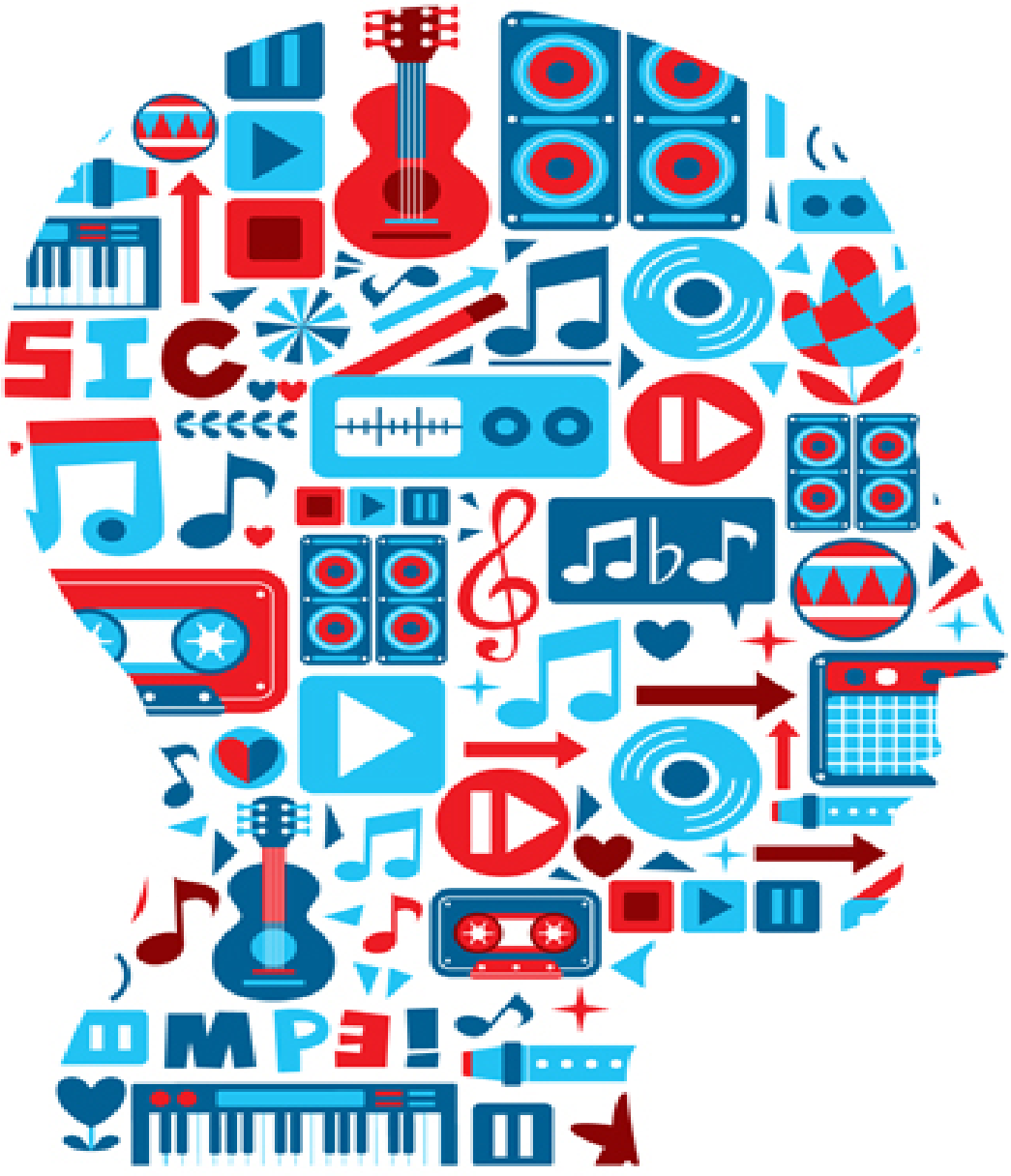
# You Are The Music



## How Music Reveals What It Means To Be Human

Victoria Williamson

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# Acknowledgements

It all started about five years ago. I did not know quite what to think when my partner Oscar gave me musicpsychology.co.uk as a birthday present. He explained himself quickly: I loved talking about the psychology of music and this was a chance to discuss my passion with the whole world. He was right (yes, I said it). The blog soon became my baby and this book is the culmination of over a decade's exploration into the wonderful world of music psychology. So thank you Oscar, for everything.

