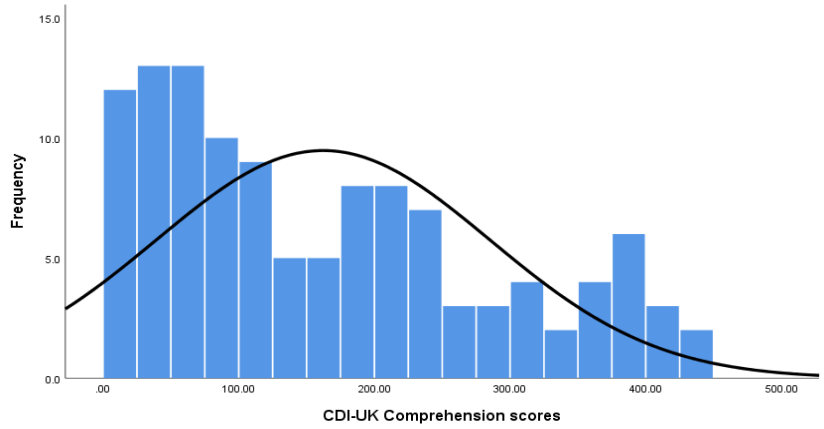
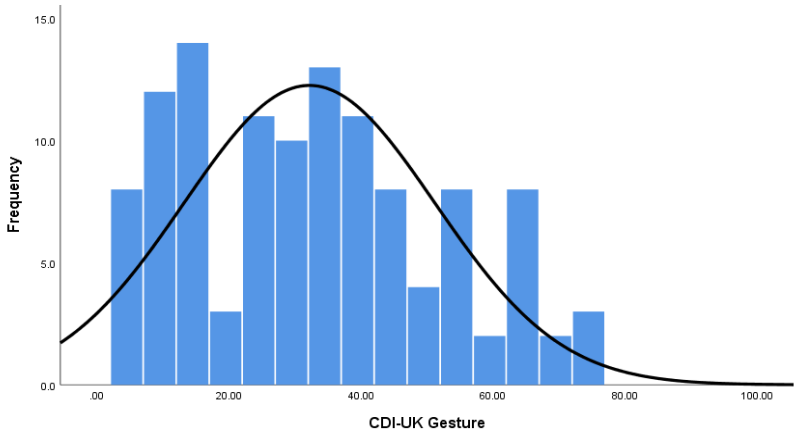


Figure 6

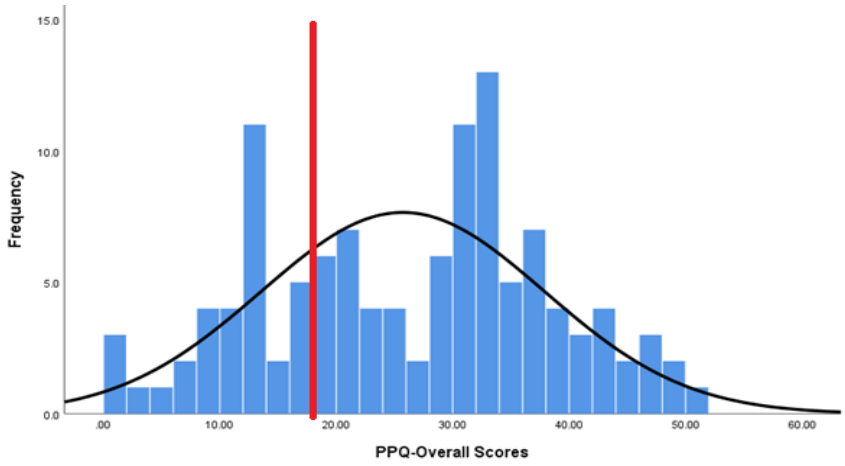
Histogram that shows the distribution of scores for CDI-UK Gesture



As observed in Figure 7 (see also Table 4), a very high number of participants scored very high on the PPQ, suggesting that they displayed symptoms of perinatal stress/trauma.

Figure 7

Histogram that shows the distribution of scores for PPQ: Overall score



Correlational analyses were conducted between all the relevant variables: Music@Home: General Factor, Music@Home: Parental initiation of singing subscale, the language development measures: CDI-UK comprehension, CDI-UK Gesture, CDI-UK Production, and STIMQ-Reading, STIMQ-PIDA, PPQ-Overall score, as well as Gestational age, Birth weight, Infants` age (corrected), Days spent in NICU, Maternal Age and Education. The results are presented in Table 5.

Table 5

Bivariate correlation between relevant variables (N=117)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Gestational age														
2	Birth weight	.85**													
3	Infants` age (corrected)	.13	.08												
4	Days spent in NICU	-.81**	-.67**	-.06											
5	Maternal age	.07	.07	-.12	-.04										
6	CDI-UK Comprehension	.09	.05	.61**	-.06	-.28**									
7	CDI-UK Production	.11	.08	.51**	-.09	-.18	.66**								
8	CDI-UK Gesture	.26**	.21*	.78**	-.14	-.11	.82**	.62**							
9	M@H-General Factor	-.01	.05	.17	.08	.04	.25**	.20*	.33**						
10	M@H-Parent initiation of singing	.07	.02	.44**	-.04	-.15	.23*	.24*	.31**	.					
11	STIMQ-Reading	.05	-.01	.13	.04	-.02	.08	-.07	.17	.00	.12				
12	STIMQ-PIDA	.12	.08	.39**	-.11	-.07	.27**	.17	.38**	.21*	.18	.38**			
13	PPQ-Overall Score	-.01	.03	-.05	.04	-.32**	.01	-.11	-.12	.00	.00	.11	.16		
14	Maternal Education	.11	.09	-.07	-.07	.35**	.08	.05	.13	.21*	.00	.04	-.07	-.06	

* $p < 0.05$; ** $p < 0.01$

As can be observed in Table 5, most significant correlations suggest the following aspects.
Firstly, concerning the demographic variables, as expected, [i] the birthweight and gestational age at birth are negatively correlated with the days spent in NICU, i.e., the higher the birth weight and gestational age, the fewer days infants spent in the NICU; [ii] both infants` corrected age and maternal age are positively correlated with CDI-UK Comprehension scores, i.e., the older infants and the mothers, the higher scores for CDI-UK Comprehension were reported; [iii] also as expected, gestational age, birth weight and infants` corrected age are positively correlated with CDI-UK Gesture: the higher the demographics mentioned, the better scores for CDI-UK Gesture were reported.

Concerning the effects of musical experience in the family, M@H: General Factor is positively correlated with all three components of the most important CDI-UK measures, meaning that the more musical activities were performed in the home setting, the higher infants scored on CDI-UK Comprehension, Gesture and Production scales. Additionally, maternal education is positively correlated with M@H: General Factor, which means that the more educated the mothers were, the more musical activities they performed with their child at home. Moreover, the caregivers offered more general stimulation (STIMQ-PIDA) to the older the infants, and this variable was also positively correlated with CDI-UK Comprehension and CDI-UK Gesture.

Lastly, maternal age is negatively correlated with the PPQ-Overall score, suggesting that the younger the mothers, the more symptoms of perinatal PTSD they reported. Interestingly, no significant association emerged between perinatal stress (PPQ) and the language measures, musical activities at home or general stimulation. However, a very weak trend can be noticed, outlining a negative correlation between PPQ-Overall score and CDI-UK Comprehension and CDI-UK Production which might suggest that the more stressed mothers were, the lower scores were reported for CDI-UK Comprehension and CDI-UK Production.

Due to the lack of significant correlation between both STIMQ-Reading and PPQ overall score with the design variables, they were not entered into the subsequent analyses concerning language

development. Before performing more sophisticated analyses, an independent group t-test was conducted to investigate whether Music@Home: General Factor scores (*M*=98.77, *SD*=15.10) differed for younger and older infants using a median split for age to divide the sample into two similar groups. With Mdn =14 months, there were N=58 infants in the younger group (<14 month) and N=59 in the older group (>14 months). The results were non-significant, $t(115)=.993$, $p = >.05$ (.32), suggesting that overall, both groups were exposed to a similar amount of musical activities in their home settings, as shown in Figure 8.

However, a similar analysis was performed to investigate whether Music@Home: Parental Initiation of Singing scores (*M*=27.84, *SD*=5.40) differed for the two groups. The results were significant $t(112)=7.00$, $p = <.001$ suggesting a difference in the amount of singing that mothers engaged their infants within the home settings, with increased singing activity with the older infants (see Figure 9).

Figure 8

Boxplots showing a comparison of Music@Home: General Factor Scores in the families of infants aged <14 or ≥14 months

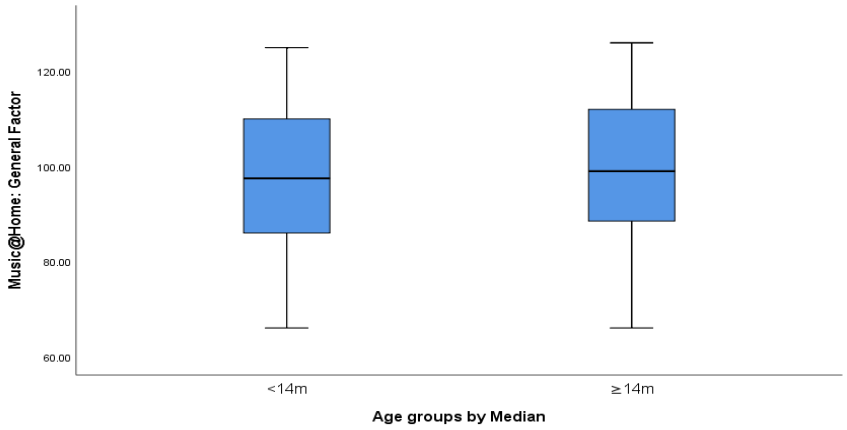
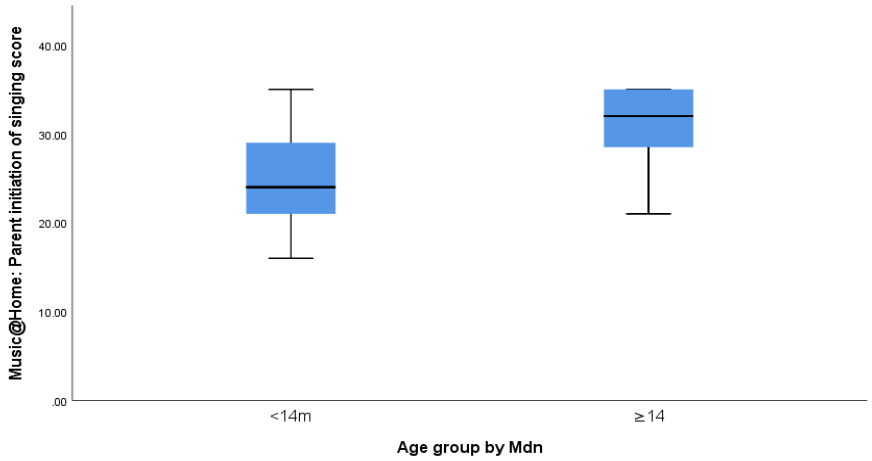


Figure 9

Boxplots showing a comparison of Music@Home: Parent Initiation of Singing Score in the families of infants aged <14 or ≥14 months



Next, in order to develop a more general understanding of the effect of several variables found in the literature to be associated with language development in preterm infants, multiple regression analyses for predicting CDI-UK Comprehension (Table 6) and CDI-UK Gesture (Table 7) were performed for Music@Home: General Factor including the following variables: Infants` age (corrected), Gestational age and Birth weight – unfortunately Days spent in NICU and Maternal Education could not be included due to skewed distributions of scores. For each of the models, backward elimination was used: gradually eliminating variables with no significant contribution to the model. The final models reported are the most parsimonious and explanatory after progressively removing the different predictors. Before reporting, the data was checked and met the assumption of normality, linearity, homoscedasticity, and absence of multicollinearity. Moreover, similar analyses were performed for Music@Home: Parent Initiation of Singing Scores. These are presented in Appendix 10 and Appendix 11 , as they did not substantially enhance the interpretability of the results.

Table 6

Multiple Regression results for M@H: General Factor and CDI-UK Comprehension, Infants` age (corrected), Gestational age and Birthweight

	β	*t*	*p*	R^2	*F*	*P*
Model 1				.39	17.99	.000
Music@Home: General Factor	.15	2.09	.03			
Infants` age (corrected)	.57	7.59	.00			
Gestational age	.07	.51	.60			
Birthweight	-.05	-.34	.72			
Model 3				.39	36.41	.000
Music@Home: General Factor	.15	2.06	.04			
Infants` age (corrected)	.58	7.80	.00			

Table 7

Multiple Regression results for M@H: General Factor, CDI-UK Gesture, Infants` age (corrected), Gestational age and Birthweight

	β	*t*	*p*	R^2	*F*	*P*
Model 1				.68	60.74	.000
Music@Home: General Factor	.21	3.89	.00			
Infants` age (corrected)	.72	13.34	.00			
Gestational age	.18	1.78	.07			
Birthweight	-.01	-.18	.85			
Model 2				.70	81.67	.000
Music@Home: General Factor	.21	3.91	.00			
Infants` age (corrected)	.72	13.45	.00			
Gestational age	.16	3.13	.00			

Concerning CDI-UK Comprehension, the most parsimonious model (model 3), seen in Table 6, suggested that development was specifically associated with infant age (corrected), predictably, but also with Music@Home General Factor, independently from the other variables, which included infants` demographic variables. A more nuanced pattern emerged for the development in CDI-UK Gesture, for which, besides the above predictors, also Gestational Age at birth had a contribution, as presented in Table 7 (model 2).

Lastly, in order to gain deeper insight into the influence of home musical interaction, independent factor ANOVAs were conducted separately for CDI-UK Comprehension and CDI-UK Gesture measures as dependent variables, Music@Home high/low scores as fixed factors (using Mdn split for M@H=100), and infants' age (corrected) entered as a covariate. Results indicated that the high/low M@H score groups were significantly different for both CDI-Comprehension, $F(1, 114) = 5.89$, $p<.05$, $\eta_p^2 = .049$ and CDI-UK Gesture scales, $F(1,114) = 14.23$, $p<.001$, $\eta_p^2 = .111$, suggesting that language skills were significantly better in the groups with higher Music@Home scores than those with lower Music@Home scores. As seen in Figure 10, for CDI-UK Comprehension in the lower music activities, the M=135.83, SD=109.83, whereas in the higher exposure to musical activities, M=189.92, SD= 130.98. Similarly, as seen in Figure 11, for CDI-Gesture, in the lower music activities, the M=27.31, SD=17.21, whereas in the higher exposure to musical activities, M=37.31, SD=19.64. The age covariate was also significant in both cases: for CDI-UK Comprehension $F(1,114) = 66.20$, $p<.001$, $\eta p2 = .367$, and for CDI-UK Gesture $F(1, 114) = 196.72$, $p<.001$, $\eta p2 = .633$.

Figure 10

Boxplot showing higher scores for CDI-UK Comprehension in the group scoring high for Music@Home: General Factor

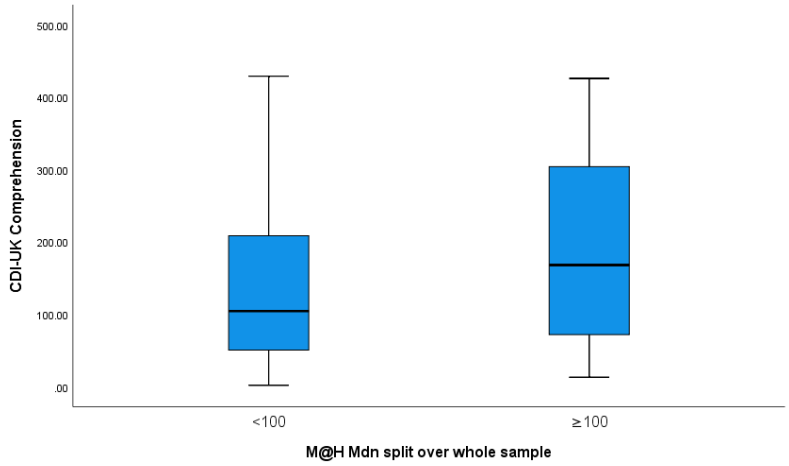
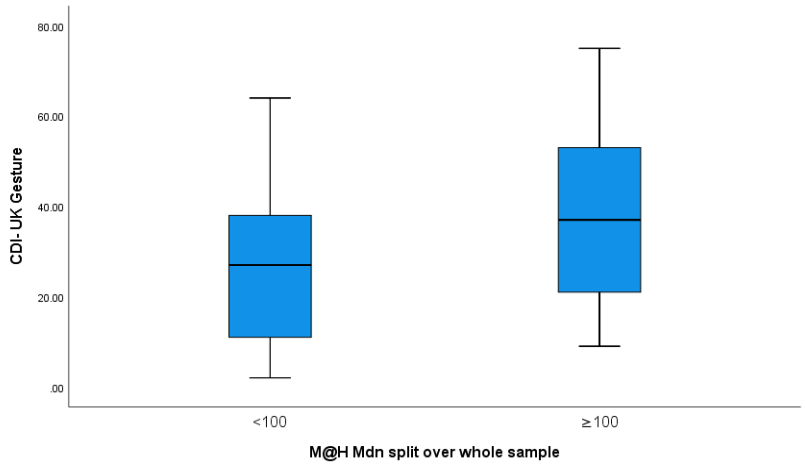


Figure 11

Boxplot showing higher scores for CDI-UK Gesture in the group scoring high for Music@Home: General Factor



Performance in language development measures is known to improve with age. Hence, in order to better understand the effect of the covariate (infants' corrected age), a 2x2 ANOVA was conducted using Music@Home high/low as above and Mdn split for age (Mdn=14 months corrected age: Younger/Older) on CDI-UK Gesture and CDI-UK Comprehension. As expected, language skills were significantly higher in the older than younger age group, as measured by both CDI subscales: CDI- UK Comprehension, $F(1,113)=49.63$, $p=<.001$, $\eta_p^2=.305$ (see Figure 12); and CDI-UK Gesture, $F(1,113)=119.63$, $p<.001$, $\eta_p^2 = .514$ (see Figure 13). However, importantly, there was no interaction between Age Group and Music@Home scores, for CDI-UK Comprehension $F(1,113)= .117$, $p=.773$, $\eta_p^2 =.001$ and for CDI-UK Gesture $F(1,113) = .553$, $p=.459$, $\eta_p^2 =.005$, suggesting that positive language outcomes, as measured by both CDI-UK Comprehension and CDI-UK Gesture, were associated with higher Music@Home scores independently from infants` Corrected Age (i.e., in both age groups).

