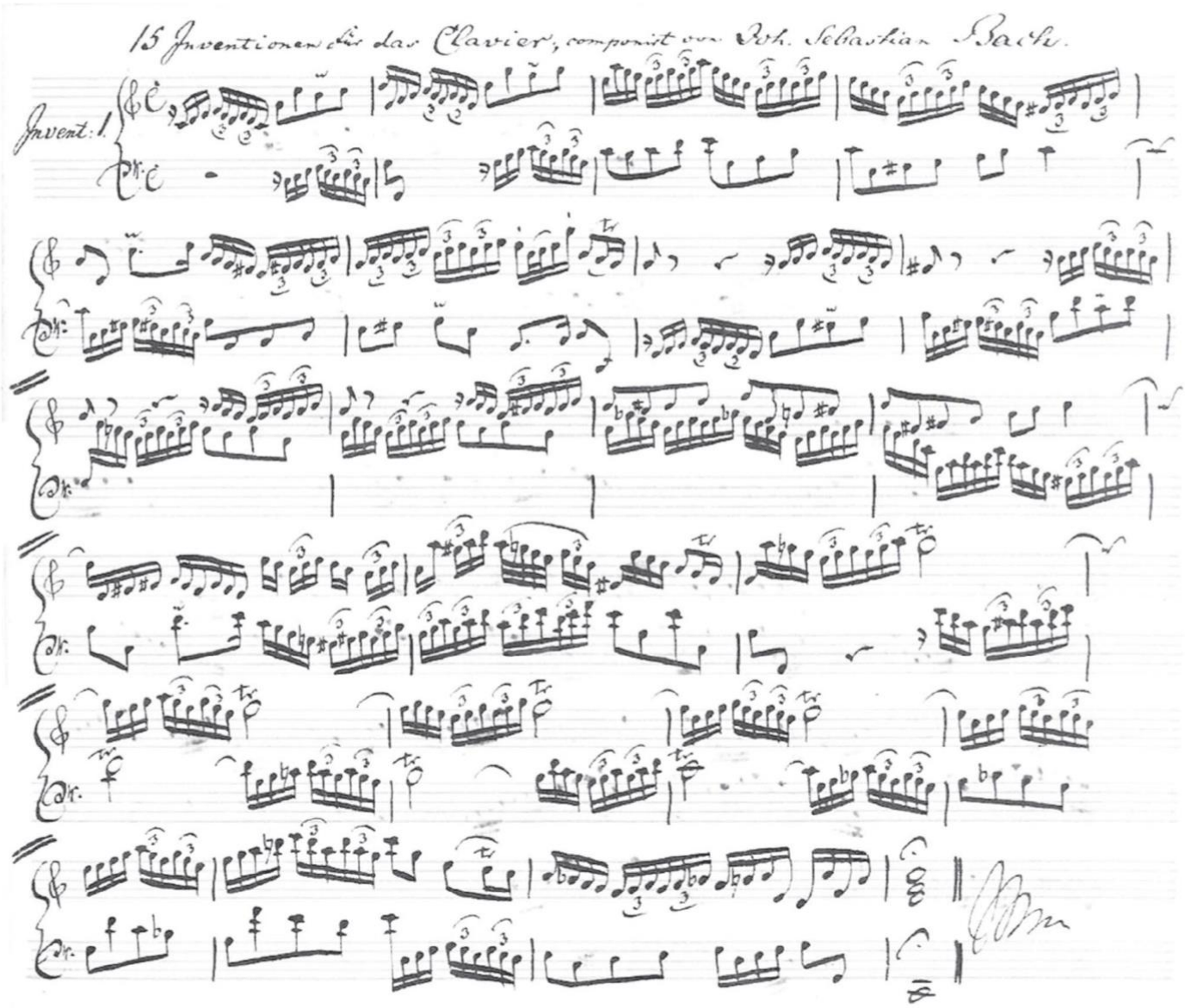


THE SYMPHONY OF THE MIND

Listening to music – shimmying to it, learning it, playing it and watching it being performed – fires up more centres in your brain than almost any other activity. Music is a marvel and pervades our lives, but why we like it and where it originated puzzles the experts.

STORY BY PETER MEREDITH PHOTOGRAPHY BY MICHAEL AMENDOLIA

Australian GEOGRAPHIC

Hooked in. At Melbourne University an EEG records Krysta Callander's brain activity. Opposite: J.S Bach composed this two-part invention, *BWV 772*, as a practice piece.