I am hugely grateful to all the magnificent people at Icon Books, especially to Duncan Heath, who supported me throughout the writing process, to Andrew Furlow and Henry Lord for their enthusiasm and creativity, and to Robert Sharman for his keen and careful eye. I am grateful, too, to the talented Richard Green for his striking cover design. I consider myself very lucky to have had such a great team behind my book.

Many students, colleagues and friends have been generous with their time in discussing both this book and the psychological impact of writing it upon the author. I could not possibly name all these kind souls but I want to make special mention to Joydeep Bhattacharya, Rhiannon Jones, Pamela Heaton, Daniel Müllensiefen, Georgina Floridou, Maurice Douglas, Danielle Richardson and Team Barcelona.

Dad, thank you for the baby taming, the music lessons, the instruments, the lifts to music centres, the speakers, the vinyl, the music-filled holidays, and for reading every chapter of this book with the same vigour and humour that

you once reserved for my maths homework. You are my hero.

Finally, this book is dedicated to my amazing, supportive, enthusiastic, loving, one-of-a-kind family.

# Introduction

*You are the music / While the music lasts*
**T.S. ELIOT, *FOUR QUARTETS***

Since you have been so kind as to consider reading this book I am going to assume that you have an interest in music; why we love it so much and how it affects us. Me too!

I promise to assume nothing else about you. To read this book requires no expert knowledge of or training in music, psychology, brain science, or any other kind of academic discipline. All you need with you on this journey is your curiosity about music.

The reason for this book, and for my career, is a passion for music. I am, at best, an amateur musician. I love my classical guitar ('The Professor') but we see each other rarely these days what with work demands, so my musical interests don't come from the viewpoint of a skilled performer. Nor would I consider myself to be particularly knowledgeable about music. I am not a sophisticated listener; more a musical chameleon. I rarely come across music that I don't enjoy on some level.

I put the blame for my music addiction squarely on my dad. When I was born he acquired a lovely book called *Baby Taming*[1] (seriously), which stated that playing loud music at bedtime helps a child to sleep deeply and with less disruption. I have no idea whether this pop psychology contains any truth – as far as I know the claim has never been tested – but my dad needed little encouragement to fire up his Celestion Ditton 66 speakers and crank out the vinyl every night.

As a result of this baby book and my dad’s love of vinyl I have been surrounded by music from day one. Not music practice or performance so much, as neither of my parents could play an instrument. Rather, in my family music was in the air.

I was fortunate to go to a primary school that offered free instrument lessons for a time and I chose to play the guitar, though I also dabbled in mandolin, recorder and flute. I had formal music lessons on classical guitar, with a charming teacher named Andrew Forrest who instilled in me a love of Spanish music, especially Fernando Sor, Francisco Tárrega and Isaac Albéniz. I enjoyed my formal lessons until the age of eighteen but took few music exams as I found them too stressful.

Alongside my formal music education I had increasing access to my favourite music as I grew up thanks to the explosion in the availability of compressed music and portable devices. And the music listening revolution has continued in my adult life with developments like cloud-based systems for musical storage. Today this means that people need never be far away from their top tunes. And I never am. I am listening to the wonderful Three Tenors as I write this introduction. I had BBC music radio playing in my car on the way to work this morning. My dad’s beloved Celestion Ditton 66 speakers now take pride of place in my living room.

Not only am I addicted to music, I am also addicted to working out why I am addicted to music. (I believe that is what is known as an over-analytical mind.) I blame my passion for studying my musical addiction on a handful of inspirational academics that I have been lucky enough to meet on my journey as I studied psychology, the psychology of music, and finally as I began my research career. There are too many people to name individually, though deserving of special mention are my ‘academic fathers’ and inspirations, Professors Alan Baddeley and Graham Hitch.

I have devoted my research career to understanding how and why music is so much a part of our everyday lives. There are already many technical books out there that explore aspects of music psychology – a young and vibrant science that examines the relationship between music and our mind, brain, and body. There are also excellent compilations, essay collections and student guides, for which I am hugely grateful as a lecturer. But I wanted a book that I could recommend to a friend who was keen to learn about the impact of music on everyday life: the person who listens to their iPod on their way to work and who refuses to contemplate a long car journey without music; the parent who takes their child to musical activity classes or pays for formal music lessons; the person who owns a shower radio, looks forward to concerts and gigs, shops to a soundtrack, and who carefully selects music for a romantic night to ensure maximum seduction; the person who can't help but be transported back to that one perfect evening when they hear 'that song'. I wanted an easy-to-access guide book that explained everyday music psychology for everyone – so I decided to write it.