Figure 12

Graph showing a comparison of CDI-UK Comprehension score and high/low Music@Home: General Factor score

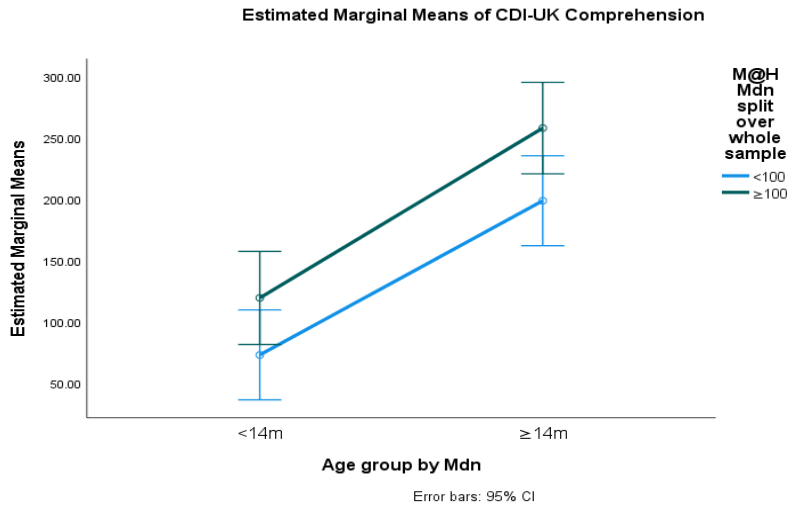
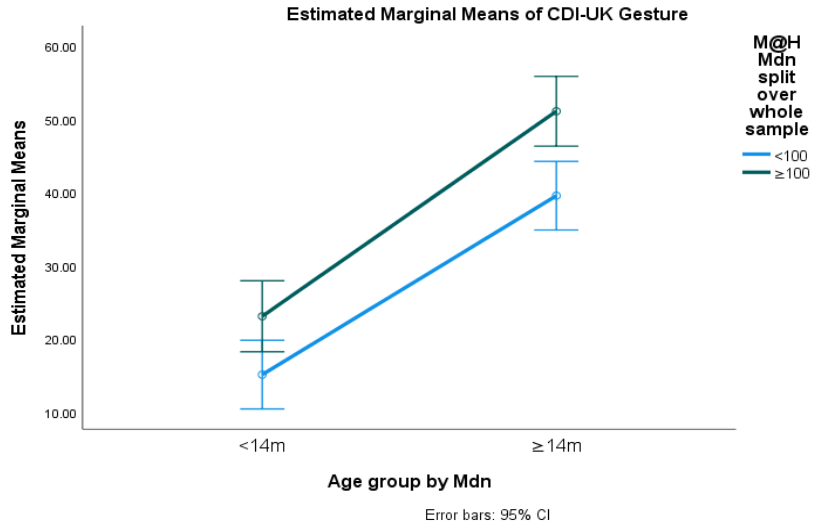


Figure 13

Graph showing a comparison of CDI-UK Gesture score and high/low Music@Home: General Factor score



3.2. Analysis of the sub-sample of infants with suspected or identified impairments

A group of (n=28) participants were analysed separately due to the infants having suspected or identified impairments (see Table 2 for description), which may produce further delay or disorder in the development of language. Although the sample is small, it was deemed important to explore whether some of the trends emerged in the main sample were also found in this disadvantaged sub-sample.

As can be seen in Table 10, the scores for CDI-UK are slightly lower in comparison to the main sample, (seen in Table 4) which is expected considering that the sub-sample comprises infants that might struggle with their development. On another note, the PPQ-Overall scores are very similar in both groups suggesting that all mothers that took part in this research project reported high levels of stress/trauma. Additionally, Music@Home scores and STIMQ scores are similar to the main sample, suggesting the same engagement with musical activities and other cognitive stimulating activities in this sub-sample.

Some correlational analyses were tentatively conducted as pilot analyses for future studies and the results are presented in Table 11.

Table 10

Descriptive statistics for the predictors and outcome variables for the sub-sample (N=28) with suspected or identified areas of difficulty

	Mean	Median	Std. Dev	Range
CDI-UK Comprehension	142.03	93.50	137.57	2.00-424.00
CDI-UK Gesture communication	29.14	25.00	19.51	0-70.00
CDI-UK Production	31.78	9.00	79.69	1.00-380.00
Music@Home: General Factor	93.57	92.00	15.56	66.00-123.00
Music@Home: Parental Initiation of Singing	25.92	26.00	5.32	11.00-35.00
STIMQ: Reading scores	11.57	11.50	3.36	5.00-18.00
STIMQ: PIDA scores	5.00	5.00	1.86	0-7.00
PPQ: Overall scores	24.82	27.00	11.75	3.00-49.00
PPQ: Intrusiveness	5.60	5.50	3.29	0-12.00
PPQ: Avoidance	9.07	9.00	4.64	0-19.00
PPQ: Arousal	10.14	10.00	4.86	0-20.00
Gestational age	30.54	31.50	4.29	2.00-37.00
Birth weight	1481.00	1365.00	749.49	453.00-3120.00
Infants` age	14.54	16.00	3.52	8.00-18.00
Maternal age	31.61	31.00	5.76	21.00-44.00

Table 11

Bivariate correlation between relevant variables for the sample (N=28) with reported infant disabilities/impairments

		1	2	3	4	5	6	7	8	9	10	11	12
1	Gestational age												
2	Birth weight	.86**											
3	Infants` age (corrected)	.16	.11										
4	Maternal age	-.17	-.10	-.49**									
5	CDI-UK Comprehension	.46*	.36	.28	.13								
6	CDI-UK Productive	.29	.40	-.36	.49*	.52*							
7	CDI-UK Gesture	.44*	.37	.35	-.09	.89**	.51*						
8	M@H-General Factor	-.06	-.07	-.02	.40*	.47*	.21	.37					
9	M@H-Parent initiation of singing	-.29	-.28	-.15	.64**	.21	.17	.01	.69**				
10	STIMQ-Reading	-.09	-.12	.02	.12	.09	-.33	-.06	.13	.24			
11	STIMQ-PIDA	-.14	-.11	.30	-.10	.13	-.57**	.14	.12	.12	.43*		
12	PPQ-Overall Score	.05	.07	.01	-.06	.14	-.34	.15	.23	.13	.30	.56**	

* $p < 0.05$; ** $p < 0.01$.

Firstly, concerning the demographics, as expected, gestational age is positively correlated with the birth weight, i.e., the higher infants` gestational ages, the bigger their weight. Additionally, gestational age is positively correlated with CDI-UK aspects: the higher the gestational age, the better scores for CDI-UK Comprehension and CDI-UK Gesture. Additionally, Maternal age was positively correlated with CDI-UK Productive and both Music@Home: General Factor and Music@Home: Parental initiation of singing, suggesting that the older the parents, the more home musical activities they experience with their infants and the higher the scores for CDI-UK Production they report.

Interestingly, PPQ-Overall score is positively correlated with the STIMQ-PIDA, which means that the more stressed the parents were, the more activities for infants' development they performed, possibly suggesting overstimulation. Consistently, a negative trend can be observed between PPQ-Overall score and CDI-UK Production, which might suggest that maternal stress could negatively impact infants` production language in this disadvantaged sample. However, unlike the findings in the main sample, STIMQ-PIDA is positively correlated with CDI-UK Production, suggesting that the more developmental activities parents engaged their children with, the more word produced language.

Critically for this study, Music@Home: General Factor was significantly positively associated with CDI-UK Comprehension, even in this disadvantaged group, which outlines the importance of such activities for language development in early years.

3.3. Qualitative analyses

A total of *n* = 32 participants completed the open question and their answers disclosed some important aspects that helped them or that they struggled with during their children`s journey with language acquisition. These aspects represent future elements to investigate and will be triangulated with the quantitative results.

Firstly, the majority of participants emphasised the negative effects that the Covid19 pandemic had on them and their families. They haven't been able to see their families and relatives, which made them feel isolated and unsupported - ``Coronavirus meant my partner couldn't be in the hospital with me that had a major effect on my stay especially with preterm labour`` (P14). Post-discharge, they

haven't been able to access the support available prior the pandemic, such as baby groups and other play activities, which made them feel that themselves and their infants would really see improvements in their social skills and language development if able to attend groups - `` With us shielding I feel like we're missing out on a lot of groups I would have liked to gone to, play dates and nursery that would have further helped his language development`` (P1), ``We are unable to attend any groups due to covid.`` (P 17). Moreover, the pandemic represented a trigger for mental health symptoms, such as trauma, depression, grief, participants being worried about their dear ones, occasionally grieving their loss - `` I got a phone call I lost my dad to covid, alot [sic] of my sadness and depression stemmed from this.`` (P24).

Secondly, prior parental profession and background turned out to be an aid in supporting their children`s development, including language skills. Thus, some of the parents were teachers, nurse practitioner, paediatric speech therapist, paediatric physical therapist - `` I am a paediatric speech therapist so have been very conscious of supporting my son's early language development at home`` (P11). They have the knowledge and the experience of how, not only to support a child, but what kind of help to seek further from professionals, or other family members in order to meet their child's physical and emotional needs and to offer age-appropriate stimulation - ``I worked as a pediatric [sic] physical therapist assistant for years before staying home with baby. We work on gross motor, fine motor, and speech and signing daily.`` (P2), ``Due to our babies cerebral palsy diagnosis we are completing early intervention with the help from physio, OT and speech therapists. He's only showing very mild symptoms I think due to all the work we've been doing with him`` (P8), ``My son is around my mother and sisters all day so we all work with him. in order to meet his physical and emotional needs and to offer him the age-appropriate stimulation.`` (P15).

Lastly, parental attentiveness sheds light on the importance that parental involvement has on child development. Parents are aware that their premature children require support and they do everything they can to provide it, beginning with their time - ``I stay home full time with my son`` (P25), continuing with the implementation of various educational methods that have been efficient - ``Trying to incorporate Wardolf [sic] education/Montessori/nature/natural education values at home`` (P9), as well as providing an enriched environment that engages the child with music - ``We play toy pianos, tambourines and maracas - shaky eggs are a favourite for rhythm work (copying a rhythm and repeating)`` (P20), `` I sing multiple times a day for myself and to entertain the baby`` (P29), `` Music is a big part of her life and she loves music.`` (P17); and reading: ``Books are read, and 'read' solo throughout the day (child-height)`` (P20). But most importantly, mothers talk to their infants, being aware that this is crucial for their infants language acquisition, and that is the eldest method used in history, before there were any other facilities to help with language - ``I try daily to describe everything I am doing out loud to them so they hear the words`` (P27), ``, `` We talk and sing a lot`` (P31), ``Lots of talking about what we are doing, how we might be feeling, inviting to repeat or repeating for him to listen again`` (P20), ``. Reading has been a huge part of language development for my preemie. We tried reading to him as a baby`` (P12), ``. He sees me sing, dance, tell stories and be huggy [sic] and that is normal for him`` (P6).

In sum, parents` comments supported the importance of attending the baby groups and other play activities for child`s social and language development, as well as activities that children are engaged within the home settings, These suggest possible ideas for interventions, such as providing parents with the information required to access baby groups both prenatal and postnatal, parental skills workshops (e.g. for musical interactions) as well as educating them on how to recreate similar experiences in the home settings, this way creating a partnership between relevant institutions and parents.

4. Discussion

The current study explored whether early language development in infants born prematurely is associated with variations in the home musical environment. This discussion will focus on the primary and secondary outcome variables from the CDI (Gestures and Comprehension, respectively), which are considered the most important predictors of language development in this age group 8-18 months (Trevor & Elison, 2021).

The results from the main sample of infants without reported areas of difficulties suggested that, in spite of prematurity, infants` language skills were not significantly delayed when compared to the normative scores reported in the UK; for example, the average scores for Comprehension were between 50th-75th percentile, and the score for Gestures were between 50th-75th percentile of the normative profiles (Alcock et al., 2020). This result is unexpected since, in the literature, various studies conclude that, compared to full-term infants, preterm infants experience significant language delays (Zambrana et al., 2021), for a variety of reasons such as low birth weight (Zimmerman, 2018), the disturbance of brain maturation (McMahon et al., 2012), protracted stays in a less-than ideal NICU environment (Kuhn et al., 2017), as well as lack of adequate contact with the caregivers, e.g., deprivation from maternal voice (Filippa et al, 2021; Moon, 2017). Not only do they experience poorer vocabulary, but they also show a decreased level of grammatical skills compared to the full-term infants (Gayraud & Kern, 2007; Sansavini et al., 2006). Moreover, some studies have signalled delays in various aspects of linguistic domains, beginning with preverbal development, when premature infants delay their first vocalisations (Salerni et al., 2007), and babbling (Rvachew et al., 2005) - perhaps due to the aversive treatments required to keep them alive (i.e., breathing machines), but also between the first and second year when it was noticed they show limited and less complex phonological skills in comparison to full-term children (D'Odorico et al., 2011).

However, there are also studies that have shown no significant difference between healthy preterm and full-term infants' language abilities (Pérez-Pereira, 2021; Pérez-Pereira et al., 2014; Suttora et al., 2020). Perhaps the differences in those nuanced results could be explained by the fact that the studies which found significant delays have assessed a variety of preterm infants, some of them with possible areas of difficulties, creating a confounding effect with prematurity on the outcomes. In contrast, the studies that did not find a significant difference in language skills between the two groups were mostly carried out with healthy preterm infants. The present study employed a similar practice, separating the group of infants with suspected or identified difficulties to avoid a confounding effect. Furthermore, an important aspect in the present study is that the sample was highly homogeneous, including mothers from professional environments and highly educated. It is likely that this relatively privileged population had resources (both intellectual and financial) that supported their caregiving in compensating or overcoming the challenges associated with premature birth. Therefore, this results may not be replicated in a sample of less educated mothers from lower SES environments. However, this result can be regarded as extremely positive and encouraging in suggesting that providing caregivers of premature babies with social care and tools to facilitate and support communication and language development could significantly mitigate the disadvantage of prematurity.

More important for our central hypothesis, the results showed that early language outcomes (Comprehension, Gestures) are positively correlated with the amount of musical activities parents engaged their infants with, in the home settings, even within this homogeneous and highly educated middle-class sample. Interestingly this effect is found across the age range studied here (8-18 months), and independently from the expected increase in language abilities between 8-18 months. These results show, for the first time, that higher levels of home musical interactions facilitate early language outcomes in preterm infants, who are considered at risk of delays in language acquisition, hence

musical activities can be considered a protecting factor in this population. By suggesting that an enriched home musical environment has direct implications for supporting word comprehension and gestural communication, the results are consistent with research that has been recently accumulating on how important musical activities enhance language development in infants (Falk et al., 2021; Franco et al., 2020; Papadimitriou et al., 2021; Politimou et al., 2018; Schaal et al., 2020).

In the context of premature birth, various studies have investigated the benefits of music therapy (Loewy, 2015) and music exposure (Lordier et al., 2019) from the NICU to post-discharge. There is substantial evidence showing that early music-based interventions have various benefits on premature infants` development, such as on feeding, sleeping, weight gain, improvement of vital signs, but also on early language development (Stamou et al., 2020). According to Lordier et al. (2019), music intervention is effective in stimulating early language development, as well as inducing functional links between the auditory cortex and other brain areas connected with music processing. Music intervention is also beneficial for infant-parent attachment (Kehl et al., 2021), which is crucial for language development. For example, Costantini et al. (2012) investigated whether premature birth and attachment security had an impact on children`s linguistic abilities. Results suggested that interactive difficulties following premature birth might have a negative impact on attachment security, which affected the outcome of linguistic development. Therefore, in the home settings, parents can engage their infants with music and enhance their language skills this way, by singing to them, organising various musical games as well as using a variety of age-appropriate musical instruments.

Continuing to explore the singing, the present study revealed that parents practiced more singing in the group of the older infants (> 14 months) than in the group of younger infants (<14 months) which is opposed to the available literature suggesting that, as infants grow older, parents sing less (Yan et al., 2021), perhaps because infants already start to talk, therefore parents might focus more on conversation. However, in the context of preterm birth, this result might be logical. Firstly, because parents might have been too busy caring for their infants who might possibly have additional needs compared to full-term infants (such as tube feeding, oxygen therapy, numerous medicines). Such needs often require a strict routine, in which it is hard to fit other activities, especially if there are siblings as well (Boykova, 2016). Secondly, parents might have struggled with their role adaptation, with establishing a parent-infant bond, while acknowledging that the infant is really theirs, considering that while in the NICU, especially during the pandemic when parents were allowed to visit their infants very rarely and for short times, it did not feel like they were the parents (Obeidat et al., 2009). Because of such situations, it is likely to have been hard to sing to infants initially, and it may have taken some time until singing came naturally.

On the same note, the multiple regression analysis suggested that development in CDI-UK Comprehension was predictably associated with infants` age (corrected), but also with Music@Home General Factor, independently from the other variables, which included infant demographic variables. These results are consistent with various studies suggesting that active musical experiences enhance not only infants` communication (Falk et al., 2021; Gerry et al., 2012), but also social and cognitive development (Zhao & Kuhl, 2016), as well as vocabulary, numeracy, attentional and emotional regulation in very young children (Politimou et al., 2019, 2020; Williams et al., 2015). It is important to mention that music has a positive impact on such a variety of individuals practicing it, of different ages, young and old. For example, musical intervention has been shown to be effective across the lifespan, from pre-birth, throughout the NICU and post discharge, in the home settings, for children (Haslbeck & Bassler, 2018; Ruokonen et al., 2021), adults (Pérez Carmona et al., 2021; Pérez Carmona et al., 2021) as well as the elderly (Biasutti & Mangiacotti, 2018; Gold et al., 2019), by supporting not only the process of learning but also the access to what was learnt.

Regarding the scores for CDI-UK Gesture, the multiple regression analysis revealed a more nuanced pattern, for which, besides the predictable infant age (corrected) and the Music@Home General Factor, gestational age at birth also contributed to predicting gesture scores. Numerous studies show that preterm children acquire their early gestures at a slower pace than their full-term peers (Benassi et al., 2016; Ortiz-Mantilla et al., 2008). Moreover, it was discovered that gestures predict later language abilities in preterm infants. That is perhaps because infants' gestures and symbolic actions lead caregivers to translate their child gestures by assigning words onto the gestures or actions (Goldin-Meadow et al., 2007; LeBarton et al., 2015). For example, if a child is pretending to sweep the floor, their caregiver might say "Are you sweeping? Thank you for helping me clean the floor with a broom!". This labelling by caregivers in response to infant gestures and actions reinforces action words and nouns (Olson & Masur, 2015), which could then explain why gesture-rich interactions lead to larger vocabularies in children (Goldin-Meadow et al., 2007), and this richer vocabulary in turn fosters better overall communicative skills. Therefore, scarce use of gesture is associated with early language delay at 22 months (Pérez-Pereira, 2021).

Furthermore, gesture scores between 9 and 13 months are positively linked to language skills at 5 years of age (Stolt et al., 2016). However, Luu et al., (2009) found that gesture can only predict language up to two years old. Either way, it is very interesting to investigate the reason behind these findings for preterm infants and understand why gestural communication is particularly affected by gestational age. It may be that preterm infants are also known to experience motor delays, which play an important part of gestural communication. Alternatively, it may be due to the mothers that took part in this study having the opportunity to answer accurately the questions concerning gestures as there was a relatively small number of these questions, compared to the questions concerning comprehension and production. Finally, it is possible that this index might be a more sensitive indicator of early communicative ability hence reflecting early challenges, given that gestural communication gets established and consolidated before verbal utterances become predominant (see also Papadimitriou et al., 2021, for similar trends in full-term infants).

In the sub-sample of participants with suspected or confirmed areas of difficulties, language scores were generally lower, possibly due to various impairment, and not only to prematurity. With the relatively low number of participants (n=28), unfortunately, it was not possible to carry out an in-depth exploration of the data. However, interestingly, and in spite of the exploratory nature of the analyses conducted, it was found that the more musical activities infants were exposed to in their home settings, the higher scores their caregivers reported for CDI-UK Comprehension, similarly to the main sample. Although these can only be considered pilot results, they are very encouraging in suggesting that the language development gains may occur in this disadvantaged sample when an enhanced musical home experience is provided. This means that recommendations can be drawn from the present study to support infants and families in this impaired group. This may include the implementation of parenting musical skills workshops whereby the importance of musical activities for development would be explained to the parents along with examples of good practice.

Contrary to our initial hypothesis, perinatal stress and PTSD symptoms reported by the mothers were not significantly correlated with CDI-UK aspects, in spite of the caregivers showing very high levels of stress (on average, above the cut-off for clinically relevant scores). This means that despite being very stressed, mothers did what was necessary to support their infants throughout the journey for language acquisition. In addition, their personal difficulties did not impact in a negative way on their infants communication skills, conversely to the body of work suggesting that mothers` mental health is negatively associated with infants` language skills (e.g., Goodman et al., 2011; Mensah & Kiernan, 2010). Oyetunji and Chandra (2020) investigated the influence of postpartum stress on infants`

developmental outcomes and concluded that infants` language was negatively affected, as well as other variables such as, sleep, growth, gross motor skills and feeding. Similar results have been found from a systematic review based on 122 studies, namely that postpartum depression negatively affects infants` physical health, language, social and cognitive skills, as well as behavioural development (Slomian et al., 2019). Nevertheless, a very weak trend was suggested that the more stressed mothers were, the lower scores were reported for CDI-UK Comprehension and CDI-UK Production. This non-significant trend needs to be followed-up in future research due to the relatively small sample of highly educated, middle-class respondents in the present study .