IT'S 5PM

ON A TUESDAY AT THE PITT STREET UNITING CHURCH IN SYDNEY'S CBD.

Turn it up. Conductor Elizabeth Lecoanet, at right, and the other members of the Sydney Sings choir meet weekly to belt out tunes.

With 50 or so other people of assorted ages and backgrounds, I'm standing near a piano and preparing to launch into *We Are The World*. Our conductor is Elizabeth Lecoanet, a trained opera singer of unlimited energy who has an infectious passion for song.

I'm here on a personal quest. I used to sing regularly at high school en masse with hundreds of other teenage boys in church services and choir practice. When 500 male voices blend for such an emotionally charged anthem as Hubert Parry's *Jerusalem*, the experience is unforgettable. My most vivid memory is of my own imperfect voice being sucked into the storm of other voices to merge perfectly, a small yet vital element of the immense dome of sound vibrating around me. I hope by coming to this church in Sydney – returning to communal singing after many a songless decade – I will recapture just a smidgen of that experience and the emotional torrent it once stirred within me.

Because my research for this story has alerted me to the complex way in which music works on the human brain – an effect that scientists are still unravelling – I also plan to analyse my reactions and am open to what the other participants say about singing in a choir, however partisan their views.

Elizabeth is as partisan as they come. She has performed with the English National Opera in London's West End and other companies on New York City's Broadway, and she directed the first French version of *Les Misérables* in Paris. She now conducts for Sydney Sings, an initiative of Creativity Australia, which promotes choir singing in the community. "It is immediately uplifting. Everyone is on a high. You can feel it," Elizabeth says. "Music is the language of the heart. Singing lets you get things off your chest – you feel so much better after you've done it, it's preventative medicine."

I am reminded of an earlier conversation with Professor Alan Harvey, a neuroscientist at the University of Western Australia in Perth, who has participated in choirs and played in folk and rock bands for most of his life. "This organism, this whole, which is made up of individuals, melds and transforms us, resulting in an unparalleled unity of purpose. I cannot think of a better expression of the power of music and its uniqueness," Alan says. "You feel this extraordinary sense of oneness with those individuals because you have experienced something unique. I think music is incredibly important for the sanity of the human species."

WATCH the Sydney Sings choir. Download the free ***viewa*** app and use your smartphone to scan this page.

Folk fever. A *rebetika* dance lesson (left) at Preston, Melbourne; rebetika is a folk music form that dates to the 19th century in Turkey and Greece. Accomplished and well-known Tibetan singer-songwriter Tenzin Choegyal (below left) performs in Sydney. Tenzin's family were nomads and he performs traditional songs.

Tickled by tunes. Professor Sarah Wilson (right), at Melbourne University's School of Psychological Sciences, leads a team that researches the brain mechanisms underpinning human hearing. In particular, music is used to study how the brain learns complex auditory tasks and responds emotionally to experiences.

While making you feel good about yourself and other people, it can trigger memories.

SO WHAT IS IT ABOUT THIS thing called music? Music is an organised flow of sound waves or vibrations of differing frequencies. But that description is entirely inadequate in explaining why singing in a choir, listening to a Beethoven symphony, drumming in a jazz combo, dancing in a trance club or being at a rock concert will trigger the rush of amazing effects that music is known to have on the brain. Why does music make us feel anything at all?

I put these questions to Professor Sarah Wilson, a clinical neuropsychologist at the University of Melbourne. Sarah is fascinated by music's effects, particularly the beneficial ones. She directs Music, Mind and Wellbeing, a university initiative that links neuroscience with music, happiness and health. Its research agenda encompasses auditory neuroscience, music neuropsychology, performance psychology and music education and therapy.