This book contains a selection of the findings and theories through which researchers have sought to tell the story of our lives with music. My aim in this book is to consider why we live this way. In terms of music's power over us I want to have a go at revealing 'the wizard behind the curtain'.

As we shall see in more detail in the pages to come, music can trigger growth in the brain at any age, a fact which has been linked to enhancement of hearing acuity, language learning and motor control. In children, music lessons have been associated with the advanced development of many physiological, social and cognitive skills and in adults music can boost sports performance by up to 15 per cent. Music provides a source of communication for those who struggle with language and it can provide significant comfort from both physical and mental pain. It can help improve recovery

from illness and injury, and support and guide transitions through life stages. Finally, it provides a personal soundtrack and an instant memory passport.

Just about everyone is exposed to music every day, whether voluntarily or not. People dedicate their time to its production, performance and consumption. There are national music days, where countries celebrate their musical heritage, talents and passions. So the issue is not whether we are engaging with music; in fact, we are gorging on it. The secrets of music psychology can help solve the question of why music has such an effect upon us. Why do we love it so much? Why is it everywhere? And how does it have so many effects on our brains, bodies and behaviours?

The underlying concept for the book is ‘the music of our lives’: from the time we are born to later adulthood. The mapping of music through life in this way allows a journey to unfold and means that there will, I hope, be something in the book for everyone.

But before we begin, there are some fundamental questions we need to consider.

#### *What is music?*

I was once asked this intriguing question as part of a radio programme hosted by Professor Lord Robert Winston. I froze completely. What could I say? Over a decade of focused study behind me and I could not think of a single decent response. I kicked myself the whole way home from the recording studio, and for several days afterwards.

I have since forgiven Professor Winston for his excellent question and have considered what my answer might be, given what I have learned so far. I have come up with the following definition: *Music is a universal, human, dynamic, multi-purpose, sound signalling system*. That description is not set in stone; it is a work in progress. For now it gives us something to work with for the purpose of this book.

***Where did music come from?***

There are many theories about how music became part of our world. Charles Darwin's theory of sexual selection posits that music evolved as a form of fitness display to attract potential mates. Or maybe we developed music as a way to soothe and educate our infants. It might have provided a valuable medium for tribes and families to identify themselves and communicate their social cooperation. Or maybe music evolved from a proto-language that allowed our ancestors to communicate crucial signals before they developed words and sentences.

I have been a firm believer in all these theories of music's origin, and more, at various points in my career. That is the best way to be as a scientist. There is nothing more boring than someone who sticks to the same tired old ideas for years, refusing to budge or admit they may need a rethink.

My preferred explanation at the time of writing comes from Mark Changizi, who muses about the origins of music and language in his fantastic book *Harnessed*.[2] He suggests that our obsession with music arose because it 'harnessed' so much of nature around us and because it used existing and ancient brain mechanisms for new and exciting purposes.

Music in this sense is not a fundamental part of human life because it's a part of our souls or the 'language of love', tempting as it is to fall back on such romantic notions. Changizi's argument stresses that music is a part of us because we designed it based on who we were and what we needed as humans. The human animal, our evolving brains and bodies, were the blueprint for music.

I like the idea that music is part of what turned us into the modern human that we recognise today. Changizi suggests that music, along with language and reading, is what turned apes into humans. We, by this definition, are the musical animal.

***Are we the only musical animal?***

We are not the only animal to make musical sounds, although you could argue that we have a tendency to anthropomorphise such behaviours. Birds, mice and whales sing, gorillas duet, seals and elephants move to the beat, and so on (see Chapter 6).

Despite these examples, to my knowledge there is no other animal on earth that is as driven by, obsessed with, and vulnerable to the strains of music as humans. No other animal invests as much in the creation or acquisition of musical sound; we devote precious energy to making instruments, constructing and maintaining music ensembles, producing music for easy consumption, and aspiring to solo musical performance perfection.