In a similar vein, it was found that the younger the mothers, the more stressed they reported to be. This is understandable for various reasons, particularly considering that being a mother requires many changes, resources and continuous learning. For example, young mothers might find the transition from being independent to becoming a mother particularly challenging. This can lead to the possibility of feeling overwhelmed by the responsibilities that having a child implies (especially the first child), such as caring for the infant, dealing with issues concerning safety, colic or chocking; as well as trying to keep the marital relationship working (Neves Carvalho et al., 2017). But most importantly, being a mother of a preterm infant requires functioning under high levels of stress and pressure, and young mothers possibly do not have time to develop such abilities, hence being negatively affected for longer. For example, mothers of preterm infants experience uncertainty, helplessness, role alternation and possibly, being an outsider hence isolation (Nyström & Axelsson, 2002).

Perhaps the inexistence of a statistical relationship between PPQ score and UK-CDI might be partially explained by the unexpectedly homogeneous sample, representative of middle-upper class, with socio-economic stability and very high educational levels. For example, a high SES possibly enabled them to access the time, as one of the participants reported - ``I stay home full time with my son`` (P25), and resources necessary to support their infants development, which can be enhanced through so many ways, as another participant stated - ``Trying to incorporate Wardolf [sic] education/Montessori/nature/natural education values at home`` (P9). More examples could refer to a parent that actively responds to infant`s needs (i.e., sensitivity and responsivity measures), but also to private sector care, for instance avoiding long waiting lists, home music therapy, play therapy, a variety of age-appropriate books and toys. Thus, these results are consistent with previous studies showing a positive relationship between SES and language development in preterm children (Duncan et al., 2012; Månsson et al., 2015; Vohr et al., 2000). Similarly, high education enables mothers to understand and possibly seek out further resources and experiences in how to support their infants' language development and respond to their needs (e.g., parenting workshops dedicated to preterm caregivers). This aspect also emerged in the qualitative part of this project - `` I am a paediatric speech therapist so have been very conscious of supporting my son's early language development at home`` (P11), shedding light on the importance of parental information and mind-mindedness (Meins & Fernyhough, 1999). Indeed, studies have suggested that parental responsivity is further linked with better language outcomes in children (Madigan et al., 2019).

In terms of the benefits of music, it is essential to note that parents play a crucial role in nurturing their children`s musical development (Parncutt & McPherson, 2002), beginning in early infancy with parents singing to, and with, a child (Trehub et al., 1997). Considering the high amount of musical engagement reported by the mothers in the present study, it is impossible not to think of the potential benefits that musical activities have had for parents too. For example, music strengthens parent-child relationship through interaction, consolidates bonding, helps to extend the repertoire of parenting skills, offers a feeling of reward for helping their children to meet developmental milestones (Abad & Edwards, 2004) and ameliorates anxiety and stress (Ettenberger & Ardila, 2018). Similarly, in Chifa et

al. (2021) parents reported that music induced a state of relaxation and comfort for both, preterm infants and themselves while in NICU, helped bonding with the baby, positively impacted infants` development and had a key role in the adaptation to the home environment after discharge from NICU. This is potentially another aspect that helped parents deal with their mental health without letting it impact infants` language. Therefore, this is an interesting area to further explore in future research, which may also elucidate indirect benefits of musical interactions for infants (i.e., via benefits for the caregivers).

In the present study, infants` corrected age at the time of completing the survey was used as the variable for development as this is deemed to be the appropriate measure (D'Agostino, 2010). Our results were consistent with results reported by Fasolo et al. (2010) who used the corrected age of 18 preterm children and did not find a significant gap for gesture score when compared to the full-term sample. Likewise, Suttora and Salerni (2012) who did not find a difference regarding the quantity and use of gesture among preterm and full-term children. Conversely, there are studies in which, even when infants` corrected age is considered, they still experience language delays (D'Odorico et al., 2011; Ortiz-Mantilla et al., 2008; Sansavini et al., 2011). However, a variety of studies have also used chronological age. For example, Cattani et al. (2010) investigated language development of 12 preterm children longitudinally, from 12 to 24 months, using both chronological and corrected age. They used MacArthur-Bates Communicative Development Inventory, Italian version (Caselli & Casadio, 1995) and revealed no delays for gesture/action scores when their corrected age was considered. However, when their actual/chronological age was considered, the scores fell between 27th-33rd centile. In sum, various studies have suggested that corrected age should be used when assessing preterm infants` development in order to accurately recognise genuine delays as opposed to perceived delays linked to infants gestational age at birth (D'Agostino, 2010). This is particularly the case in children up to 3 years old, in order to avoid an underestimation of their abilities, considering preterm infants` greater immaturity in their relation to the postmenstrual age (Harel-Gadassi et al., 2018).

Taken together, the findings from the present study are largely consistent with the relevant literature. However, a few limitations must be considered. Firstly, the sample was unexpectedly homogeneous, representative of middle-upper class, with socio-economic stability which does not offer the opportunity to further extend the interpretability of the results to the general population of preterm infants' caregivers, including low SES and education. Secondly, the sample was relatively small, which may have impeded the detection of further significant results; for example, stronger correlations between PPQ and CDI-UK components for which only a weak negative trend was observed. However, it is important to consider that the sample per se is substantial, considering the age range that was required for eligibility (8-18 months), in the context of preterm birth, which represents a small percentage in comparison to full-term birth (less than 10% of all births in the UK) (Bliss, 2019) and sufficiently powered for the test of the main hypothesis. Furthermore, this sample was limited by the gender bias – only mothers took part in the survey. Fathers have not been represented despite a substantial increase in fathers' involvement in childcare or even becoming the main caregiver in recent years (Prouhet et al., 2018; Yakobson et al., 2021). Lastly, some variables, such as maternal education and STIMQ _PIDA were skewed and did not meet the criteria to enter the analyses. Therefore, it was not possible to explore the impact of these variables on language development. In spite of the acknowledged limitations, the present study provides an unprecedented insight into the activities that preterm infants can be engaged with in their home settings to support their language development.

There are a number of suggestions for future research stemming from the present study. Given an extensive literature reporting important associations between parental education and language development, the present findings should be consolidated by extending the research to a sample of

less educated parents. Should this research replicate the findings of the present study, this would inform practices supporting prematurely born children and their parents, by proposing to include music-based parenting courses in early intervention facilitating language development. The impact of introducing such music parenting groups on developmental outcomes could then be measured within a randomised control trial with a representative sample.

The present study used a simultaneous design, i.e., measures of home musicality and language development were taken at the same point in time. However, it would be important that further research could adopt a longitudinal design (Fitzmaurice et al., 2012; Sansavini et al., 2011) which could help identifying crucial time windows for intervention by isolating causal relationships. For example, caregivers of pre-term infants could provide data on home musical and other activities at 6, 14 and 20 months of age of their children, and the relationship of these measures could be studied in relationship with early language development. Indeed, there is some suggestion that parental singing at 6 months predicts early language outcomes at 14 months in full-term infants (Franco et al., 2020). Initial work could be conducted using online surveys (quantitative) and parental diaries (qualitative), but remote observational methods could be fruitfully employed (Robledo Del Canto, 2020).

An important implication of the present study is the need to create a partnership with relevant institutions, such as NICUs, baby groups and early childcare settings. This partnership should aim to develop parenting workshops including musicality dedicated to preterm caregivers, as well as to provide parents the information required that would facilitate the access to those activities (e.g., baby music groups). Specifically, it would be useful to educate parents with regards to practicing similar musical activities at home, considering that such institutions have a key role in acknowledging the importance of an adequate home learning environment for children`s overall development.

In sum, the present study has revealed novel findings in a crucial area of early development (language) for a population with known delays in this area: the importance of musical home interactions. This finding has the potential to inspire research-based practice of considerable societal impact.

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7. Appendices

Appendix 1

MacArthur-Bates CDI Questionnaire (Alcock, Meints, & Rowland, 2020).

A. FIRST SIGNS OF UNDERSTANDING

Before children learn to speak, they often show signs of understanding by responding to familiar words and phrases. Below are some common examples - does your child do any of these?

Yes (1) No (0)

1. Respond when his or her name is called (e.g. by turning and looking at the speaker) (1)
2. Respond to 'no' (by stopping what she or he is doing, at least for a moment) (2)
3. React to 'there's Mummy/Daddy' by looking round for them (3)

B. THINGS CHILDREN UNDERSTAND

In the list below, please mark the phrases that your child seems to understand.

understands (1)

Are you hungry?
Are you tired/ sleepy?
Be careful
Be quiet
Clap your hands
Change nappy
Come here/come on
Daddy/Mummy's home
Do you want more?
Don't do that
Don't touch
Get up
Give it to Mummy
Give me a hug
Give me a kiss
Go and get
Good girl/boy
Hold still
Let's go bye bye
Look/look here
Open your mouth
Sit down
Spit it out
Stop it
Time to go night night
Throw the ball
This little piggy
Want to go for a ride?

C. WORD LIST

Please mark the circles next to the words your child understands or understands and says below.

Remember to give your child credit for using different or local words with the same meaning.

Sounds

understands (1);
understands + says (2); does not understand (3)

baa baa
choo choo
cockadoodledoo
grr
meow
moo
ouch
quack
uhoh
vroom
woof
yum
tweet-tweet

Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Animal words

understands (1);
understands + says (2); does not understand (3)

animal
bear
bee
bird
bug/beastie
bunny/rabbit
butterfly
cat/pussy cat
chicken
cow
dog/doggie
donkey
duck
elephant
fish
fly
frog
giraffe
goose
horse
kitten/kitty
lamb
lion
monkey
mouse
owl
penguin
pig
puppy
sheep
snake
spider
squirrel
tiger

Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Vehicle Words
understands (1);
understands + says (2); does not understand (3)
aeroplane/plane
bicycle/bike
boat
bus
car
fire-engine
lorry/truck
pram
pushchair/buggy/stroller

tractor
train
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for toys
understands (1);
understands + says (2); does not understand (3)
ball
balloon
block
book
brick
bubbles
doll
pen
teddy/teddy bear
toy
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Food and drink words
understands (1);
understands + says (2); does not understand (3)
apple
banana
biscuit
bread
butter/spread/marge
cake
carrots
cereal
cheese
chicken
chips
chocolate
coffee
drink
egg
fish
food
ice cream
jam
juice
meat
milk
orange
pasta
peas
pizza
potato/spud/tattie
sandwich/butty
sausages
tea/brew (drink)
toast
water
yoghurt
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for body parts
understands (1);
understands + says (2); does not understand (3)
arm
back
belly/tummy
belly button/tummy button

buttocks/bum/bottom
cheek
chin
ear/tab
face
feet
eye
finger
foot
hair
hand
head
leg
lips
knee
mouth
nose
toe
tongue
tooth/teeth
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for clothes
understands (1);
understands + says (2); does not understand (3)
bib
boots
button
cardigan

coat
dress
glasses/specs
hat
jacket
jumper
nappy
pyjamas/PJs/jim jams
scarf
shoes
sock
trousers/pants/britches
vest
zip
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Furniture words
understands (1);
understands + says (2); does not understand (3)
bath/bathtub
bathroom
bed
bedroom
chair
cooker
cot
door
downstairs
drawer
high chair
kitchen
living room
oven
refrigerator/fridge
settee/sofa/couch
sink
stairs
table
television/telly/TV
toilet/lav/loo
upstairs
window
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for small household items
understands (1);
understands + says (2); does not understand (3)
bag
bin
bottle
bowl
box
broom
brush
bucket
clock
comb
computer/laptop
cup
dummy/dodie/soother
fork
glass
hoover
key
lamp/light
medicine
money
paper
phone/telephone/mobi
picture
pillow
plant
plate
purse
radio
rubbish
scissors
soap
spoon
toothbrush
towel
watch
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Outside words
understands (1);
understands + says (2); does not understand (3)
flower
garden
grass
house
moon
outside
park
party
rain
road
shop
sky
slide
snow
star
stone
sun
swing
tree
wall
water
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for people
understands (1);
understands + says (2); does not understand (3)
aunt/auntie
baby/bairn/wee one

boy/laddie
brother
child's own name
dad/daddy/da
girl/lassie
grandma/nan/granny/nann
y
grandpa/granddad
lady
man
mum/mummy/mam/ma

people/folk
police/policeman
sister
uncle
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Words for games and routines

understands (1);
understands + says (2); does not understand (3)
bath
breakfast
brush teeth
bye/byebye/cheerio
clap hands
dinner
don't/dinnae
goodnight/night night
hello/hi/hiya
hush/shh
lunch
music
nap
no
oops
peekaboo/peepo
(call on) phone
please
sorry
tea (meal)
thankyou/ ta
this little piggy
wait
want to
yes/yeah/aye
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Action words

understands (1);
understands + says (2); does not understand (3)
bite
blow
break
bring
bump
carry
catch
clean
come
cry/blub/weep
cuddle
dance
draw
drink
drop
eat
fall
feed
find
finish
get
give
go
help
hit
hug
hurry
jump
kick
kiss
like
look
love
open
play
pull
push
put
read
ride
run
say
see
show
shut/close
sing
sleep
smile
splash
stop
swim
swing
take
throw
tickle
touch
walk
wash
wipe
Remember to give your child credit for using different or local words with the same meaning as those in the box above. Please write these words here:

_____

Describing words

understands (1);
understands + says (2); does not understand (3)
all gone
asleep
big
blue
broken
careful
clean

cold
dirty/mucky
empty
fast
gentle
good
happy
hot
hungry
hurt
naughty
nice
old
pretty
sad
sleepy
soft
thirsty
tired
wet
yellow
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

Question words
understands (1);
understands + says (2); does not understand (3)
how
what
when
where
who
why
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

Words about time
understands (1);
understands + says (2); does not understand (3)
day
later
morning
night
now
today
tomorrow
tonight
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

Words about people and things
understands (1);
understands + says (2); does not understand (3)
he
her
his
I
it
me
mine
my
she
that
this
you
your
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

Words about places
understands (1);
understands + says (2); does not understand (3)
back
down
in
inside
off
on
out
there
to
under
up
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

Words about amounts
understands (1);
understands + says (2); does not understand (3)
again
all
another
more
none
not
some
Remember to give your child credit for using different or local words with the same meaning as those in the box above.
Please write these words here:

_____

ACTIONS AND GESTURES

Not yet (0); Sometimes (1); Often (2)

1. Extends an arm to show you something she or he is holding.
2. Reaches out and gives you a toy or some object that she or he is holding.
3. When you look/point at toy across the room, does your child look at it?
4. Points (with arm and index finger extended) at some interesting object or event.
5. Waves bye-bye on his or her own when someone leaves.
6. Extends his or her arm upward to signal a wish to be picked up.
7. Shakes head "no".
8. Nods head "yes".
9. Gestures "hush" by placing finger to lips. (9)
10. Requests something by extending arm and opening and closing hand
11. Blows kisses from a distance.
12. Shrugs to indicate "all gone" or "where did it go".

Games and Routines

No (0) Yes (1)

1. Plays 'peekaboo'/'peepo'.
2. Plays 'pattycake'/ 'pat-a-cake'.
3. Plays chasing games.
4. Sings.
5. Dances.
6. Claps hands.
7. Plays 'high five'/'gimme five'.

Actions with objects

Does your child do or try to do any of the following?

No (0) Yes (1)

1. Eat with a spoon or fork, holding or helping to hold the spoon or fork.
2. Drink from an open cup containing liquid
3. Comb or brush own hair.
4. Brush teeth.
5. Wipe face or hands with a towel or cloth.
6. Put on a hat.
7. Put on a shoe or a sock.
8. Put on a necklace, bracelet, or watch.
9. Lay head on hands and squeeze eyes shut as if sleeping.
10. Blow to indicate something is hot.
11. Hold plane and make it "fly".
12. Put telephone to ear.
13. Sniff flowers.
14. Push toy car or truck.
15. Throw a ball.
16. Pour pretend liquid from one container to another.
17. Stir pretend liquid in a cup or pan with a spoon.
18. Pretend to 'drink' from a cup or other object.

Pretending to be a parent

Here are some things that young children sometimes do with stuffed animals or dolls. Please mark the actions that you have seen your child do. No (0) Yes (1)

1. Put to bed.
2. Cover with blanket.
3. Feed with bottle or at the breast.
4. Feed with spoon.
5. Brush/comb its hair.
6. Push in pram/buggy.
7. Rock it.
8. Kiss or hug it.
9. Try to put shoe, sock or hat on it.
10. Wipe its face or hands.
11. Talk to it.
12. Try to put nappy on it.

Imitating other adult actions (Using real objects or toys)

Does your child do or try to do any of the following?

No (0) Yes (1)

1. Sweep with a broom or mop.
2. Put a key in a door or lock.
3. Bang with a hammer or mallet.
4. Attempt to use a saw.
5. "Type" at a typewriter or computer keyboard.
6. "Read" (opens book, turns page).
7. Hoover.
8. Play a musical instrument (e.g. piano, trumpet).
9. "Drive" a car by turning steering wheel.
10. Washing up / wash dishes.
11. Clean with a cloth or duster.
12. Write with a pen, pencil, or marker.
13. Dig with a spade.
14. Put on glasses.

Appendix 2

Music@Home Questionnaire (Politimou et al., 2018).

	Item label
1.	I believe that children should learn to play an instrument
2.	I believe that music is part of a well-rounded education
3.	My child was deliberately sung to/exposed to music whilst in the womb
4.	I believe music has an impact on my child's intelligence
5.	My child displays no physical signs of engagement when there is recorded music on (e.g. bouncing or tapping)
6.	I encourage my child to move along to music
7.	I have noticed my child moving in time with the beat of the music
8.	My child does not dance/move to music on the stereo or television
9.	Music does not evoke a physical response from my child
10.	My child rarely makes music
11.	I sing in playful contexts to/with my child at least once a day
12.	I sing to/with my child several (e.g. 5 - 10) times a day
13.	I teach my child new songs
14.	I sing to/with my child in many different situations (e.g. during playtime, with friends and family)
15.	During our daily routine, I do not spend much time singing about what we are doing
16.	Making music with my child (including toy instruments) is a regular part of playtime at home
17.	I make music with my child (including toy instruments) almost everyday
18.	I do not make music with my child (including toy instruments) more than once or twice per week

Note: Response scale and scoring weight for each statement: (1) Completely disagree; (2) Strongly disagree; (3) Disagree; (4)Neither agree nor disagree; (5) Agree; (6) Strongly agree; (7) Completely agree.

Appendix 3

STIMQ Infant Questionnaire (Dreyer et al., 1996)

	Question label
1.	How many books altogether do you have at home that you read to your child?
2.	How many of these books are “board books” (books that are made of hard cardboard and are made especially for a baby)?
3.	How many days each week do you read children's books to your child? Enter # from 0 to 7.
4.	Do you read nursery rhymes such as Mother Goose or other simple rhyming books to your child? Y N
5.	Do you read books to your child especially made for infants that teach about: activities of an infant’s day (such as mealtime, bath time, bedtime, playtime, going places, getting dressed, etc.)?
6.	body parts?
7.	simple shapes such as squares, circle, and triangles?
8.	things around the house (chair, table, bed, book, etc.)?
9.	Do you read books to your child that show toys and favourite things (e.g., ball or rattle)?
10.	Do you read books to your child about animals?
11.	Do you read books to your child that contain photographs of babies?
12.	While you read to your child, do you point to pictures and name them or describe them, or is your child too young or distractable for that?
13.	Do you have the opportunity to point to things around the house and name them for your child?
14.	Do you have the chance to point out the names, the colours or the sizes of items in the grocery store when taking your child there, or are you too busy getting your shopping done?
15.	Do you play with your child and show her/him how to pile up baby blocks or use other toys that stack up in a tower, or has the baby learned to do this on her/his own?
16.	Do you teach your child body parts by playing with him and touching parts of his body while saying the name of what you are touching? (I.e., “Here is baby’s nose” or “Here is baby’s foot”)
17.	Do you teach your child to press buttons or turn knobs, or has the baby learned to do this on her/his own?
18.	Do you play with your child and show her/him how to put blocks and other things in a container such as a plastic box, beaker or can?
19.	Do you play roll-a-ball games with your baby while sitting on the floor or bed with her/him?

Note: Apart from the first three questions, where a number is entered, the response scale and scoring weight for the rest question is: (1) Yes; (0) No.

Appendix 4

Perinatal PTSD Questionnaire (Callahan et al., 2006)

Number	Question label
1.	Did you have bad dreams of giving birth or of your baby's hospital stay?
2.	Did you have upsetting memories of giving birth or of your baby's hospital stay?
3.	Did you have any sudden feelings as though your baby's birth was happening again?
4.	Did you try to avoid thinking about childbirth or your baby's hospital stay?
5.	Did you avoid doing things that might bring up feelings you had about childbirth or your baby's hospital stay (e.g., not watching a TV show about babies)?
6.	Were you unable to remember parts of your baby's hospital stay?
7.	Did you lose interest in doing things you usually do (e.g., did you lose interest in your work or family)?
8.	Did you feel alone and removed from other people (e.g., did you feel like no one understood you)?
9.	Did it become more difficult for you to feel tenderness or love with others?
10.	Did you have unusual difficulty falling asleep or staying asleep?
11.	Were you more irritable or angry with others than usual?
12.	Did you have greater difficulties concentrating than before you gave birth?
13.	Did you feel more jumpy (e.g., did you feel more sensitive to noise, or more easily startled)?
14.	Did you feel more guilt about the childbirth than you felt you should have felt?

Note: Response scale and scoring weight for each question: (0) not at all; (1) once or twice; (2) sometimes; (3) often, but less than 1 month; (4) Often, for more than a month.

Appendix 5

This Appendix contains parents` answers to the open question asking: *"Is there anything you would like to add regarding your home environment/child? This can concern any of the topics addressed before. Please write in the box below*."

1. With us shielding I feel like we're missing out on a lot of groups I would have liked to gone to, play dates and nursery that would have further helped his language development.

2. I worked as a pediatric physical therapist assistant for years before staying home with baby. We work on gross motor, fine motor, and speech and signing daily.

3. Physically seems to be meeting all milestones and with motor skills and ability with toys but is only saying a couple of words.

4. I worry all the time that my child is super behind in speech.

5. Love to take part in groups activity

6. Our home life is full of laughter and silliness is absolutely day to day. He sees me sing, dance, tell stories and be huggy and that is normal for him...hes very responsive and will copy me in phrases, often in the car. If I say something, like please stop trying to open the door! He laughs. So I end up saying hey, it's me who makes the rules! He then copies me, and we laugh a lot! He is very verbal, from around 8 to 9 months old but chose to not walk or run til 17 months...he couldn't be bothered, then he just stood up and ran!!!! He now is quite clear in his speech, expressive and is all about ME! However, we are nowhere near toilet training....he gets too involved in things...

7. I have 6 other children at home n I always stay strong for them n hardly show my emotions

8. Due to our babies cerebral palsy diagnosis we are completing early intervention with the help from physio, OT and speech therapists. He's only showing very mild symptoms I think due to all the work we've been doing with him

9. Our daughters hosptial stay was incredibly traumatic for us as first time parents as she nearly died from Group B Strep Sepsis then we watched her lose some of her limbs. Have taken the time to try to heal now home Trying to incorporate Wardolf education/Montessori/nature/natural education values at home getting back to what we would have valued in our birthing/parenting journey from the start had it not been so traumatic All is well and bubs is doing incredibly well after her start in life an incredibly active, happy and inqisitive little girl! Loves to move very busy. Will now try incorporating more deliberate pointing at objects around house/at the store and naming them for bubs as this is something I do only a little, but not heaps. I usually just talk all day to her about what I/we are doing

10. I am the grandmother, who was with him from the moment my daughter went into labor until today, I have custody and she isn't involved, yet the emotional questions were only geared toward the birth parent. It doesn't feel like accurate results.

11. I am a paediatric speech therapist so have been very conscious of supporting my son's early language development at home

12. Reading has been a huge part of language development for my preemie. We tried reading to him as a baby but he had very little interest, and so we did it infrequently. He had next to no words at 17 months (actual). Almost overnight he became interested in books and we started to read everyday.

His language skills started to really develop after this (about 18 months actual). At 20 months (actual), 18 months (adjusted) he is repeating everything we say and has new words every day.

13. My son is fast on the up take of motor skills just his speech Is still developing but he is trying.

14. Coronavirus meant my partner couldn't be in the hospital with me that had a major effect on my stay especially with preterm labour

15. My son is around my mother and sisters all day so we all work with him.

16. Concerned that the babies are not saying any words yet

17. My daughter has regular physio therapy due to right sided weakness she is unable to walk unaided. Music is a big part of her life and she loves music. We are unable to attend any groups due to covid. I have 3 older children all with adhd or autism and sensory needs. My daughter too displays sensory needs.

18. My son uses gestures and some Makaton signs to aid his communicationbut extremely limited words despite opportunities for good language models.

19. I just also had another preemie at 26 weeks

20. We play toy pianos, tambourines and maracas - shaky eggs are a favourite for rhythm work (copying a rhythm and repeating) Books are read, and 'read' solo throughout the day (child-height) Lots of talking about what we are doing, how we might be feeling, inviting to repeat or repeating for him to listen again –

21. Born during pandemic so had minimal contact with family members other than her mum and dad. Dad works full time and so spends majority of time with mum

22. I'm an early years teacher so feel I know the importance of singing and reading to my children. My twins were born very prematurely and the nicu drs told me that all my reading and singing has really helped their development which is so lovely to hear! My daughter also has severe glue ear so is virtually deaf so her speech and language skills are very delayed compared to her twin brothers.

23. I just want to note that I had to have a premie baby due to cancer and needing my treatment to start. He already had to have radiotherapy with me as I was diagnosed very early and was asked if I wanted to terminate. I was very well looked after (he became like a prince to the doctors and nurses) and nothing was too much for his care. He is a shining, happy little boy, who had no further issues he was just premie.

24. Roman was a surviving twin, we lost his identical brother at 18 weeks after having lazer key hole surgery to split my placenta, my waters broke at 26+1 I was taken away from my elder 3 children to a hospital w and a half hours away where I stayed for 10 days, I was then moved to a hospital that was only an hour away, 10 days after I arrived I went into labour and delivered both my boys. After Romans SCBU which was pretty smooth sailing I think we came home and on our first morning I got a phone call I lost my dad to covid, alot of ny sadness and depression stemmed from this .

25. I stay home full time with my son

26. My child is currently still in hospital

27. I am a nurse practitioner I work full time 40hrs/week ,my husband works as an electrician 60+hrs /week, we have a small cow/calf beef cattle farm, I am constantly stressing about if my children are

speaking how they should be, the pediatrician is not concerned but I am. I try daily to describe everything I am doing out loud to them so they hear the words, but I am not sure if they are catching on.

28. Can often be hard to find time everyday to sit down and play / teach babies due to having twins as meal times and change times take extra long, especially with partner working

29. I was brought up with music in my life, I have sung in choirs and I find it helps me with my anxiety, so I sing multiple times a day for myself and to entertain the baby

30. I'm a primary teacher and I'm on the senior leadership team at work. I specialise in EYFS and KS1. I have a long experience in child development and use a lot of my practice and experience in raising my children. We talk and sing a lot. We do a lot of practical activities. We do baby signing classes. My full term son had over 200 signs by 18 months and was talking in sentences at 1 year old.

31. In regards to the previous section regarding feelings, note that I have been regularly seeing a psychologist that specializes in dealing with NICU parents and mothers who have dealt with traumatic pregnancies and births. The answers that I provided were before I sought help (from 0 to 5 months corrected).

32. Boy/girl twins so I answered for both of them since they are right around the same level of language development. It has been hard to gain exposure to "normal" life activities due to COVID 19.

Appendix 6

Summary scores for Music@Home Questionnaire

Label of the question	M	SD	Min	Max
1. I believe that children should learn to play an instrument.	5.03	1.24	1	7
2. I believe that music is part of a well-rounded education.	5.72	1.17	1	7
3. My child was deliberately sung to/exposed to music whilst in the womb.	5.26	1.43	1	7
4. I believe music has an impact on my child's intelligence.	5.07	1.40	1	7
5. My child displays no physical signs of engagement when there is recorded music on (e.g. bouncing or tapping).	5.91	1.40	1	7
6. I encourage my child to move along to music .	6.13	.93	4	7
7. I have noticed my child moving in time with the beat of the music.	5.15	1.53	1	7
8. My child does not dance/move to music on the stereo or television.	5.62	1.60	1	7
9. Music does not evoke a physical response from my child.	5.86	1.42	1	7
10. My child rarely makes music.	5.05	1.57	1	7
11. I sing in playful contexts to/with my child at least once a day.	6.11	1.06	3	7
12. I sing to/with my child several (e.g., 5 - 10) times a day.	5.46	1.45	2	7
13. I teach my child new songs.	5.48	1.22	3	7
14. I sing to/with my child in many different situations (e.g. during playtime, with friends and family).	5.81	1.21	2	7
15. During our daily routine, I do not spend much time singing about what we are doing.	4.91	1.54	1	7
16. Making music with my child (including toy instruments) is a regular part of playtime at home.	5.26	1.26	2	7
17. I make music with my child (including toy instruments) almost every day.	5.10	1.39	2	7
18. I do not make music with my child (including toy instruments) more than once or twice per week.	5.65	1.38	1	7
Total scores	98.77	15.10	66.00	126.00

Appendix 7

Summary scores for PPQ

Label of the item	M	SD	Min	Max
1.Did you have bad dreams of giving birth or of your baby's hospital stay?	1.97	1.47	.00	4.00
2.Did you have upsetting memories of giving birth or of your baby's hospital stay?	2.82	1.33	.00	4.00
3.Did you have any sudden feelings as though your baby's birth was happening again?	.88	1.40	.00	4.00
4.Did you try to avoid thinking about childbirth or your baby's hospital stay?	1.38	1.40	.00	3.00
5.Did you avoid doing things that might bring up feelings you had about childbirth or your baby's hospital stay (e.g., not watching a TV show about babies)?	1.66	1.64	.00	4.00
6.Were you unable to remember parts of your baby's hospital stay?	.91	1.00	.00	3.00
7.Did you lose interest in doing things you usually do (e.g., did you lose interest in your work or family)?	1.88	1.52	.00	4.00
8.Did you feel alone and removed from other people (e.g., did you feel like no one understood you)?	2.52	1.36	.00	4.00
9.Did it become more difficult for you to feel tenderness or love with others?	1.35	1.48	.00	4.00
10.Did you have unusual difficulty falling asleep or staying asleep?	2.40	1.57	.00	4.00
11.Were you more irritable or angry with others than usual?	2.41	1.42	.00	4.00
12.Did you have greater difficulties concentrating than before you gave birth?	2.15	1.46	.00	4.00
13.Did you feel more jumpy (e.g., did you feel more sensitive to noise, or more easily startled)?	1.54	1.55	.00	4.00
14.Did you feel more guilt about the childbirth than you felt you should have felt?	2.45	1.53	.00	4.00

Note. Response scale and scoring weight for each question: (0) not at all; (1) once or twice; (2) sometimes; (3) often, but less than 1 month; (4) Often, for more than a month. Also, the reliability of this instrument was established by the authors; therefore, it was not repeated in this project.

Appendix 8

Scale norms for CDI-UK Gesture, Comprehension and Production for the main sample (n=117)

	Preterm infants					
	Gestures		Comprehension		Production	
Months	Percentile based on mean	Range	Percentile based on mean	Range	Percentile based on mean	Range
8	75th	2.00-27.00	75th-90th	2.00-149.00	50th -75th	.00-8.00
9	75th	8.00-54.00	75th-90th	13.00-288.00	75th	.00-23.00
10	50th-75th	5.00-37.00	90th-95th	12.00-402.00	90th – 95th	.00-60.00
11	50th-75th	2.00-41.00	75th-90th	3.00-364.00	50th -75th	.00-18.00
12	75th	14.00-43.00	50th-75th	38.00-175.00	75th	3.00-22.00
13	50th -75th	13.00-47.00	50th -75th	51.00-325.00	50th -75th	.00-22.00
14	75th-90th	21.00-58.00	75th -90th	108.00-304.00	50th -75th	5.00-42.00
15	75th	25.00-64.00	50th -75th	54.00-278.00	50th -75th	.00-68.00
16	50th -75th	24.00-62.00	50th -75th	37.00-408.00	50th -75th	3.00-207.00
17	25th-50th	27.00-67.00	50th -75th	48.00-386.00	50th -75th	.00-169.00
18	>95th	18.00-75.00	75th -90th	47.00-429.00	75th -90th	14.00-397.00

Appendix 9

Scale norms for CDI-UK Gesture, Comprehension and Production

	Normative values					
	Gestures		Comprehension		Production	
Months	50th Percentile	5th-95th Range	50th Percentile	5th-95th Range	50th Percentile	5th-95th Range
8	7	1-15	17	0 - 81	1	.00-11.00
9	10	3-23	25	1-118	1	.00-13.00
10	14	5-29	36	3-153	2	.00-16.00
11	18	7-35	50	7-186	3	.00-20.00
12	22	9-40	67	13-218	5	.00-25.00
13	26	12-45	87	19-248	8	.00-36.00
14	29	14-49	110	28-276	12	1.00-57.00
15	33	17-52	136	38-303	18	1.00-88.00
16	37	20-54	164	49-328	26	2.00-129.00
17	41	23-56	196	62-351	34	2.00-181.00
18	44	26-57	230	76-373	44	3.00-243.00

Appendix 10

Multiple Regression results for M@H: Parental Initiation of Singing and CDI-UK Comprehension

	β	*t*	*p*	R^2	*F*	*P*
Model 1				.37	17.99	.000
Music@Home: Parental Initiation of Singing	-.05	-.60	.54			
Infants` age (corrected)	.62	7.43	.00			
Gestational age	.04	.31	.75			
Birthweight	-.03	-.25	.80			
Model 4				.36	36.41	.000
Infants` age (corrected)	.60	8.16	.00			

Appendix 11

Multiple Regression results for M@H: Parental Initiation of Singing and CDI-UK Gesture

	β	*t*	*p*	R^2	*F*	*P*
Model 1				.64	50.53	.000
Music@Home: General Factor	-.04	-.73	.46			
Infants` age (corrected)	.78	12.42	.00			
Gestational age	.14	1.31	.19			
Birthweight	.02	.20	.83			
Model 3				.64	102.01	.000
Infants` age (corrected)	.76	13.51	.00			
Gestational Age	.16	2.85	.00			

Appendix 12

Participant Information Sheet (opening paragraph in Qualtrics survey)

Music & language development in the lives of prematurely born infants

Thank you for reading the initial information and opening the link to this survey!

You and your child are invited to take part in a research study. Therefore, to help you decide whether you would like to take part, this information sheet explains why the research is being done and what it will involve. Please take your time to read the following information carefully and discuss it with others if you wish.

What is the purpose of this research?

The purpose of this research is to understand further how some factors may be related with language development in prematurely born infants; for example, different types of play activities at home and parental stress. It is generally reported that prematurely born infants often experience language delays; thus, it is hoped that this study will bring recommendations that will contribute to closing the gap between preterm infants` language acquisition and their full-term peers.

Who is conducting this research?

This research is being conducted as part of an MSc by Research project at Middlesex University:

Researcher: Maria Chifa **E-mail**: MC1785@live.mdx.ac.uk or mariachifa20@gmail.com

Position: MSc by Research student and researcher at the Music Cognition & Communication Lab (MCC Lab) at Middlesex University London

Supervisor: Dr Fabia Franco **E-mail**: F.Franco@mdx.ac.uk

Position: Senior Lecturer and Head of MCC Lab

Is my child eligible to take part?

If your child was born prematurely (before 37-week gestation), is now is aged between 8 and 18 months and if English is their first language spoken at home, we would love you to participate.

What would taking part involve?

The study should take approximately 30 minutes to complete. You will be able to take breaks in between, and your answers will be saved as long as you **do not** close the browser.

The study consists of answering questions regarding your child`s early vocabulary (understanding and saying words), gestures they use in communication and musical activities at home. Additionally, there will be some demographic questions, and questions about the stress that you might have experienced as a result of giving birth prematurely and your child being hospitalised. These may bring back upsetting memories, but based on previous experience with the same material, we do not expect it to be a particularly distressing experience for you. You will be free to leave the survey at any time if you do not wish to complete it (just close your browser) or please see below a list of support sources that you may wish to access should some questions have made you feel upset.

What are the advantages and possible disadvantages or risks of taking part?

There will be no immediate advantages or disadvantages to participants for taking part in the study. There are hopes that this study will inspire further research by opening the doors to the discussion of the benefits that musical experience has for language development.

Will my taking part in this project be kept confidential?

All the information collected about you and your child during the research will be kept strictly confidential. You will not be identifiable in any reports or publications. When you submit your survey, your data will automatically appear with an anonymous code.

The University takes its obligations under the GDPR very seriously and will always ensure personal data is collected, handled, stored and shared securely. The University's Data Protection Policy can be accessed here: https://www.mdx.ac.uk/about-us/policies/?a=449245 and is reposted in full below.

Do I have to take part?

It is entirely up to you to decide if you would like to participate. If you do decide to take part, you will be asked to confirm that you agree to participate. You can withdraw your data anytime by closing the browser. If you submitted your answers but change your mind about participation, you can still withdraw your data by contacting the researcher below with a unique number that will be provided at the end of the questionnaire. This will be possible during the two weeks following your submission, when data may enter the analysis process. You do not have to give a reason for withdrawing.

If you have any complaints about this project, please contact the Chairs of the Psychology Research Ethics Committee Dr N. Brunswick, n.brunswick@mdx.ac.uk and Dr Camille Alexis-Garsee, c.Alexis-garsee@mdx.ac.uk.

If you have any questions, comments or want to receive a summary of the results (available from April 2022) do not hesitate to contact the researchers:

Researcher: Maria Chifa E-mail: MC1785@live.mdx.ac.uk OR mariachifa20@gmail.com. Position: MSc by Research student and Researcher at MCC Lab.

Supervisor: Dr Fabia Franco E-mail: F.Franco@mdx.ac.uk. Position: Senior Lecturer and Head of MCC Lab.

We do not envisage any distress caused by the questions in this survey. However, if some questions awoke unpleasant memories, and should you feel upset as a result, we provide below a list of support sources that you can access:

- **Your GP,**
- **MIND- https://www.mind.org.uk/,**
- **Samaritans- https://www.samaritans.org,**
- **NHS Mental Health Help- https://www.nhs.uk/oneyou/every-mind-matters/,**
- **Anxiety.UK- https://www.anxietyuk.org.uk/,**
- **Step Change - https://www.stepchange.org/,**
- **MindEd- https://www.minded.org.uk/,**
- **Peer support- Facebook- Parents of premature babies UK**

Appendix 13

Informed Consent

Music & language development in the lives of prematurely born infants

1 to 4 to follow the Information paragraph in the Qualtrics survey

4 (repeated) and 5 to 8 at the end of the Qualtrics survey

1. I confirm that I have read and understood the information provided about this project and that I have had the opportunity to contact the researcher with questions.
2. I understand that I will be asked about about my child's language and other communication skills, about my child`s exposure to musical activities, and about the level of stress I possibly experienced after giving birth prematurely and my child being hospitalised.
3. I understand that I will be given information about where I can find support, should I consider it useful, in the Debriefing section.
4. I understand that my participation is voluntary and that I am free to withdraw from the project at any time, by closing the browser, without having to give a reason and without any consequences.
5. I understand that I can still withdraw after submitting my answers, by contacting the researchers with the unique number provided at the end of the survey, within 2 weeks from my submission when data may enter the analysis process as anonymous data. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
6. I understand that any information recorded in the research process will remain confidential and no information that identifies me will be made publicly available.
7. I understand that the researchers are aiming to disseminate and publish the findings of the study (always without the possibility to identify any individual child/family) in academic journals and scientific conferences. They will also be part of a Masters dissertation at Middlesex University London, and may be used for simple dissemination aimed to the general public and relevant policy making or consultation bodies.
8. I am aware that if I have any complaints about this research, I can contact the Chairs of the Psychology Ethics Committee Dr N. Brunswick, n.brunswick@mdx.ac.uk and Dr Camille Alexis-Garsee, c.Alexis-garsee@mdx.ac.uk

Researcher:Maria Chifa (mc1785@live.mdx.ac.uk) **Supervisor**:Dr Fabia Franco (f.franco@mdx.ac.uk)

Please click here if you agree to participate (submit your survey):

- YES, I CONSENT TO TAKE PART IN THE SURVEY and PROVIDE MY ANONYMISED DATA FOR THE STUDY AND POSSIBLE PUBLICATION OF THE RESULTS

Or here if you do not wish to take part (do not wish to submit your survey:

- NO THANKS, I DO NOT WISH TO TAKE PART.