I do not mean to say that other animals can't share in aspects of musical perception, production or enjoyment. It would be a pretty strange world if we humans had developed a skill that did not exist in any form in any other animal – that would make us a musical alien. My premise for this book is instead that we are far and away the most musical animal this planet has ever seen. In this sense our musical lives provide a unique glimpse into what it means to be human.

The book is divided into three sections. **The first section** deals with music as we grow up. **Chapter 1** begins at the start, with the music we hear before we are even born. We see that babies come into the world with an impressive catalogue of musical skills that lay the foundation for their musical adulthood. Through **Chapters 2 and 3** we explore the effects of music in childhood through to adolescence, including the link between music and IQ, the ingredients for a successful musical education, and the role that music plays in our personal, emotional and social development.

The **second section** takes a look at music in the adult world: the true hidden musical talents within us and the transformations that occur in the brain when an individual trains as a musician (**Chapter 4**). We will also take a look at individuals who struggle with music their whole lives and find out what it is to be ‘tone deaf’. We then take a tour through the music in our modern adult world, at work (**Chapter 5**) and at play (**Chapter 6**).

The **third and final section** takes a reflective journey through the importance of music across the whole of the human lifespan. **Chapter 7** is devoted to musical memory, my personal academic passion. We look at feats of musical memory and explore cases of musical memory surviving extensive brain damage. Then there is the intriguing question of why musical memories get stuck in our heads. Finally, we build on these and other studies in **Chapter 8** to explore how music can help support health and well-being at all life stages.

I can appreciate that this looks like quite a journey – after all, it’s a whole human life – but you are free to dip in and out of the book as you like. The chapters are designed to be largely self-contained so you can jump right to your personal interest, whether it’s musical babies, music lessons, music for romance, music for work, music for exercise, or music for stress relief.

So, my fellow musical animal, let’s begin our exploration of what the world of science and psychology can tell us about our day-to-day, lifelong, love of music.

# PART I

# Music in early life

Chapter 1

# First musical steps

*‘I was born with music inside me. Music was one of my parts. Like my ribs, my kidneys, my liver, my heart. Like my blood. It was a force already within me when I arrived on the scene.’*

**RAY CHARLES**

Wolfgang Amadeus Mozart was born in Salzburg in 1756 and went on to become one of the world’s most prolific and influential composers. Although he lived for only 35 years and died over 200 years ago, sales of his exquisite music regularly top the classical music charts and he is frequently voted in the top five composers of all time.

Mozart was playing and composing music by the age of five. Because of this he is often cited as the prime example of a human being who was ‘born musical’ – far more musical, in fact, than the rest of us. But was he?

There is no doubt that Wolfgang Amadeus Mozart had a very early start to his musical career and that he had a ‘pushy parent’. Johann Georg Leopold Mozart was one of Europe’s leading music teachers and in the year of his seventh child’s birth he published his dense textbook *Versuch einer gründlichen Violinschule* (‘A Treatise on the Fundamental Principles of Violin Playing’). According to reports, little Mozart received intensive musical instruction from his father before he could even speak.

There is such a thing as talent and there are such things as prodigies, though our present understanding of both concepts is still hotly debated.[1] Perhaps because of this fact

I am inclined to believe that it was mostly Mozart's unique upbringing that set him apart musically from the rest of us. Whether Mozart possessed advanced natural musical ability or not, the point I want to make here is that all babies are born musical, not just our finest composers.

We are born musical because our first experiences of music are pre-birth, as the womb is flooded with the musiclike sounds of our world: the pitch glides, the melodies and the beats of body movements, voices, natural and artificial sounds. As a result of this early exposure, newborns come into this world possessing an impressive set of basic musical skills that play an important role in general development, quite aside from the issue of whether or not the child goes on to learn how to play a piano or pluck a violin.

When it comes to musicality, everyone had to start somewhere, including Mozart. And as we shall see we all have something in common with Ray Charles: we were born with music already inside of us.

## Music in the womb

I have never seen a 'prega-phone' but I remember the first time I was told about their existence. I was giving a lecture on music psychology for the Open University, during which I discussed the origins of musical skills. A member of the audience raised their hand to point out that you could improve a baby's lifelong musical skills by playing them music through a microphone strapped to a pregnant woman's tummy: the aptly named prega-phone. It turns out that you can buy all sorts of similar devices.