Appendix 14

Debriefing

Music & language development in the lives of prematurely born infants

Thank you for completing the survey!

This research study aimed to explore how musical environments and other playful activities are distributed when interacting at home, and if/how they relate to early language development in prematurely born children. Various research suggests that communication with babies is often described as being "musical" since the intonation and pitch is changed when talking to babies, and it has been found that this 'baby talk' is more attractive and engaging for the infant. Moreover, the study intended to explore the connection between carer`s level of stress and the home activities and the child`s language development, as literature suggests that stress may impact on the quantity and quality of language directed to the child.

With the results of the project, it is hoped to understand whether primary caregivers use music to engage with their babies, such as through singing and simple musical games. Recent studies suggested that this may be beneficial for language development. It is also hoped to gain some information as to a possible role of parental stress in these activities. Thus, the findings from this study would be a first step towards providing recommendations on how to support communication development and overcome preterm infants` common language delays.

We hope that this questionnaire did NOT make you feel distressed or awoke unpleasant memories. Should you feel upset as a result of completing the questionnaire, we provide below a list of support sources that you can access:

- **Your GP,**
- **MIND- https://www.mind.org.uk/,**
- **Samaritans- https://www.samaritans.org,**
- **NHS Mental Health Help- https://www.nhs.uk/oneyou/every-mind-matters/,**
- **Anxiety.UK- https://www.anxietyuk.org.uk/,**
- **Step Change - https://www.stepchange.org/,**
- **MindEd- https://www.minded.org.uk/,**
- **Peer support- Facebook- Parents of premature babies UK** or

If you have any questions, comments or want to receive a summary of the results (available from April 2022) do not hesitate to contact the researchers:

Researcher: Maria Chifa E-mail: MC1785@live.mdx.ac.uk OR mariachifa20@gmail.com. Position: MSc by Research student and Researcher at MCC Lab.

Supervisor: Dr Fabia Franco E-mail: F.Franco@mdx.ac.uk. Position: Senior Lecturer and Head of MCC Lab.

Please, make a note of the unique 4 digits number! If at a later time you would like to withdraw your data from the study, this code will be the only way to do so, as all participants are anonymised upon clicking 'submit'. You will be able to withdraw your data within the two weeks following your submission.

Appendix 15

Ethics Approval Letter

Middlesex University London

Psychology REC

The Burroughs
Hendon
London NW4 4BT

Main Switchboard: 0208 411 5000

20/11/2020

APPLICATION NUMBER: 15225

Dear Maria Chifa and all collaborators/co-investigators

Re your application title: Language development in preterm infants

Supervisor: Dr Fabia Franco

Co-investigators/collaborators:

Thank you for submitting your application. I can confirm that your application has been given APPROVAL from the date of this letter by the Psychology REC.

The following documents have been reviewed and approved as part of this research ethics application:

Document Type	File Name	Date	Version
Aims, objectives and hypotheses	References MSc	02/11/2020	1
Materials	PPQ MSc	02/11/2020	1
Materials	Music@Home MSc	10/11/2020	1
Materials	STIM-Q MSc	10/11/2020	1
Informed Consent Form	Final Informed Consent MSc	10/11/2020	1
Informed Consent Form	Final Participant Information Sheet MSs	10/11/2020	1
Further details	Final Debriefing MSc	10/11/2020	1
Materials	MacArthur	11/11/2020	1
Aims, objectives and hypotheses	Proposal for Ethics Approval	11/11/2020	1
Participant Recruitment Information	Recruitment media for participants	20/11/2020	1
Resubmission Response to Feedback Summary	Resubmission of ethics approval form	20/11/2020	1

Although your application has been approved, the reviewers of your application may have made some useful comments on your application. Please look at your online application again to check whether the reviewers have added any comments for you to look at.

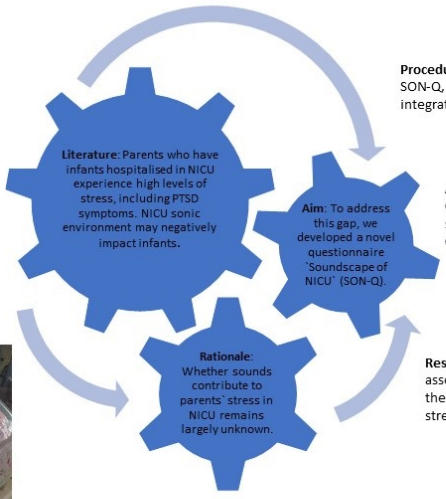
Also, please note the following:

1. Please ensure that you contact your supervisor/research ethics committee (REC) if any changes are made to the research project which could affect your ethics approval. There is an Amendment sub-form on MORE that can be completed and submitted to your REC for further review.

2. You must notify your supervisor/REC if there is a breach in data protection management or any issues that arise that may lead to a health and safety concern or conflict of interests.

3. If you require more time to complete your research, i.e., beyond the date specified in your application, please complete the Extension sub-form on MORE and submit it your REC for review.

NICU soundscape



Procedure: N=368 completed SON-Q, PPQ and demograhics integrated in a Qualtrics survey.

Analysis
Quantitative: PCA, exploration of the relationships between subscales of the SON-Q and the PPQ, moderation analysis.
Qualitative: thematic analysis on 'one memory of sound in NICU

Results: demonstrate systematic associations between aspects of the NICU soundscape and parental stress/trauma.

Recommendations: Findings highlight the importance of developing research on the NICU soundscape and devising interventions to best support parents` mental health, which could in turn support infants` developmental outcomes.

children

MDPI

Article

The Soundscape of Neonatal Intensive Care: A Mixed-Methods Study of the Parents' Experience

Maria Chifa [1], Tamar Hadar [2], Nina Politimou [3], Gemma Reynolds [1] and Fabia Franco [1,*]

[1] Psychology Department, Faculty of Science and Technology, Middlesex University, London NW4 4BT, UK; MC1785@live.mdx.ac.uk (M.C.); G.Reynolds@mdx.ac.uk (G.R.)
[2] Division of Expressive Therapies, Graduate School of Arts & Social Sciences, Lesley University, Cambridge, MA 02138, USA; Thadar@lesley.edu
[3] Institute of Education, University College London, London WC1H 0AA, UK; n.politimou@ucl.ac.uk
* Correspondence: F.Franco@mdx.ac.uk

Abstract: Parents who have infants hospitalised in neonatal intensive care units (NICUs) experience high levels of stress, including post-traumatic stress disorder (PTSD) symptoms. However, whether sounds contribute to parents' stress remains largely unknown. Critically, researchers lack a comprehensive instrument to investigate the relationship between sounds in NICUs and parental stress. To address this gap, this report presents the "Soundscape of NICU Questionnaire" (SON-Q), which was developed specifically to capture parents' perceptions and beliefs about the impact that sound had on them and their infants, from pre-birth throughout the NICU stay and in the first postdischarge period. Parents of children born preterm (n = 386) completed the SON-Q and the Perinatal PTSD Questionnaire (PPQ). Principal Component Analysis identifying underlying dimensions comprising the parental experience of the NICU soundscape was followed by an exploration of the relationships between subscales of the SON-Q and the PPQ. Moderation analysis was carried out to further elucidate relationships between variables. Finally, thematic analysis was employed to analyse one memory of sounds in NICU open question. The results highlight systematic associations between aspects of the NICU soundscape and parental stress/trauma. The findings underscore the importance of developing specific studies in this area and devising interventions to best support parents' mental health, which could in turn support infants' developmental outcomes.

Keywords: prematurity; sound in NICUs; premature infant outcomes; parent perinatal stress and PTSD

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1. Introduction

This paper aims to focus on the parental experiences associated with the specific soundscape of neonatal intensive care units (henceforth NICUs). The literature has provided a wealth of information about various developmental aspects associated with infants' early sonic experiences, including those in NICUs. In order to provide a rich picture of the parent–infant dyad's experience with the NICU soundscape, we will first review relevant studies concerning the infants' early development, but we will then focus specifically on the parents' experience with sounds in NICUs.

It is well established that newborns prefer the sound of a human voice (particularly speaking or singing) over and above any other auditory stimulus, likely to be for the adaptive function of orienting towards conspecifics [1]. As part of well-known prenatal auditory learning [2–7], infants recognise their mother's voice [8] and their orientation to it is part of neonatal paediatric-behavioural assessments [9]. Early parent–baby vocal exchanges are important not only for establishing the basis of vocal communication, but also for bonding and attachment [10]. Therefore, vocalisation and sound are crucial aspects of early development and parenting [11]. This raises the question as to what happens

when the typical natural path of auditory, vocal and bonding development is disturbed by premature birth and an often-prolonged period in neonatal intensive care.

Every year, approximately 15 million infants are born before term worldwide [12] with around 60,000 in the UK [13]. According to Bliss [14], each year in the UK, 1 in 7 infants are cared for in NICUs, for various reasons such as meconium aspiration syndrome (MAS), asphyxia (lack of oxygen at birth), jaundice, hypoglycaemia (low blood sugar), infection or breathing problems and most commonly, prematurity [13]. An infant is considered premature, if s/he is born earlier than 37-week gestation (extremely preterm: <28 weeks; very preterm: 28–32 weeks; and moderately to late preterm: 32–37 weeks). The average length of the stay in NICUs for infants born under and up to 27-week gestation is 92 days, compared to 4 days of hospitalisation for infants born at term (over 37-week gestation) [15]. Risks of delays or deficits in cognitive and language development are more prevalent in preterm than term births [15–19]. A small loss of hearing or difficulty with attention can have a profound effect on learning, communication and emotional bonding [16–22]. The aetiology of these weaknesses is likely to be multifactorial [23], with risk factors being related to preterm birth and the iatrogenic effects of neonatal intensive care [23,24].

When considering the soundscape to which an infant is exposed, in the womb, a foetus is exposed to the sounds of the maternal body physiology and environmental sounds (including voices and music), transmitted through the amniotic fluid, conducted through bones and filtered by maternal body muscles, fat and tissue [25]. Conversely, infants in NICUs are exposed to a soundscape including hospital staff and their workings and, in particular, sounds from a variety of machines and medical equipment, which are intended to save infants' lives and help them thrive (see Supplementary Materials: Table S1 for a list of equipment associated with sounds in NICUs). These sounds are transmitted through air coming from various directions, depending on the location of the source. Many nurseries exceed the sound levels of 45 dB (65 dB at peaks) recommended by the American Academy of Paediatrics (AAP) [26–29].

Excessive sounds from NICUs can negatively impact a preterm infant, affecting her/his development and the discharge period, by producing physiological changes in blood pressure, heart rate, breathing rate and oxygenation. This causes autonomic instability [30] by being distracted during feedings [31]; having adverse effects on the neuroendocrine and immune system [32], impacting sensory functioning (e.g., tactile abilities) [33] and interfering with sleep, which plays an important role in consolidating auditory memories in the prenatal period [34]. Considering that auditory learning begins from around 28-week gestation [35], instead of learning about the mother's voice, speech, patterns of language and music, accompanied by tactile and vestibular stimulation associated with her breathing and movements as it happens in the womb [25], in NICUs, the voices are masked by electronic, non-biological sounds. These may occur 24 h a day, making it difficult to distinguish foreground from background sounds at 60 db or to filter out and process noxious stimuli [36–38]. In this environment, the preterm infant is being deprived of the exposure to the human voice and speech, which is associated with the neurobiology of language development [39–49].

Despite the literature showing the negative impact that high levels of NICU noise have on the development of the preterm infant [50,51], there is a scarcity of research on the reduction of NICU sounds. Based on the Cochrane Central Register of Controlled Trials, Almadhoob and Ohlsson [52] selected studies that involved sound reduction for preterm infants and found only one quality study investigating the impact of silicone earplugs compared to that of a control group without earplugs, in infants of 34-week gestation. The results demonstrated a significant difference in developmental outcomes favouring the use of earplugs at 18 to 22 months. Additionally, private rooms on neonatal units were recommended to avoid excessive noise, although there is a risk that infants could be deprived of sensory stimulation if parental involvement is minimal [53].

In order to support an optimal environment for the auditory experience of infants in NICUs [54,55], it has been suggested that parents provide the most appropriate sound

environment in skin-to-skin care, which also provides an opportunity to hear voice (talking, humming and singing to their baby) and body sounds [56]. Music has also been found to have beneficial effects on premature infants' development [57–60], notably maternal humming/singing [21]. Some parents consider introducing recordings of instrumental music to their infants while in NICUs, which have been accompanied by a note of caution as, differently from the human voice, they do not provide any form of reciprocation, have no specific links to the uterine sensory and might possibly become just another noise [39,61]. Music therapy, defined as a live-performed musical intervention, which may facilitate the active involvement of parents [62], has been found to positively impact the vital bio-physiological functions [63] and support stress reduction and faster hospital discharge [64]. In sum, the literature clearly indicates that infants' development is negatively affected by two major aspects of the NICU soundscape: the NICU noisy environment and the lack of exposure to parental voice, with some forms of musical interaction potentially playing a role in mitigating these negative effects.

Besides infants, premature birth can also negatively impact parents. Instead of holding their baby, touching, talking and taking her/him home, the baby is rushed to the NICU, exposing the parents to the overwhelming NICU soundscape which, according to Segal, is "a combination of control tower, server room and busy canteen" [65]. This interruption in the typical transition to parenthood requires parents' adaptation and acceptance of the real infant, compared to their thoughts about the expected infant, making it harder to be identified as parents [66–68]. Additionally, parents may experience high levels of stress and helplessness [69], the inability to always be part of their infant's care [70], the need to leave their infant in the hospital feeling like "an amputation, over and over" [65] and the worry about their infant's developmental outcomes both while in NICU and at home [71,72]. All these aspects may contribute to the emergence of symptoms of post-traumatic stress disorder (PTSD) [73,74], which can affect the quality of the child–parent relationship and parenting skills [75].

Compared to the vast evidence supporting the impact that the NICU soundscape has on infants, the literature is far more limited with regards to the parents' experience and whether they are negatively affected by it. There is evidence suggesting that excessive noise may impair hearing and trigger various diseases (e.g., cardiovascular disease) [76–78]. Perhaps, a more compelling finding is that parents experience high levels of stress as soon as they arrive at an NICU with their infants. For instance, Alkozei et al. [79] reported that 52% of mothers experienced high levels of stress at NICUs and 38% presented significant depressive symptoms. The study found that stress is not associated with demographic factors, pregnancy factors or mental health. However, NICU sounds and sights were mentioned as factors that contributed to the mothers' level of stress, together with traveling long distances and marital status [79]. Feeley et al. [80] used a questionnaire to compare Canadian mothers of preterm infants in an open ward to those in a separate room. They explored the impact on symptoms of depression, readiness for discharge, sleep disturbance as well as the perception of staff–parent support. The two groups did not differ significantly on symptoms of depression or sleep disturbance, but the results found lower stress and higher readiness for discharge in mothers whose babies were in a separate room. Alternatively, mothers in an open ward reported higher sound stress and more restrictions in their parental role. However, infants' conditions were not taken into consideration when forming the groups, which may have created uneven distributions of types and levels of preoccupation in the mothers.

There is a large body of evidence showing that NICU parents are widely affected by their experience with prematurity. Suttora et al. [81] surveyed 87 mothers of premature infants and 156 mothers of full-term infants, with their children being from 1 to 36 months, to investigate the role of PTSD symptoms linked to childbirth in the development of parenting stress. The results showed that the mothers of full-term children reported fewer PTSD symptoms than the mothers of premature children. When applying the clinical threshold of the questionnaire used (Perinatal PTSD Questionnaire (PPQ)) [1],

55% of mothers of premature children and only 16% of mothers of full-term children, showed perinatal PTSD. Moreover, O'Donovan and Nixon [82] interviewed seven mothers and six fathers to explore parents' experiences in the context of premature birth. They found that parents considered premature birth as traumatic, leading to overprotective parenting styles and hypervigilance. Fathers of preterm infants are underrepresented in the literature, and there are suggestions that they may respond differently to mothers regarding trauma such as lower anxiety levels with their difficulties being more rarely expressed [83]. However, similarly to mothers, Koliouli et al. [84] showed that fathers of preterm infants experience more symptoms of PTSD than their peers of full-term infants. Additionally, fathers might feel excluded from their babies' care and discharge plans, which triggers a lack of confidence and increased stress in caring for their preterm babies [85]. Nonetheless, a significant percentage of both mothers and fathers present PTSD symptoms even beyond one year after their infant's birth [86].

Parental trauma and PTSD symptomatology are important as infants of parents with PTSD are at higher risk of cognitive delays as well as behavioural and attachment issues [86,87]. Considering the negative associations between parental stress in NICUs and beyond the child development, and some sparse suggestions that the NICU soundscape may have an aversive impact not only on infants, but also on parents, the present study aims to specifically investigate the parental sonic experience of NICUs. Using a mixed-method design, a novel survey was developed in order to explore parents' perception of the NICU soundscape and how it affects their ways of communicating with their infants. Four areas were studied: (1) the pre-birth soundscape and initial NICU environment; (2) parents' observation of infants' responses to NICU sounds and ways of communicating with their infants in NICUs; (3) the first postdischarge period at home; and (4) general impressions about the NICU environment. The first quantitative part of this paper will study the association between these areas of the sound experience in the perinatal context of premature infants and demographic variables and perinatal stress measured with the PPQ separately [88]). In order to triangulate aspects of the quantitative results with observations from parents, the second part of the paper will report qualitative analyses exploring some insights into the parents' memories of sounds in NICUs coming from one open question in the survey.

2. Method

2.1. Participants

English-speaking participants (including non-native, fluent and native speakers) from English-speaking and other countries responded via social media such as Facebook, Instagram and WhatsApp, as well as via the researchers' personal and professional networks (e.g., BLISS Baby Charity). Inclusion criteria were that participants had spent some time in NICUs with their infants and that their children were less than four years of age, to capture a fresh memory of the experience. In order to avoid the awakening of painful memories, parents who had lost an infant were excluded from taking part in this study. For the qualitative data, all the responses were included, regardless of the age of the child at the time of completion. A total of 1264 individuals took part initially. However, the majority of these respondents were eliminated for the following reasons: 189 participants did not qualify for the study (e.g., they did not spend any length of time in NICUs); 25 participants completed the survey, agreed consent initially but did not click "consent and submit" at the end of the survey; 15 participants left just before completing the demographic section; and 624 participants (49.4%) did not complete the survey having left it at various stages. From the remaining 411 participants that completed the survey, 25 participants were eliminated from the quantitative analyses because of having children outside the range reported above. A total of 386 participants (30.5%) were therefore included in the analyses with complete responses. Respondents were mainly female (97%). The mean age of the participants was 31.78 years (SD = 5.79). Detailed information about the sample is reported in Tables 1–3.

Table 1. Descriptive statistics of the sample (parents and infants).

	M	SD	Minimum	Maximum
Age of the respondents (years)	31.78	5.79	18	53
Gestational age at the birth of the infants (weeks)	30.79	4.27	22	42
Days spent in NICUs (N)	53.03	48.78	1	327
Infant birth weight (kg)	1.614	0.839	0.420	4.490
Age of child when the survey was completed (months)	17.96	11.86	1	46

Table 2. Infant sample characteristics.

Gender of the Child	Cause of the Birth	Categories of Weight	Categories of Prematurity	Status	Equipment Infants Were Discharged with
199 (51.6%) Female	90 (23.3%) Preterm rupture of membranes	111 (28.8%) Extremely low birth weight	113 (29.3%) Extremely preterm	329 (85.2%) Singleton	284 (73.6%) None
187 (48.8) Male	79 (20.5%) Preeclampsia	84 (21.8%) Very low birth weight	113 (34.5%) Very preterm	51 (13.2%) Twins	67 (18.4%) Oxygen Concentrator
	16 (4.1%) Elective preterm delivery	142 (36.8%) Low birth weight	113 (29.3%) Moderately to late preterm	1 (0.3%) Triplets	16 (4.1%) Feeding pump
	201 (52.2%) Other *	49 (12.7%) Normal birth weight	27 (7.0%) Full-term	5 (1.3%) Other	5 (1.3%) Saturation monitor 3 (0.8%) Optiflow 3 (0.8%) CPAP

* Other causes of birth mentioned by parents are placenta abruption, spontaneous labour, HELLP, incompetent cervix, gestational diabetes, absent diastolic flow, IUGR, chorioamnionitis, haemophilus influenzae, septicaemia, abnormal dopplers, uterine infection, obstetric cholestasis, uterine rupture and reduced movements of the foetus.

Table 3. Respondents' demographic characteristics in order of prominence in the sample.

Gender	Ethnicity	Occupational Groups	Highest Level of Education Achieved	Years Spent in Education
378 (97.9%) Female	361 (93.5%) White	111 (28.8%) Intermediate managerial/ professional/ administrative	193 (50%) College or university	162 (42%) 14–18
7 (1.8%) Male	8 (2.1%) Asian/Asian British	101 (26%) Supervisory or clerical/junior managerial	94 (24.4%) Postgraduate (e.g., Master)	108 (28%) Over 18
1 (0.3%) Prefer not to say	6 (1.6%) Mixed	48 (12.4%) Skilled manual Worker	69 (17.9%) Higher/ secondary	59 (15%) 12–14
	3 (0.8%) Black British	36 (9.3%) Higher managerial/ administrative	26 (6.7%) Secondary up to 16 years of age	40 (10.4%) 9–12
	6 (1.6%) Other	24 (6.2%) Homemaker	3 (0.8%) Postgraduate (e.g., doctorate)	9 (2.3%) 6–9
	2 (0.5%) Prefer not to say	48 (17.3%) Other	1 (0.3%) Primary school	8 (2.1%) Less than 6

2.2. Materials

(i) The sound in the NICU questionnaire—Soundscape of NICU Questionnaire (henceforth SON-Q)—was developed through the consultation with parents and relevant professionals. The questionnaire was designed to cover the following areas: (1) About your baby (demographics about infants, collected at the start of the questionnaire); (2) You and sound: Going to an NICU; (3) Your baby and sound in the NICU; (4) At home after being in the NICU; (5) About the NICU in general; and about

you (demographics about parents, collected at the end of the questionnaire). Overall, the SON-Q included 32 questions articulated in 204 items evaluated on a 5-point Likert scale. Given that the SON-Q was long, due to its exploratory nature, we deemed it important to include some negatively worded items (e.g., "I did not notice vocalisations") to introduce some "checks" of respondents' sincerity and avoid acquiescence bias, thus increasing reliability [89]. Section (4) also presented one open question (optional), in which parents could share a memory they had from their experience in NICUs, which was associated with sound.

(ii) The PPQ was used to investigate the presence of PTSD symptoms in the parents. The PPQ comprises of 14 items scored on a five-point scale, ranging from 0 = not at all to 4 = often, more than a month (e.g., Did you have bad dreams of giving birth or of your baby's hospital stay?). Higher scores are indicative of more severe PTSD symptomatology. There are also three subscales measured: intrusion symptoms, avoidance symptoms and hyperarousal symptoms.

2.3. Procedure

The SON-Q was constructed and distributed using the Qualtrics survey tool [90]. The parents were invited to complete the survey by clicking an online link, which was posted on social media and parent networks. Following the information section, the participants were first required to give their informed consent and then complete the SON-Q followed by the PPQ, ending with the demographic sections. The completion of the survey took no more than 60 min, depending on the amount of details that the respondents reported in the open question. However, the participants had the opportunity to take short breaks during the completion of the survey, with their answers being saved. The respondents had to click the "submit and agree to share anonymized data for publication" button at the end of the survey in order to be included as participants. The respondents did not receive any compensation for completing the survey.

2.4. Data Analysis

Quantitative analysis: Data were analysed using IBM SPSS v25. First, principal component analysis (PCA) was employed for the four parts of the SON-Q in order to identify relevant dimensions underlying the data and possibly reduce the number of contributing items. Six factors extraction was implemented. The criteria used for factor extraction included Kaiser's criterion (only factors with eigenvalues of >1 were retained) and visual inspection of the scree plot [91].

Next, Pearson's correlations were used to investigate associations of interest, e.g., correlations between the different parts of the SON-Q and the PPQ scores, with alpha set at $p \leq 0.05$.

Based on the correlations, a linear regression model was built with backward elimination, to determine the variables that would be more explanatory with respect to perinatal stress. Finally, moderation analyses were employed to further elucidate relationships between variables.

Qualitative analysis (SON-Q open question): A thematic analysis of the parent's narrative data, transcribed verbatim from the SON-Q open question, was conducted, which offered the opportunity to triangulate aspects of the quantitative results with qualitative analyses. Guided by the steps of thematic analysis [92], the first author initially engaged in reading through the data several times and making notes. In the second phase, the data were organised into tentative codes, focusing on the most prominent memories parents mentioned in relation to their experiences with sound in the NICU. After this, through team discussion, the codes were further organised into themes, and finally, these themes were defined and named.

2.5. Ethics

The research proposal was approved by the Psychology Research Ethics Committee of Middlesex University (#8279) as conforming to the ethical principles of the British Psychological Society and the WMA Helsinki Declaration. The participants received information about the study before participation, explicitly consented to take part in the survey and were provided with full debriefing, which included information about sources of support for participants, if needed. All data were collected anonymously.

3. Results

The results are presented in two sections: (i) quantitative analyses of the SON-Q; (ii) qualitative data analysis (open question).

3.1. SON-Q Quantitative Analyses Results

With the aim of identifying meaningful and cohesive dimensions of the sound in the NICU experience and to reduce the initial number of the items of the SON-Q for the ease of subsequent analyses, a PCA with promax rotation on the SON-Q items was conducted. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis (KMO = 0.677; $p < 0.001$). An initial analysis was run to obtain eigenvalues for each factor in the data. The scree plot was ambiguous and showed inflexions that would justify retaining at least 10 factors. Six factors were extracted based on eigenvalus of >1 (factor loadings after rotation can be found in Table S2 of Supplementary Materials). Items loaded negatively and/or on more than one factor were eliminated.

All factors presented high or moderate reliability. The items that cluster on the same factor suggest that F1 represents "A challenging NICU soundscape" (Cronbach's $\alpha = 0.867$); F2 represents "Infants' reactions towards noises and voices in NICU" (Cronbach's $\alpha = 0.900$); F3 represents "Singing and using recordings for infants in NICU" (Cronbach's $\alpha = 0.913$); F4 represents "Interacting and bonding with infants in NICU" (Cronbach's $\alpha = 0.754$); F5 represents "Parenting confidence (parental attention to infants' sounds)" (Cronbach's $\alpha = 0.810$); F6 represents "Perception of the home environment" (Cronbach's $\alpha = 0.815$). Each of the factors was explored further in combination with the qualitative data (final questionnaire items can be found in Questionnaire S1 of Supplementary Materials). Correlational analyses were then conducted between birth weight and parental age and all factors of the sound in the NICU questionnaire. As can be seen in Table 4, the ages of the parents were significantly associated with the lower intensity of infant reactions towards voices and sounds in the NICU. Parental age was also negatively associated with higher scores in "Parenting confidence". Interestingly, the lower the birth weight, the more attention the parents paid to infant reactions and the more the singing and interacting–bonding was reported. Furthermore, the lower the birth weight, the higher the engagement of the parents by using singing and recordings and the higher the behaviours towards bonding with the infants. Finally, there were significant associations among most of the factors of the SON-Q.

Next, correlational analyses were conducted between birth weight and parental age with the PPQ-Total Score and PPQ-Intrusiveness, PPQ-Arousal and PPQ-Avoidance scales separately. As can be seen in Table 5, no significant associations emerged with infant birth weight, but the PPQ-Total Score and subscales showed significant negative associations with parental age.

Table 4. Bivariate correlations between birth weight, parental age and all factors of the SON-Q.

	Birth Weight	NICU Soundscape	Infant Reactions	Singing-Recordings	Interacting-Bonding with Baby	Parenting Confid.	Home Environ.
Child Age		−0.04	0.01	0.00	−0.06	−0.09	−0.02
Parent Age	−0.06	−0.05	−0.15 **	−0.04	0.08	0.26 **	0.09
Birth Weight	-	−0.12 *	−0.16 **	−0.22 **	0.15 **	0.04	0.01
NICU Soundscape			0.31 **	0.08	0	−0.03	−0.04
Infant Reactions				0.26 **	0.10	0.31 **	−0.05
Singing-Recordings					0.31 **	0.29 **	0.16 **
Bonding with Baby						0.14 **	0.22 **
Parenting Confidence							0.10 *

* $p < 0.05$; ** $p < 0.01$. Note: Child Age = Child Age at the time of the questionnaire completed; Parent Age = Parental Age; NICU Sound = Challenging NICU soundscape factor; Infant Reactions = Infants' reactions towards noises and voices in the NICU; Singing-Recordings = Singing and using recordings for infants in the NICU; Interacting–Bonding with Baby = Bonding with infants in the NICU; Parenting Confid. = Parenting confidence (parental attention to infants' sounds); Home Environ. = Home Environment.

Table 5. Bivariate correlations between birth weight, parental age and all subscales of the Perinatal Post-Traumatic Stress Disorder Questionnaire (PPQ).

	Birth Weight	PPQ-Total Score	PPQ-Intrusiveness	PPQ-Avoidance	PPQ-Arousal
Child Age		0.01	0.03	0.04	−0.02
Parent Age	−0.05	−0.12 *	−0.12 *	−0.10 *	−0.10 *
Birth weight	-	0.05	−0.03	−0.05	−0.05
PPQ-Total Score		-	0.81 **	0.92 **	0.90 **
Intrusiveness			-	0.64 **	0.66 **
Avoidance				-	0.74 **

* $p < 0.05$; ** $p < 0.01$. Note: Child age = Child age at the time of questionnaire completion; Parent Age = Parental Age.

Finally, correlational analyses between all factors of the SON-Q and the PPQ-Total Score and subscales are shown in Table 6. The more challenging the sound environment in the NICU perceived, the more perinatal stress, intrusiveness, avoidance and arousal the parents experienced. Similarly, the higher their attention and tuning to their infants' reactions, the higher the perinatal stress. Lastly, a perception of the home environment was negatively associated with all PPQ subscales.

Table 6. Bivariate correlations between birth weight, parental age and all factors of the sound in the neonatal intensive care unit (NICU) questionnaire and all PPQ subscales.

	PPQ Total Score	PPQ-Intrusiveness	PPQ-Avoidance	PPQ-Arousal
NICU soundscape	0.46 **	0.42 **	0.43 **	0.39 **
Infant Reactions	0.12 *	0.19 **	0.05	0.13 *
Singing-Recordings	0.01	0.07	−0.04	0.04
Interacting-Bonding with Baby	0.03	0.06	−0.02	0.07
Parenting Confidence	−0.04	0.00	−0.05	−0.05
Home Environment	−0.28 **	−0.19 **	−0.30 **	−0.24 **

* $p < 0.05$; ** $p < 0.01$.

To explore the independent contributions of the different dimensions of the SON-Q in perinatal stress, a linear regression model was built with backward elimination, using perinatal stress (PPQ-Total Score) as a dependent variable and the "NICU soundscape", "Infant Reactions", "Singing-Recordings", "Interacting–Bonding with Baby", "Parenting Confidence", "Home environment" and parental age as independent variables. This was carried out in order to determine whether which model would be more explanatory and parsimonious in explaining variance in perinatal stress, after progressively removing different predictors based on the F criterion (see process and all models in Table S3 of Supplementary Materials). As can be seen in Table 7, in the final model, "NICU Soundscape", "Home Environment", "Interacting–Bonding with Baby" and Parent age significantly contributed to the variance in the PPQ-Total Score, suggesting that all these variables have a significant influence on perinatal stress. Interestingly, the sound in the NICU explained the biggest amount of variance in the PPQ-Total Score. No obvious patterns were observed, and residuals did not appear to deviate from a straight line in the model, therefore meeting the assumptions.

Table 7. Final regression model predicting the PPQ-Total Score after progressively removing "Singing-Recordings", "Parenting Confidence" and "Infant Reactions".

	β	t	p	R^2	F	p
Final model				0.30	42.45	<0.001
NICU Soundscape	0.45	10.60	<0.001			
Home Environment	−0.28	−6.54	<0.001			
Bonding with Baby	0.10	2.35	<0.05			
Parent Age	−0.08	−1.9	=0.05			

Finally, based on theoretical considerations, the relationship between NICU soundscape and perinatal stress was explored to identify whether it was modified by either singing and using recordings for infants in the NICU or interacting and bonding with infants in the NICU. A moderation analysis using PROCESS in SPSS was conducted. Two models were built, where the outcome variable was perinatal stress and the independent variable was NICU Soundscape. In the first model, the moderator evaluated was the Singing-Recording subscale, and the results showed that the interaction was not significant ($B = -0.002$; 95% C.I.: (−0.008, 0.004); p = n.s.). In the second model where the moderator variable was Interacting–Bonding with Baby in the NICU, and the interaction approached significance ($B = -0.03$; 95% C.I. (−0.07, 0); $p = 0.06$). The conditional effect of a "challenging NICU soundscape" on perinatal stress was weakened in the function of the values of interacting-bonding with the baby: at low values of Interacting-Bonding with Baby (−3.26), the conditional effect was strongest ($B = 0.71$; 95% C.I. (0.54, 0.88); $p < 0.001$); at middle values of Bonding with Baby (.00), the conditional effect was slightly lower ($B = 0.60$; 95% C.I.: (0.49, 0.70); $p < 0.001$); and at high values of Bonding with Baby (2.16), the effect was slightly weaker although still significant ($B = 0.52$; 95% C.I.: (0.40, 0.65); $p < 0.001$). With respect to the relationship between a "challenging NICU soundscape" and perinatal stress, it is interesting to note that the level of interacting and bonding with the infant was found to be a marginally significant moderator. That is, the parents that bonded more strongly with their infant were less affected by the challenging sound environment in terms of their stress levels. On the other hand, the parents whose bond with their infant was not perceived to be as strong were more negatively affected by the sound environment in the NICU.

3.2. Open Question Qualitative Analysis

A total of $n = 239$ participants completed this question, and their answers disclosed their perceptions of NICU sounds. The findings reflect the thick and ever-changing texture of the NICU soundscape, highlighting feelings of stress and at times helplessness experienced by the parents.

Four themes emerged (see Table 8) with each having two subthemes. The first theme captured possible influences of different mechanical sounds on the parents' experience of the NICU ("Sounds from machines and various inanimate object: What's a beep?"). The second theme illuminated parents' reactions to the sounds originating from the medical staff and other families hospitalised in the NICU ("Sounds from human sources"). The third theme revealed the parents' difficulty to connect to their own voice as parents taking care of their baby in the NICU ("Unheard sounds of parents—'we couldn't vocalize'!"). The fourth theme emphasised the importance of incorporating music into the NICU soundscape in order to support families in their stay at the hospital ("The sound of music as supporting parents and babies"). All themes and subthemes are presented separately below with verbatim extracts of participants' responses. Each theme will be illustrated with full verbatim quotes from anonymised participants.

Table 8. Qualitative analysis of themes and subthemes.

Themes	Subthemes
Sounds of machines and various inanimate objects: What's a "beep"?	Constant "beeping" as a symbol of the parents' ceaseless worrying
	The role of "beeps" as traumatic reminders
Sounds from human sources	The sounds of medical staff
	The sounds of other hospitalized families
Unheard parents' sounds: "we couldn't vocalize!"	Parents' feelings of transparency and incapability
	Parents' perplexity towards other babies' cry
The sound of music as balancing the NICU's cacophony	Music as a supporting agent for parents and babies in the NICU
	Music as a transitional object for families when entering their home environments

Theme 1: Sounds of machines and various inanimate objects: What's a "beep"?

The majority of the participants mentioned memories of sounds originating from machines and various inanimate objects. This theme predominated the parents' comments and formed the most rich and elaborated aspect of parents' descriptions. The monitor alarm appeared most frequently amongst parents' comments, in addition to other NICU machines such as the ventilator, opening–closing incubator doors and Bipap machines. Noteworthily, many of the parents' comments revealed their awareness of sporadic and commonly unnoticeable sounds, such as the sound of a stapler, an opening of syringe packets, a trolley pushed around, the ring of doorbells, noisy shoes squeaking, speaker announcements, butterfly oscillator, the ringing of milk heaters, apron dispensers, on-hold music on the phone and the hums and the ticks of the clock while waiting. The parents mentioned their own responses to not only machine sounds, but also their babies' sounds. This suggests that any noise in the NICU's vicinity can trigger anxious responses based on personal circumstances and casual coincidences, due to the parents being susceptible to environmental signals.

> "The soft beeping of the monitors is overwhelmingly etched in my memory" (P92).
>
> "I'll never forget the high pitch patterned beep if the UV light for jaundice and the alarm when heart rate went to low or oxygen went low" (P213).
>
> "The sound of the doors opening; the sound of shoes on the highly buffed floors" (P100).

This theme was dominated by two subthemes: "Constant 'beeping' as a symbol of the parents' ceaseless worrying"; and "The role of "beeps" as traumatic reminders", as follows.

Constant "beeping" as a symbol of the parents' ceaseless worrying.

The comments highlighted the perpetual "beeping" as reflecting the parents' general experience of continual stress: constant sense of urgency and preoccupation over their babies' health; continuous running; constant fear of losing their babies; an endless struggle to divide themselves between home and hospital; and an immeasurable desire to do more for their babies.

> "The relentlessness of the sounds was overwhelming, but I think more than the sounds alone, was what they represented-danger; sickness; probable death. And it was that combination that I found torturous" (P176).
>
> "During my son's NICU stay his condition deteriorated rapidly. His belly was swollen and his oxygen saturation's suddenly dropped whilst on bipap breathing support. The machines were getting louder and louder, doctors were running around taking turns to try and stabilise him. Another doctor was on the phone to a higher level NICU hospital for an emergency transfer. No one could tell me what was going on. Between the noisy machines, not being able to be near my son as there were four doctors working on him, the noise from doctors & nurses rushing. I was completely overwhelmed" (P34).

> "I remember that every time the emergency alarm was on I felt that my world is breaking. I would let anything behind, run to my babies' nursery and pray that they were well, and the alarm was not on because they needed help" (P1).

> "Beeping. Incessant beeping. Of different tones and pitches but beeping. One time my baby's oxygen monitor went off whilst I was feeding her but I couldn't differentiate this as urgent, compared to all the other beeps that we going on" (P78).

The role of "beeps" as traumatic reminders. The comments reveal the complex and enduring effects of the alarm and portray sound as contributing to the parents' overactivated nervous system, in many cases possibly resulting in PTSD. Parents' comments emphasised the association of the sound with their babies' clinical state, suggesting that they represented much more than acoustic signals. The comments revealed that once the parents transitioned with their baby to the home environment, the mechanical sounds became haunting, causing nightmares and bringing back vivid memories by associating everyday sounds to the ones of the NICU.

> "Alarms going off is associated with my babies desats. I think I have PTSD according to my reaction to alarms" (P58).

> "The Asystole and bradycardia and Apnea alarms haunt me" (P74).

> "The low loud "boom boom" sound that the monitors made will stay with me forever. Whenever I look back at recordings of my son and I hear that noise in the background it makes me well up. It's a haunting sound" (P117).

> "Once a very sick baby crashed 3 times in 25 min in our ICU room. It was terrifying. I still have nightmares almost 2 yrs later. The crash alarm rings in my ears so loud. I'll never forget it as long as I live" (P232).

> "Regular beeping noise still create feelings of stress and anxiety for me" (P210).

> "I just remember that for many years my son was terrified of sudden high pitches noises. He could go from floor straight into my arms at one leap if he heard something like a monitor sound. But could sleep through a Hoover next to his cot!" (P174).