Given what I knew about music and brain development I thought it unlikely that intensive prenatal music exposure could benefit later musical development but I set out to investigate this question anyway. If nothing else, then the next time I was faced with a similar comment I could be a

little more useful to the audience than simply playing devil's advocate.

Before we look at the effect of prenatal music listening on development, let's deal with the first important physiological question: what does music sound like before we are born?

Music doesn't sound like anything until about the fourth month of pregnancy, the stage at which human hearing begins to function. It then takes about another two months for the fine structures of the ear that detect frequencies (for example, the cochlea) to fully form.[2] At this point an *in utero* baby becomes aware of a range of auditory stimulation from the environment. What they actually hear is a matter very much open to debate.

Given that a foetus is surrounded by amniotic fluid, we can assume that they perceive sounds a little like when they are played under water. Not many swimming pools are fitted with underwater speakers and there is a good reason for this; in this submarine environment you may be aware of pitch movements in the low register, changes in volume and maybe a strong beat, but the fine detail is largely lost. Picking out instruments or singers can be almost impossible, because of the loss of high frequencies, and finer points of melody are also hard to detect.

A developing foetus would find it even harder to follow the exact detail of music early on, as they will be hearing other sounds much closer to them, such as the mother's digestive system, air movements through her lungs, and the activity of her heart and blood vessels.

At the time of writing there are no known studies of musical sound in the human womb (recordings are only really possible during labour) but recordings in pregnant sheep have found at least a 10-decibel reduction in external sound within the womb,[3] with less reduction in low frequency sounds compared to higher frequencies. If you

tried to identify words in this kind of environment you would probably get about 40 per cent of them right.[4]

What does all this mean for our prega-phone? I have seen no evidence that *in utero* hearing devices offer anything more in terms of sound transmission than a pair of headphones over the abdomen or a seat close to a speaker, although I'm assured that they offer some ergonomic comfort for the mother. What is undeniable is that a typically developing foetus can hear what is going on in their external world during the last trimester.

Although we can't know exactly what a foetus hears in the womb, their brain responses to sound can be studied using a specially adapted form of fMEG (foetal magnetoencephalography). This kind of scan requires a mother to kneel with her tummy enclosed with a specially adapted series of sensors (known as a SQUID array) that pick up the minute magnetic changes around the foetal head caused by brain activity.

Using the SQUID array device researchers have shown that from around 28 weeks gestation the majority of foetuses can detect frequency changes in the range of 250Hz, equivalent to the gap across five white notes in the upper middle section of a piano (octave five).[5] What is more, research conducted during labour using a hydrophone has found that foetal hearing reaches impressive levels, being described in some studies as near perfect.[6]

I have often been asked whether a foetus enjoys music in the womb; for example, when a baby kicks in response to music I have heard it said that this is because they like the sound. I'm sure I don't have to tell you that it's not possible to determine the aesthetic preferences of a foetus: in terms of their movement and heart rate, being asleep probably appears similar to being bored, and being excited probably appears similar to annoyance. That is assuming, of course, that such emotional states are possible in one so young.

And while a foetus can certainly respond to music, there is no suggestion that this is in any way different to how they respond to all manner of external auditory stimuli, including sirens, animal cries or, as we shall see in a minute, aircraft take-off. So let's leave the point of musical preference on one side for now.

Whether or not unborn babies have a preference for sound has little bearing on the question of whether they remember what they hear. We have known for a long time that babies can remember sounds that they have experienced *in utero* because of their behaviour once they are born. Newborns respond more frequently and regularly to their mother's voice, the voice with which they are undoubtedly most familiar because of the direct transmission it gets through her body.

A great example of foetal memory for other sounds was a study conducted with babies whose mothers had lived near Osaka International Airport, Japan during pregnancy. After they were born these infants were not woken by, and had little or no discernible brain wave reaction to, recorded aircraft noise. By comparison they were awakened and disturbed by a music sequence that had similar characteristics to the sound of planes taking off.[7]

In theory therefore a foetus can become accustomed to and remember musical sounds if they hear them as frequently as those babies heard aircraft take-off – but can newborns really remember complex music, given the increased difficulties with the muffled nature of the sound?