Nevertheless, the findings emphasised that despite the "beeps" being distressing for parents, they also reassured them regarding their infant's health. If given a choice, parents would more often prefer to hear a sound than not to, and feel relieved, against the uncertainty and fear that something adverse might be going on with their baby, portraying the "beep" sounds as a double-edged sword.

> "Sounds are scary to start with but become reassuring" (P192).

> "For a while after coming home, I'd have to put the radio on quietly in the bedroom. Bings and bongs were somewhat reassuring" (P149).

> "My son used to suffer from desats where the monitor used to alarm if it happened which was quite frequent. When it was being discussed he could go home they turned off this monitor just a few days before discharge which I felt gave me anxiety because I got into a habit of relying on the noise to tell me when it was happening" (P124).

> "When returning home in the evenings, I would constantly hear all the beeping from the machines in the NICU, on occasion I would wake up after hearing the urgent call response (although I was at home) prompting me to ring the NICU throughout the night. The noises from the machines were so reassuring yet so traumatic" (P138).

> "The sounds of the monitors became familiar & strangely comforting, especially when I visited our daughter alone" (P118).

Theme 2: Sounds from human sources.

The parents' comments suggested that the NICU soundscape did not include only desolate sounds from machines and objects, but also human sounds made by medical staff caring for the hospitalised infants as well as parents and families visiting the NICU.

The sounds of medical staff.

Parents' comments showed that occasionally, they were disturbed by staff's volume of speech and private conversations held in the vicinity of their baby's bed.

> "My daughter was very sensitive to sound. Even with signs reminding staff to talk softly they would talk very loudly, and her stats would drop" (P62).

> "Staff talking too loud/laughing" (P11).

> "Staff talking loudly and often about non-work-related matters" (P115).

The sounds of other hospitalised families.

The comments reveal the parents' sensitivity to sounds originating from other families hospitalised in the NICU of adults as well as those of young siblings of NICU babies.

> "Visitors of one of the babies were regularly very loud with children running and screaming which visibly affected my baby" (P132).

> "Staff (rightly) weren't in control of the volume of other parents, some at times were loudly derogatory about staff and I felt so torn about leaving my baby and felt so guilty knowing I was leaving her in such a toxic environment (thankfully this was the minority (but loudest!) of parents" (P 99).

> "Other parents were loud" (P146).

Theme 3: Unheard parents' sounds: "we couldn't vocalise!".

The findings revealed parents' thoughts about their position in the NICU environment and their struggles and pain for not being able to practice parental skills. This was reflected in parents' reports in two different ways: (1) on the one hand, the comments highlighted feelings of transparency and incapability; (2) on the other hand, the parents expressed feelings of helplessness relating to hearing other babies cry, while fearing their own baby might be subjected to similar moments of discomfort, when they were absent from the NICU.

Parents' feelings of transparency and incapability.

Separated from their baby, by the alarming as well as the lively sounds of the NICU, seemed to induce a state of detachment on the parents' side. The parents emphasised sensing a lack of their parental voice throughout their NICU stay. The parents reported that in trying to keep quiet, their thoughts and desires were suppressed, affecting their ability to communicate with their babies.

> "I found it difficult to connect with my baby as it was too quiet, and I didn't want to disturb the rest of the unit at times." (P82).

> "So quiet around us that we preferred not to talk rather than have everyone hear us. I was embarrassed and overwhelmed and just went into myself. I didn't want to be there and I didn't know what I was doing" (P88).

> "I hadn't held my baby and didn't let myself feel anything for him so there was no questions of me singing or chatting to him in that situation. I had to wait until I was at home alone with him for that" (P88).

> " . . . the fear of speaking too loud and/or making noise. Feeling like you had to be silent" (P166).

> "My baby was taken off me by the NICU nurse and rubbed and manitoulated (sic) until the oxygen levels were restored. I've thought about that moment a lot

> that I could and should have done more but I didn't because I didn't know what this beeping was telling me" (P78).

Parents' perplexity towards other babies' cry.

In light of the absence of their parental voices, the comments illuminated the stress induced by hearing other babies in the NICU crying, which seemed to connect the parents even more to their sense of parental incompetence. The cry of other babies, in that sense, symbolised for the parents their inability to fulfil their parental roles and stand by their baby at all times, while being hospitalised in the NICU.

> "The most heart-breaking noise for me was the crying of other babies when nobody was around to attend to them. I worried that when my daughter started to cry, she would be left in the same way. I really didn't mind the alarms, but I hated hearing the other babies cry" (P204).

> " . . . staff would often not have time meaning babies next to mine sat crying or their monitors went off and nobody appeared to look at them, it made me anxious did they ignore my baby when I wasn't there?" (P194).

> "The crying of other people's babies made me feel frustrated that we could not be at home enjoying each other's company in our own bubble. As a first-time parent, you expect to enjoy a certain time of calm and to be used to your new arrival, the NICU attacks all your senses and everything you have prepared your baby for. The sounds are as unfamiliar to baby as they are to you" (P188).

Theme 4: The sound of music as balancing the NICU's cacophony.

As opposed to the aforementioned themes, which focused mainly on the distressing aspect of the NICU soundscape, this theme reveals the power of music as contrasting and mitigating "harmful sounds" and as facilitating for both parents and their babies a more comforting and supporting experience.

Music as a supporting agent for parents and babies in the NICU.

The findings showed that music transformed the parents' experience of the NICU in several ways: (1) music helped parents to feel at home and encouraged infant–parent bonding; (2) music induced a state of relaxation and comfort for babies and parents and, in some cases, supported them in processing their stressful experience of being hospitalised; (3) music in the NICU had an influence on infants' development.

> "I remember my baby's night nurse would sing and hum as she did her rounds. It seems like when she hummed during feedings, the babies would take to the bottles better. When she hummed my baby would turn in her direction, or her heart rate would even out while she was being held and hummed to by her (much like she did being held by her parents). Sound is very important to babies, especially those in loud NICUs, in order to maintain a peaceful demeanor" (P68).

> "Special care unit towards the end of our stay started to play music in the corridors between the nursery and it made all the difference to the parents as it made it feel less like a hospital setting" (P38).

> "Whilst pregnant, I played piano everyday (I play to a high standard) and got heavily into a particular composer. His work will be forever associated with that time as after my daughter's birth, I downloaded an album of his played work and played it to her throughout NICU and beyond. Her experience of NICU was very calm-she slept through it. Literally. I believe it was aided by as much kangaroo care as I could give, and music. Non-stop music that the nurses let me play to her" (P43).

> "It seems like when she hummed during feedings, the babies would take to the bottles better" (P68).

Music as a transitional object for families when entering their home environments.

In addition, parents shared that music made the hospital–home transition smoother for them and for their infants. Being discharged from the NICU is a widely acknowledged stressful event, due to parents' feeling wholly responsible for their infants' health, without the hermetic protection of nurses and doctors, for the first time. The findings suggested that the same music parents chose to listen to in the NICU (and sometimes already when pregnant) served them as transitional objects when taking their baby home for the first time. This emphasises not only the important role of music in the NICU, but also its sustained impact over time and space.

> "My husband and I slept with music on for two months after bringing our daughter home" (P197).
>
> "There is a song by a band Athlete called 'Wires' written about their experience in NICU. Every time I hear it, I bawl my eyes out. Certain noises or in this instance songs bring back the vivid memories" (P154).
>
> "I loved being able to sit in a rocking chair with my son with my worship music playing. He was the most active while I was pregnant listening to that music and the most relaxed in the NICU and once home" (P61).

4. Discussion

The results of this study present a systematic survey of the parent's perception of the NICU soundscape, from the perspective of a large sample of parents of premature infants, from which perinatal stress measures were also collected. To the authors' knowledge, this is the first attempt to capture specifically and in detail, from a parents' perspective, a multifaceted representation of the parental experience of the NICU soundscape. For this purpose, the exploratory questionnaire, SON-Q, was developed to investigate parental experiences across the birth throughout their infant's stay in an NICU and the initial postdischarge period at home. The quantitative results from the questionnaire were then triangulated with insights based on parents' generated memories from one open question of the SON-Q. Overall, the quantitative and qualitative results have been highly convergent, showing that the NICU soundscape plays a central part in the parents' most stressful, sometimes traumatic, experiences with their preterm infants while they were hospitalised. Although some studies suggest that there is no association between sounds in NICUs and parents' stress [93], the findings from the present study are in line with those reported by Turan et al. [94], who found that parents in NICUs experience stress due to sound, among other factors such as sights, infants' appearances or parental role alteration.

The first evaluation of the SON-Q identified six factors with moderate to high reliability. In order to shed light on the parental concerns identified by these factors, the results of the quantitative analyses were complemented by the content analysis of the open question of the SON-Q, asking parents to share some of their more personal memories of the NICU soundscape. The themes that emerged from the qualitative analysis are consistent with and illuminate the interpretation of the dimensions of parental concern identified by the factors.

The first factor that emerged from the SON-Q, "A Challenging NICU soundscape", captured parents' beliefs with regards to the NICU soundscape and the impact that it had on them. Although the relationship between sound and stress is under-investigated, a review of the literature suggested that the NICU sound environment might trigger physiological and behavioural responses, which may negatively impact communication and job performance [95]. From the staff's perspective, Santos et al. [96] outlined that the levels of noise from NICU were excessive, with an emphasis on noise from equipment. This factor suggests that parents also perceived the NICU soundscape as a negative environment, increasing their stress levels. They also emphasised that specific times of the day were noisier, making it challenging to communicate with their infants and concentrate on the care they needed to provide them, making various suggestions for improvements.

Moving the focus to the infants, "Infants' reactions towards noises and voices in NICU" portrays various reactions that parents observed in their babies, in particular towards noises from medical equipment and voices speaking or singing in NICUs. Due to the descriptive nature of the responses, it is difficult to assess whether the reactions were perceived as positive or negative ones. However, previous studies have shown that the exposure of premature infants to continuous loud noises, such as sounds from equipment, triggers negative physiological responses [97,98]. On the other hand, there is evidence that premature infants show positive reactions towards their mothers' speaking and singing, which is consistent with the literature on infants' sensitivity to the biologically meaningful and attractive sounds of their mother's and other voices [21,99]. Suggestions from the qualitative data also highlight that inadequate volume of voices, such as staff talking or children visiting their siblings being particularly loud, also negatively impacted their infant's reactions and would present challenges to understand speech and communication [38].

Interestingly, the third factor captured the specific aspect of musical communication, with "Singing and using recordings for infants in NICUs" representing parents' beliefs about singing to their babies and using recordings in NICUs, such as keeping babies' company, supporting their development, expressing thoughts and feelings and covering aversive noises in NICUs. These results are in line with findings showing benefits of singing for infants in NICUs [100,101], especially with live vocal contact that fosters multimodal co-regulation, intuitive parenting, unconscious mimicry, as well as reciprocal synchronization, with all vital aspects supporting attachment and bonding [102]. Whilst some studies emphasised that parents, staff and physicians would prefer recorded music for infants in NICUs [103], there is evidence suggesting that live music is far more beneficial for premature infants than recorded music [99,104]. Consistently, the parents revealed how singing to their babies encouraged bonding, but also highlighted that the NICU environment made them feel prone to suppress their wishes to communicate and sing to their babies, feel the need to be quiet and not to disturb other hospitalised infants and their parents, thus justifying somehow the use of recorded music.

The factor "Interacting and bonding with infants in NICUs" represents parents' manifestations towards their babies while in NICUs, such as talking to them, holding hands on them and being able to discriminate a pain cry, which is in line with the literature emphasising the parents' desire for physical contact [67,105]. Cogently, exposure to higher parent talk during infants' hospitalisation is linked to increased infant vocalisation at discharge and better cognitive outcomes and language skills in toddlerhood [106]. However, the bonding process in NICUs is threatened by the aversive environment and the need for separation [107]. Despite the changes in the NICU towards a family-centred approach, with parents being increasingly involved in their babies' care, intensive care still makes it difficult to experience parent–infant closeness [108]. This can cause parental depression and feelings of guilt, but also poorer developmental outcomes in infants [109]. Indeed, in the qualitative analyses, the parents revealed that they felt that bonding with their infants was affected by the NICU sound environment, suggesting that quiet interaction time with an improved soundscape, including music on the background, could promote this aspect.

Further developing the previous aspects, the factor "Parental confidence and attention to infants' sounds" referred to not only various vocalisations produced by infants in the NICU, allowing the parents to identify them among other babies, but also various types of crying that parents were able to discriminate within their babies, such as pain and tiredness crying. Parent's intuition about the importance of infants' vocalisation is compatible with research investigating infants' vocalisations in NICUs. While research is still relatively scarce, there is evidence suggesting that infants start to vocalise from as early as 32 weeks, which is an ability that increases over time [105], and that also includes non-cry vocalisations ('protophones") [110]. However, this ability could be affected by complications in premature birth and related interventions required (e.g., intubation) [111], which may in turn explain language delays in preterm infants [45,112].

Importantly, communicative signals and the amount of time spent in contact with an infant and the direct caregiving experience also modulated parental functioning. Despite these actions being constrained in the NICU, the parents from the present study still reported recognising their infant/s as well as their infants' needs by the sounds they made, which may be due to "intuitive parenting" [113]. However, such parental perceptions might be influenced by various factors, such as culture or depression, but might be also related to their specific attention towards their infants' clinical state, derived from their experience in NICUs, and the awareness that misunderstanding the signals can compromise the infant [114].

Finally, "Perception of the home environment" outlines a contrast in the parents' beliefs about the home environment after the first postdischarge at home. On the one hand, they perceive the home environment as a negative one, which is consistent with robust research about the difficulties that premature infants' parents experience after the first discharge at home. In particular, with difficulties in the transition to parenthood conflated with the transition from hospital to home, any unresolved issues in hospital continue at home (e.g., stress and anxiety [115], depression and grief [116], lack of confidence and self-efficacy in parenting [117] or a need for additional professional and social support [118]), which are some of the reasons why parents described their home environment as chaotic and discouraging in the present survey. On the other hand, discharge to home brings various benefits to parents, such as not having to do the tiring travel to the hospital [119], being able to bond with their infants without medical sounds and sights, as well as not being impacted by the dynamics of the NICU including other babies crying and variety of medical staff caring for the infants. The findings from this factor are in line with parents' comments explored in the qualitative analyses, in which the majority of participants (73.6%) reported that their infants were discharged from the hospital without additional equipment, suggesting that their infants did not have severe health problems.

Besides the remarkable convergence between the quantitative and qualitative results, this study also revealed important relationships with demographic aspects and parental perinatal stress. For instance, the lower the birth weight, the more attention parents paid to infants' reactions to sounds and the more singing and interaction–bonding reported. Although the literature indicates that premature birth can undermine the development of efficient parent–infant bonding [120,121], these findings highlight parents' intuition or awareness of the vital role that interaction and bonding play in their infants' development [122]. Moreover, reading the signals from the tiniest babies and trying to establish a connection with them might stimulate the parents to find a place for themselves in their infants' life to be identified as parents [122–124]. In other words, even if their babies cannot respond, the parents still activate their parenting schemes.

Regarding the relationship between perinatal stress and the NICU soundscape, PPQ scores were higher in parents who perceived the NICU sound environment as aversive and challenging and who had infants with very-low birth weight, which is consistent with previous research suggesting that the NICU environment is overwhelming [125,126]. There was no overall significant relationship between PPQ scores and the birth weights of the infants, which is inconsistent with the literature suggesting that maternal PTSD is linked to low birth weight [127,128] but align with the suggestion that all parents who experience an NICU stay can potentially display PTSD symptoms, regardless of how preterm an infant was born [87,129]. However, the moderation analysis revealed that the PPQ scores in parents who had a very low-birth-weight baby were higher for younger parents than for older parents. This might be explained by the fact that apart from the baby being unwell, the younger parents might be experiencing various other difficult situations [130], such as lower levels of education [131], unplanned pregnancy [132], unstable material situation or unclear marital status [133].

Indeed, it has been shown that parental posttraumatic stress and trauma adversely affect parenting and bonding, thus posing a risk for children's developmental outcomes [134,135]. Thus, it is interesting to note that the level of interacting and bonding with the infant

was found to be a marginally significant moderator in the relationship between the NICU soundscape and perinatal stress. Specifically, the parents that bonded more strongly with their infant were slightly less affected by the challenging sound environment in terms of their stress levels. On the other hand, a trend was observed for parents whose bond with their infant was not perceived as strong to be more negatively affected by the sound environment in the NICU.

In sum, the novel findings form this study are substantially consistent with the relevant literature. However, a few limitations of this study might be considered. First of all, this is an exploratory correlational study; hence causal interpretations cannot be made. Only a randomised controlled trial comparing parental stress in an equivalent population exposed to different NICU soundscapes could establish a possible causal relationship between characteristics of the NICU soundscape and parents' stress and trauma levels. Second, the numerosity of the sample was relatively small for the particular statistical analysis performed, i.e., PCA (recommended number of participants per item [91]. However, the other necessary conditions for PCA were consistent with the use of this form of analysis for the SON-Q data, which will be further elaborated to create a reduction/simplification of the items and develop a leaner version of the questionnaire to be used in future research. It is important to consider that the sample is per se substantial at n = ~400, since the proportion of parents who had an infant in an NICU represents a small percentage of infants [13], respectively, 1 in 7 babies is admitted to NICU each year in the UK [15] where the data were collected, suggesting that a high number of these parents wanted to express their views on their sonic experience in NICU. The sample was further limited by two potential biases: (i) gender bias—97.9% of the respondents were female, which is congruent with the literature available, suggesting that fathers of premature infants were underrepresented in our sample [85]; (ii) selection bias—more than 50% of respondents who engaged with the survey did not complete it. Although this is not uncommon in online surveys, it is possible that demographic variables (e.g., education) affected this decision, we were not able to compare demographic variables between respondents who did and did not complete the survey at the end of the survey due to the parent demographic section.

In spite of the acknowledged limitations above, the present study provides an unprecedented level of details in consideration of the importance of the soundscape in the early stages of the parental experience, particularly for those parents experiencing traumatic scenarios at the beginning of the lives of their infants.

5. Conclusions

This study was successful in developing a novel tool to investigate parents' experience with the soundscape in NICUs. The study highlights associations between the soundscape in NICUs and parental stress. Additionally, it provides initial suggestions to stimulate further research, audience involvement and interdisciplinary collaborations aiming to improve parents' mental health, as well as supporting early bonding and facilitating positive developmental outcomes for infants in need of intensive care. Some practical considerations and suggestions for future research are as follows:

(i) It is important to address parents' needs in order to support their mental health. For instance, being delivered in a family-centred approach in combination with Kangaroo Care, music therapy in NICUs has been shown to be beneficial, helping to reduce parents' anxiety and stress and improve their mood, restfulness and motivation [136]. Additionally, it improves breastfeeding [137], relaxation [138] and parent–infant bonding [100,139], which is supported by emerging parental identity [140].

(ii) Future research is important to extend this study cross-culturally and to investigate the sonic experience of premature infants and their parents during both their NICU stay and early postdischarge across a variety of cultural and social contexts [141–144]. The convergent quantitative/qualitative results demonstrated the importance of opening a conversation between parents who have experience in NICUs, medical and nursing staff, psychologists and engineers, to plan strategies for improving the

sonic experience in NICUs. This is crucial for both infants and parents, encompassing support for parent–infant vocal interaction and the mitigation of noxious aspects of the NICU soundscape, especially those derived from medical machines.

(iii) In this respect, future research may involve partnerships with technology developers targeting the overall improvement of the NICU soundscape. The present study focuses on the subjective parental experience with the NICU soundscape, but two important points need to be kept in mind. Indeed, different brands of the same equipment may use more/less loud or unpleasantly pitched signals and hence may affect the NICU soundscape in different ways; similarly, the layout and space available in the wards may also increase/diffuse noxious sound effects. Last but not least, the noisy equipment in NICUs in many cases has a life-saving function, and hence, the relevant question is not about having or not having the equipment, but regarding implementing changes in which signals could be designed either based on current understandings of human emotional responses to sounds with different characteristics or based on the exploration of other sensorial modalities (e.g., vibration) or a combination of sensorial modalities allowing for different levels of sensitivity. Objective measures of specific acoustical parameters should be the basis for new standards and future interdisciplinary studies comparing outcomes in both infants (e.g., auditory development) and parents (e.g., perinatal stress affecting their parenting ability and coping) across environments.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/children8080644/s1, Table S1A: Sounds created by Machines. Table S1B: Sounds created by Other than machines. Table S2: Summary of principal component analysis results for SON-Q (N = 386, Items = 204). Table S3: Regression models predicting the PPQ-Total Score. Questionnaire S1: Final questionnaire items (n = 77) following PCA.

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children

The soundscape of neonatal intensive care: A mixed methods study of the parents' experience

Maria Chifa[1], Tamar Hadar[2], Nina Politimou[3], Gemma Reynolds[1] & Fabia Franco[1]
[1] Middlesex University, London (UK)
[2] Lesley University, Cambridge MA (USA),
[3] University College London (UK)

* *Correspondence: Dr Fabia Franco, Email: F.Franco@mdx.ac.uk*

SUPPLEMENTARY MATERIALS

Supplementary 1: Noises/sounds found in the Neonatal Intensive Care Unit (NICU) based on their sources: 1A) Machines, 1B) Other sources

Table S1A. Sounds created by Machines.

Description of the Equipment / Machines	The sound that it produces
Incubator - the box where the baby is kept.	Occasional sounds, e.g., when opening the top, when the temperature is too high, or there is some defect. M.: "The new ones we have make currently the loudest noise on the unit. It's really loud and continues until off button pressed after being unplugged" (Neonatal nurse, London, personal communication).
Ventilator – breathing machine for mechanical ventilation.	This can have various modes, such as high-frequency oscillation, volume guaranteed etc., depending on what works better for the child. This machine can produce a mixture of sounds: continuous vibration in case of high-frequency, continuous sound made by the humidifier and occasional alarms if the pressure drops, if the child needs resuscitation or some tubing that needs to be changed.
Bilevel Positive Airway Pressure (**BIPAP**) - provides pressurized air into airways.	Soft and rhythmic, with occasional alarms if the pressure drops or something is not working.
Continuous positive airway pressure therapy **(CPAP**) – provides less pressure than the BIPAP.	This machine can vibrate, hum, and be noisy.
Heated, humidified high-flow nasal cannula (also called HHHFNC, **high-flow** or **optiflow)** – delivers warm, moist air with or without oxygen into child lungs via a nasal cannula.	Soft, continuous sounds, with occasional alarms.
Vital signs **monitor** – for heart rate, blood pressure, breathing rate, oxygen saturation and so on.	This makes the most alarms than any other machines in NICU. It alarms if any of the previously mentioned go below or above the limit, ranging from a slow to fast rhythmic, obsessive sound.
Infusion pumps – delivers fluid at an established rate, in small or big quantities.	It only beeps when the infusion is about to finish, when it is finished, or if there are any blockages. The sound is loud and rhythmic.
Tecotherm (Freezing machine) – lowers and keeps a child`s temperature at 33` degrees	Continuous, buzzing sound.

Feeding pump – pushes the milk via a tube.	Soft, continuous sound.
Portable x-ray	Its wheels make a very low noise, and when it flashes, it makes the sound of a toy gun, just one-off.
Portable cupboard - with the materials necessary, e.g. for long line insertion.	Its wheels make a shaky noise.
Portable echo – for brain, heart scans etc.	Its wheels make a quiet and mysterious noise. Head scans particularly, one setting makes similar sounds as an ECG machine.
Portable incubator – it is used to transfer babies to other hospitals.	Again, only the wheels are noisy.
Fridges – to deposit moms` milk and medicines.	Really loud high pitch noise. Usually, it takes quite a long time to stop because if open too long, it needs to reach a certain temperature
Apnea alarm – to detect babies` breathing.	Beeping sound if it doesn't detect breathing for longer than 20 seconds.
Doctors' bleeps – special transmitters on which doctors receive various messages.	Intensive, alarming sounds until attended.
Computers on the wheels – used for electronic health record system.	When they run out of battery it makes a high pitch continuous beep.
Expressing pumps – most of the time moms express in the expressing room. However, there are cases when the pump is brought into the nursery and the expressing is done next to the incubator.	Continuous, regular sound.

Table S1B. Sounds created by Other than machines.

Sources of sound	The type of sound
People- nurses, doctors, relatives, including siblings, and other professionals.	Loud noise when talking.
Bins – they are used most of the time, such as when a nappy is changed, baby fed, treatment administered. Its bag is changed several times a day.	Banging sounds.
Cleaning equipment	Irregular sounds.
Staplers	Loud click.
Syringes – used for feeding and treatments (there hundreds/day opened).	When the package is opened, it makes a ripping sound.
Sink	Running water falling on the sink makes a calming sound.
Chairs – there are stools to sit for parents and big chairs, similar to sofas, for when they hold the baby or express milk.	They make a scratchy sound when moved around.
Mobile curtain – in case some parents require privacy or staff considers the treatment they administer cannot see others` patients relatives.	They are moved around on the wheels and make a monotonous sound.

Plastic bags – when parents enter the NICU, they are required to put all the things they brought to their babies (e.g., nappies, muslins, milk) in huge plastic bags and get them out of the nursery and put them in the incubator drawer.	Cracking sounds.

Table S2. Summary of principal component analysis results for SON-Q (N=386, Items=204).

Questionnaire item	F1	F2	F3	F4	F5	F6
5. 2. 1. The sound environment in NICU was too loud	.673					
5. 2. 5. The sound environment in NICU was disorientating	.638					
5. 3. 4. I would not make it quieter	.583					
5. 3. 3. I would change generic hospital sounds	.579					
5. 1. 3. NICU was encouraging/ reassuring	.568					
5. 3. 5. I would not change noise from staff	.564					
5. 2. 3. The sound environment in NICU was making me tired	.545					
5. 2. 4. The sound environment in NICU was not affecting the care I provided to my baby/s	.541					
2. 4. 3. Staff talking or laughing made me feel stressed	.509					
2. 5. 1. Morning was noisy	.506					
2. 5. 3. When a new baby was brought to the nursery it was noisy	.503					
5. 2. 2. The sound environment in NICU was not affecting my ability to communicate with the staff/my baby/s	.502					
5. 3. 1. I would not change sounds from machines	.477					
2. 4. 1. Emergency alarm made me feel stressed	.441					
2. 4. 6. The crying of other babies made me feel stressed	.439					
2. 2. 5. Stressful	.434					
2. 2.2. Reassuring	.433					
5. 1. 5. NICU was emotionally cold	.426					
5. 1. 1. NICU was aversive	.415					
2. 5. 5. Visiting time (if scheduled) was noisy	.414					
2. 2. 3. Tiring	.413					
3. 4. 8. I noticed oxygen saturation change (goes up or down)		.786				
3. 4. 6. I noticed respiration change (slower or faster)		.763				
3. 4. 7. I noticed heart rate change (slower or faster)		.747				
3. 3. 8. I noticed oxygen saturation going up or down		.695				
3. 3. 6. I noticed respiration change (slower or faster)		.644				
3. 3. 7. I noticed heart rate change (slower or faster)		.621				
3. 4. 2. I noticed smiles		.564				
3. 4. 5. I noticed movement in parts of body		.520				
3. 3. 4. I noticed crying/whimper		.478				
3. 3. 10. I noticed the baby/s to look away from the voice / cover face with hands		.443				
3. 3. 2. I noticed smiles		.443				
3. 1. 1. I noticed my baby/s to react to constant and loud noises from the machines (e.g., ventilator, CPAP)		.414				
3. 6. 3. I did sing to keep my baby/s company			.741			
3. 6. 5. I did sing to familiarise baby/s with me			.713			
3. 6. 1. I did sing to calm my baby/s			.700			
3. 6. 2. I did not sing to stimulate the baby/s, to help with their development			.699			
3. 6. 4. I did not sing to express my feelings and thoughts			.694			
3. 7. 6. I did not use recordings to cover the noises in the NICU			.681			
3. 7. 1. I used recordings to calm/soothe my baby/s			.672			
3. 7. 5. I used recordings to familiarise baby/s with me			.657			
3. 7. 3. I did use recordings to keep my baby/s company			.654			
3. 7. 2. I did not use recordings to stimulate the baby/s, to help with their development			.630			

3. 7. 4. I did not use recordings to express my feelings and thoughts			.626			
2. 8. 6. I was singing/humming			.602			
2. 11. 2. I did sing / hum to my baby/s			.601			
3. 6. 6. I did not sing to cover the noises in the NICU			.557			
3. 2. 3. I noticed my baby/s to react to my voice singing/humming			.451			
2. 11. 5. I did not make recordings to be played to my baby/s			.431			
3. 5. 1. I did speak/ talk to calm my baby/s				.556		
3. 5. 3. I did speak/ talk to keep my baby/s company				.519		
2. 11. 1. I did not talk to my baby/s				.518		
3. 5. 5. I did speak/ talk to familiarise baby/s with me				.496		
2. 8. 1. I was holding hand on her/him				.482		
2. 11. 4. I did hold hand on my baby/s (if allowed)				.447		
4. 4. 1. I have been able to discriminate pain cry				.438		
4. 5. 3. I was not talking				.420		
2. 10. 1. I was able to recognise my baby/s by his/her cry					.594	
2. 10. 3. I was able to recognise my baby/s by his/her hiccups					.519	
2. 10. 2. I was not able to recognise my baby/s by his/her whimper					.513	
2. 10. 7. I was able to recognise my baby/s by his/her laugh					.505	
2. 10. 6. I was not able to recognise my baby/s by his/her gurgling					.500	
2. 10. 5. I was able to recognise my baby/s by his/her babbling					.493	
2. 10. 4. I was not able to recognise my baby/s by his/her cooing					.442	
2. 7. 6. I have been able to discriminate tiredness cry					.436	
2. 7. 1. I have been able to discriminate pain cry					.429	
3. 3. 3. I did not notice vocalisations					.421	
2. 6. 1. My baby`s cry was loud					.404	
4. 7. 1. I found it relaxing						.722
4. 7. 3. I found it peaceful						.698
4. 7. 4. I did not find it reassuring						.670
4. 7. 5. I found it discouraging/inadequate						.585
4. 7. 7. I did not find it enjoyable						.583
4. 7. 6. I found it chaotic						.516
4. 3. 1. I thought that baby/s cried more often						.467
4. 3. 5. I thought the baby's cry was easier to calm						.467
Eigenvalues	7.924	5.374	4.065	2.632	2.557	2.123
% of variance	10.208	10.540	11.452	9.431	9.146	7.655
α	.867	.900	.913	.754	.810	.815

Key: items number represents, in order respectively, the part of the questionnaire with Likert-scale items (2 = You and sound: Going to NICU; 3 = Your baby and sound in NICU; 4 = At home after NICU; 5 = About NICU in general,), the question (overall n = 32), and the individual item (presented with a 5-point Likert scale) – e.g., the first item in the table is from part 5 (About NICU in general), question 2 (How would you describe the sound environment in NICU? Please rate the following statements.), item 1.

Questionnaire S1: Final questionnaire items (n= 77) following PCA.

*Note***:** original item number is presented in brackets, e.g., [5.2.1], see Table S2.

1. How would you describe the sound environment in NICU? Please rate the following statements.
- *The sound environment in NICU was too loud [5.2.1]*
- *The sound environment in NICU was disorientating [5. 2.].]*
- *The sound environment in NICU was making me tired [5. 2. 3.]*
- *The sound environment in NICU was not affecting the care I provided to my baby/s [5. 2. 4.]*
- *The sound environment in NICU was not affecting my ability to communicate with the staff/my baby/s [5. 2. 2.]*

2. If you had the possibility, how would you change the sound environment in NICU? Please rate the following statements.
- *I would not make it quieter [5. 3. 4.]*

- *I would change generic hospital sounds [5. 3. 3]*
- *I would not change noise from staff [5. 3. 5]*
- *I would not change sounds from machines [5. 3. 1.]*

3. How would you describe the NICU environment in general? Please rate the following statements.
- *NICU was encouraging/ reassuring [*5. 1. 3.]
- *NICU was emotionally cold [5. 1. 5.]*
- *NICU was aversive [5. 1. 1.]*

4. How stressed/anxious did the following sounds make you feel?
- *Staff talking or laughing made me feel stressed [2. 4. 3.]*
- *Emergency alarm made me feel stressed [2. 4. 1.]*
- *The crying of other babies made me feel stressed* [*2. 4. 6.]*

5. If your baby/s was premature or sick and went to NICU, how would you describe your general experience of the sounds there?
- *Stressful [2. 2. 5.]*
- *Reassuring [2. 2.2.]*
- *Tiring [2. 2. 3.]*

6. How noisy was NICU in the situations below?
- *Morning was noisy [2. 5. 1.]*
- *When a new baby was brought to the nursery it was noisy [2. 5. 3.]*
- *Visiting time (if scheduled) was noisy [2. 5. 5.]*

7. Please score the different types of reactions that you noticed in your baby/s towards the noises in the NICU (e.g. from machines, opening incubator, doors, tap water etc.)? Please, score the below reactions.
- *I noticed oxygen saturation change (goes up or down) [3. 4. 8.]*
- *I noticed respiration change (slower or faster)* [*3. 4. 6.]*
- *3. I noticed heart rate change (slower or faster) [3. 4. 7.]*
- *I noticed smiles [3. 4. 2.]*
- *I noticed movement in parts of body [3. 4. 5.]*

8. Please describe the different types of reactions that you noticed in your baby/s when s/he listened to voices speaking or singing to her/him in the NICU?
- *I noticed oxygen saturation going up or down [3. 3. 8.]*
- *I noticed respiration change (slower or faster) [3. 3. 6.]*
- *I noticed heart rate change (slower or faster)* [*3. 3. 7.]*
- *I noticed crying/whimper [3. 3. 4.]*
- *I noticed the baby/s to look away from the voice / cover face with hands [3. 3. 10.]*
- *I noticed smiles [3. 3. 2.]*
- *I did not notice vocalisations [3. 3. 3.]*

9. Please, indicate if your baby/s reacted to the following noises while in NICU.
- *I noticed my baby/s to react to constant and loud noises from the machines (e.g., ventilator, CPAP) [3. 1. 1.]*

10. Did you sing to your baby/s while in the NICU? Please, rate the options below to indicate the reasons you might have had to sing to your baby/s.
- *I did sing to keep my baby/s company [3. 6. 3.]*
- *I did sing to familiarise baby/s with me [3. 6. 5.]*
- *I did sing to calm my baby/s [3. 6. 1.]*
- *I did not sing to stimulate the baby/s, to help with their development [3. 6. 2.]*
- *I did not sing to express my feelings and thoughts [3. 6. 4.]*

- *I did not sing to cover the noises in the NICU [3. 6. 6.]*

11. Did you use recordings of your voice or music for your baby/s while in the NICU? Please, rate the options below. If you did not use recordings, please skip and go to the following question.
    - *I did not use recordings to cover the noises in the NICU [3. 7. 6.]*
    - *I used recordings to calm/soothe my baby/s [3. 7. 1.]*
    - *I used recordings to familiarise baby/s with me [3. 7. 5.]*
    - *I did use recordings to keep my baby/s company [3. 7. 3.]*
    - *I did not use recordings to stimulate the baby/s, to help with their development [3. 7. 2.]*
    - *I did not use recordings to express my feelings and thoughts [3. 7. 4.]*

12. Did you do the following to comfort/calm your baby/s in NICU?
    - *I was singing/humming [2. 8. 6.]*
    - *I was holding hand on her/him [2. 8. 1.]*

13. How did you communicate with your baby/s at the NICU?
    - *I did sing / hum to my baby/s [2.11. 2.]*
    - *I did not make recordings to be played to my baby/s [2.11. 5.]*
    - *I did not talk to my baby/s [2. 11. 1.]*
    - *I did hold hand on my baby/s (if allowed) [2. 11. 4.]*

14. Please indicate how your baby/s reacted to the following sounds from people in the NICU.
    - *I noticed my baby/s to react to my voice singing/humming [3. 2. 3.]*

15. Did you or any other person speak to your baby/s while in the NICU? Please, rate the options below to indicate the reasons you might have had to speak to your baby/s.
    - *I did speak/ talk to calm my baby/s [3. 5. 1.]*
    - *I did speak/ talk to keep my baby/s company [3. 5. 3.]*
    - *I did speak/ talk to familiarise baby/s with me [3. 5. 5.]*

16. At home, have you been able to discriminate different types within your baby`s crying?
    - *I have been able to discriminate pain cry [4. 4. 1.]*

17. How did you comfort/calm your baby/s when crying at home?
    - *I was not talking [4. 5. 3.]*

18. When approaching the nursery your baby/s was in, did any of the following sounds make recognise her/him?
    - *I was able to recognise my baby/s by his/her cry [2. 10. 1.]*
    - *I was able to recognise my baby/s by his/her hiccups [2. 10. 3.]*
    - *I was not able to recognise my baby/s by his/her whimper [2. 10. 2.]*
    - *I was able to recognise my baby/s by his/her laugh [2. 10. 7.]*
    - *I was not able to recognise my baby/s by his/her gurgling [2. 10. 6.]*
    - *I was able to recognise my baby/s by his/her babbling [2. 10. 5.]*
    - *I was not able to recognise my baby/s by his/her cooing [2. 10. 4.]*

19. Have you been able to discriminate different types of cry within your baby`s crying in NICU?
    - *I have been able to discriminate tiredness cry [2. 7. 6.]*
    - *I have been able to discriminate pain cry [2. 7. 1.]*

20. If your baby/s was able to cry, how was her/his crying in NICU?
    - *My baby`s cry was loud [2. 6. 1.]*

21. Compared with the NICU, how did you find your home environment when home?

- *I found it relaxing [4. 7. 1.]*
- *I found it peaceful [4. 7. 3.]*
- *I did not find it reassuring [4. 7. 4.]*
- *I found it discouraging/inadequate [4. 7. 5.]*
- *I did not find it enjoyable [4. 7. 7.]*
- *I found it chaotic [4. 7. 6.]*

22. Did you think that your baby's crying changed once at home? Please rate the following options.
    - *I thought that baby/s cried more often [4. 3. 1.]*
    - *I thought the baby's cry was easier to calm [*4. 3. 5.]

N.B. Negative items were reversed for scoring.

Table S3. Regression models predicting the PPQ -Total Score.

	Model	B	β	t	Sig.	F change	Sig. *F* change
1						24.51	0.000
	Parental Age	−0.24	−0.099	−2.19	0.029		
	NICU soundscape	0.58	0.46	10.27	0.000		
	Infant_Reactions	−0.06	-0.05	−1.09	0.277		
	Singing – Recording	0.01	0.01	0.21	0.831		
	Bonding with Baby	0.48	0.11	2.42	0.016		
	Parenting Confidence	−0.05	−0.03	−0.63	0.525		
	Home Environment	−0.60	−0.28	−6.45	0.000		
2						0.04	0.831
	Parental Age	−0.24	−0.09	−2.19	0.029		
	NICU soundscape	0.58	0.46	10.30	0.000		
	Infant Reactions	−0.06	−0.05	−1.07	0.285		
	Bonding with Baby	0.49	0.11	2.56	0.011		
	Parenting Confidence	−0.04	−0.02	−0.60	0.544		
	Home Environment	−0.60	−0.28	−6.48	0.000		
3						0.36	0.544
	Parental Age	−0.22	-0.09	−2.11	0.035		
	NICU soundscape	0.59	0.47	10.50	0.000		
	Infant_Reactions	−0.07	−0.06	−1.33	0.184		
	Bonding with Baby	0.48	0.11	2.51	0.012		
	Home Environment	−0.61	−0.29	−6.61	0.000		
4						1.76	0.184
	Parental Age	−0.20	−0.08	−1.93	0.054		
	NICU soundscape	0.57	0.45	10.60	0.000		
	Bonding with Baby	0.45	0.10	2.35	0.019		
	Home Environment	−0.60	−0.28	−6.54	0.000		

The independent variables gradually eliminated are: Singing – Recordings", "Parenting Confidence" and "Infant Reactions"