In my previous research post I spent many a happy coffee break chatting about life with our head technician, Maurice, a good friend of mine. When I mentioned I was writing this chapter he told me a story about one of his wife's pregnancies. At the time she was a fan of *Neighbours*, the long-running Australian soap opera. The show had had the same theme tune for years, marked by large pitch leaps and

a steady beat, two musical features that have a good chance of getting through to a foetus. Maurice says that when little Matthew was born he would react strongly to the *Neighbours* theme: his face lit up, he searched around for the source of the sound, and he made animated noises. Maurice is convinced that Matthew remembered the *Neighbours* theme tune from his time in the womb, as he didn't react this way to other music.

This everyday anecdotal experience of infant response to *in utero* music is supported by science. In 2011, Carolyn Granier-Deferre and her team played women a novel descending piano melody twice daily during the 35th, 36th, and 37th weeks of their pregnancy.[8] At six weeks old the newborn babies were played these melodies again while they were asleep, along with a similar control melody that went up instead of down. The researchers measured the heart rates of these 25 babies and compared them to the responses of 25 'control' babies who had not heard any of the tunes before.

All the tunes triggered a decrease in the babies' heart rates (by about five to six beats per minute) but the familiar tunes had twice the relaxing effect on the 25 babies who had heard them in the womb.

This extra deceleration in heart rate in response to the downward melodies is a remarkable finding when you consider that the babies had not really heard the melodies very often – probably less frequently than little Matthew had heard the *Neighbours* theme tune over the course of his mum's pregnancy and certainly less than the Osaka babies had heard aircraft taking off – but still their sleeping heart rate responses gave away the fact that they remembered this musical shape.

*In utero* exposure to music may be limited and missing the full complexity that we hear outside the womb, but the fact that babies are sensitive to and can learn to recognise

musical sounds means that by the time they are born they have had months of exposure to some of the basic features of music (rhythms and contours) and thereby months of opportunities to learn about musical sound.

This finding leads to a series of interesting questions, that take me right back to the comment made by my Open University student: does prenatal exposure impact on later musical skills? Will increasing foetal exposure to music make for a more musical baby or, even more controversially, a smarter baby?

The majority of the evidence says ‘no’. Not a single study to date has convincingly demonstrated that increasing prenatal music exposure above the typical amount heard in everyday life improves later musical perception or production. It’s not the case, for example, that parents who are both musicians always produce a child who is interested in or skilled in music.

I doubt that we will ever see evidence for a direct effect of prenatal music on musical skill either, for one good reason: what happens *after* a child is born, as with young Mozart, is lilkely to be far more important to musical development than degree of exposure in the womb.

It’s important to emphasise that all sounds, whether we think of them as musical or not, will transmit ‘musical’ information to a foetus due to the qualities of the womb environment. In the final trimester a foetus hears the sounds of voices, industry, and nature as a series of beats and movements in pitch. It’s not clear how or why flooding the foetus with extra music makes any difference – if anything, such a strategy may block exposure to the wide variety of useful sounds that they might otherwise hear, such as familiar voices.

I will leave it to my next chapter to get into the debate about whether musical exposure can boost intelligence – suffice to say there is no evidence that *prenatal* musical exposure improves intelligence in *newborns*. And while it

may be possible to create a musical memory for a newborn that they associate with beneficial relaxation responses, we now know that familiar voices, a human heartbeat and even planes taking off can all have similar effects.

Prenatal music intervention may not lead to a more musical baby or a smarter baby but the sounds that babies hear in the womb are still important. In the next section we see how our young are born with some pretty impressive basic musical skills – partly due to typical *in utero* sound exposure.

There will always be a debate about nature and nurture when it comes to newborns' abilities, but exposure to musical aspects of sound in the womb influences the development of the building blocks for later musical skills. The crucial thing about building blocks, though, is that they are basic and can go only so far – if you don't continue to build with them, they will stay at the same level.

## Newborn rhythm

A newborn's experience is not the coherent assemblage of sensory streams, neatly knitted together into a thread of consciousness, which we take for granted as an adult. The American philosopher and psychologist William James famously stated that the newborn infant perceives their new world 'as one great blooming, buzzing confusion'.[9] When you think about it, it's no wonder they cry.

In spite of this sensory chaos, newborns are attracted to and can respond to sound patterns that already make a degree of sense to them, and we have just seen how they remember sensory experiences from their time in the womb, particularly ones involving sound.

One of the consequences of the early development of hearing in humans, compared to other senses such as vision, is that babies are born primed with skills that they can use to learn about musical patterns in their

environment. One of the most important is their sense of ‘the beat’.

Rhythms are perhaps the strongest and most coherent lowfrequency auditory messages that a foetus experiences regularly, hearing as they do the rhythms of speech, the rhythms of musical and environmental sounds, and the rhythm of their mother’s walk and heartbeat. One might suppose, therefore, that if we were to be born with any musical skills then we must be born with an idea of the beat. This appears to be the case.

In 2009, István Winkler and colleagues published a landmark paper called ‘Newborn infants detect the beat in music’.[10] They studied musical skill in infants that were only two to three days old – while they were asleep.

The researchers took advantage of a feature of our brain responses known as the ‘mismatch negativity’, or MMN, which is measured using electroencephalography, or EEG. An EEG scan measures the minute electrical activity across the scalp caused by brain activity, usually by means of a person wearing what looks like a shower cap covered in wires.

The MMN is a particular brain wave pattern that happens in response to a change in an otherwise consistent sequence of environmental events. MMN responses occur in all the senses but of course we are interested in sound. If you hear ten beeps of a certain note and the eleventh note changes, then your brain will give an MMN response. The MMN is the neural signature that your brain has spotted the ‘oddball’, the deviation in your expectation of what should come next. The interesting thing is that your brain will show an MMN response whether or not you are paying attention to the sounds – and this makes it an ideal brain response to study in sleeping babies.

Winkler and his colleagues used a specially adapted EEG system to measure MMN responses in newborns, smaller

and more delicate than the adult version, accounting for infants' fine skin and petite features. The researchers fitted the baby EEG and waited until the babies had a nice big meal and fell asleep.

Once the babies were sleeping, they were played sound sequences based on a typical rock drum accompaniment pattern, featuring a snare, bass and hi-hat. Occasionally the pattern missed a downbeat, the first strong beat of a unit of music, which adults hear as a rhythm break or a moment of strong syncopation. The dropped downbeat creates a rhythmic 'oddball'. Would two- to three-day-old babies be aware of this oddball, and show an MMN response?

The answer is 'yes'. Even when asleep the newborns gave an MMN reaction to the dropped beat. Importantly, this reaction wasn't simply triggered by the missing note; dropped notes at non-rhythmic points did not trigger an MMN. This evidence shows that newborn babies can extract the beat from musical sequences. That is pretty impressive for a two-day-old brain, and strongly implies that infants are born with sensitivity for rhythmical sounds.

The researchers of this study suggest that newborns' beat detection skills may have been learned partly because of hearing rhythms *in utero* and partly due to an innate drive. More specifically, newborns may apply their innate sensitivity for patterns in order to assemble rhythms and generate expectations in sound sequences. This makes them capable of basic beat induction, which, as we shall see in Chapter 6, is a skill missing in nearly all other animals on the planet.

Beat induction is an example of a basic music building block that is essential for later musical behaviours such as playing in synchrony and dancing, and which appears to be ready and willing to go right from the start of our lives.

## Newborn name that tune

Newborns' musical skills extend beyond detecting the beat to include sound discrimination based on features such as volume, duration and pitch.[11] Not only this, newborns can discriminate between different contours, the equivalent to spotting the difference between two melodies, and they can use this information when listening to speech.

Thiery Nazzi and colleagues[12] tested French newborns' ability to discriminate between two lists of Japanese words that differed only in their contour, either going up or down. The researchers used a measurement technique that takes advantage of newborns' natural inclination to suck. They gave them a special pacifier that measured every suck, noting its strength and time of occurrence. They started testing with 121 newborns but, as is often the case with infant research, they had a few drop-outs: 34 fell asleep (awww), fifteen rejected the special pacifier, seventeen committed the crime of 'irregular or insufficient sucking', and fifteen did not settle. That leaves us with 40 willing and able babies.

These 40 babies were played one of two word lists for a few minutes; one list contained words that went up in sound and one comprised words where the contour went down. During this familiarisation period the baby gets used to the sound and their sucking rate steadies to a consistent rate. Then half the babies – the experimental group – were played a different list while half – the control group – continued to hear the same list as before.

If the babies were capable of discriminating a change to the contour, it was predicted that their sucking rate would change – they would suck more as they became alert to and interested in the new sound. The control babies, who were hearing the same sound, were expected to continue on at a steady suck.

This is exactly what happened. The babies in the experimental group clearly noticed the change in the