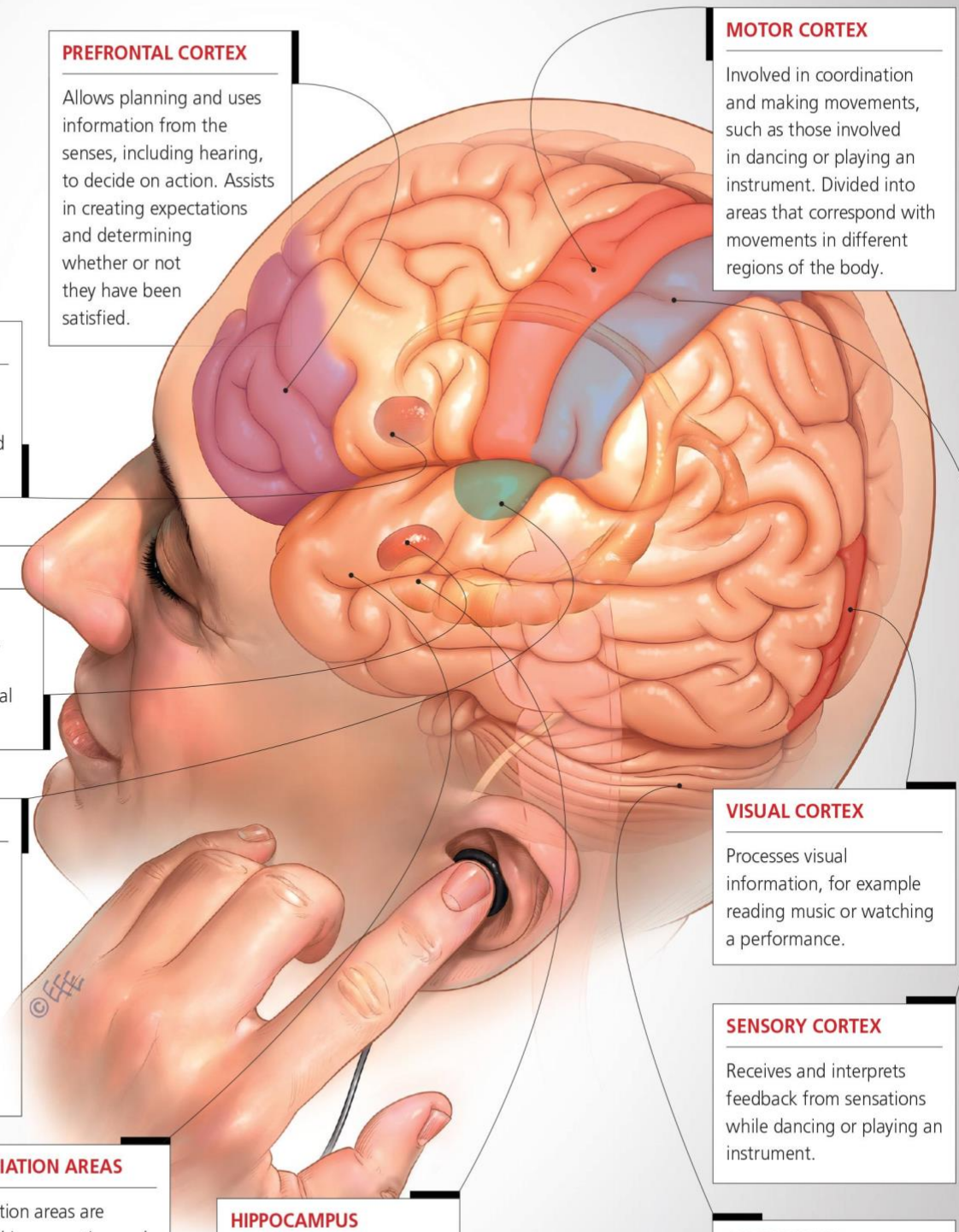
Neuroscientists have begun to realise that music has its powerful effect because it fires up cerebral zones connected with not just hearing but also vision, touch, movement, rhythm, emotion and memory. Its effects are felt on the right side, the left side, the front, the back, in the deep interior and on the surface of the brain. While making you feel good about yourself and other people, it can trigger memories of emotionally significant events and make you want to move in time with it, either by just tapping out its beat with your feet or using your whole body.

The complex route by which music penetrates the brain begins, of course, with those parts connected with hearing. From the ears, its signal travels via the auditory nerve to the brain's auditory cortex, in the temporal lobes.

Continued page 48 ▶

MUSICALLY MINDED

Processing music requires many parts of the brain to work in harmony like an expertly conducted orchestra.



PREFRONTAL CORTEX

Allows planning and uses information from the senses, including hearing, to decide on action. Assists in creating expectations and determining whether or not they have been satisfied.

MOTOR CORTEX

Involved in coordination and making movements, such as those involved in dancing or playing an instrument. Divided into areas that correspond with movements in different regions of the body.

NUCLEUS ACCUMBENS

Involved in emotional reactions to music, appreciation of reward and the release of dopamine.

AMYGDALA

Involved in long-term and emotional memory. It is one of the areas responsible for emotional reactions to music.

AUDITORY CORTEX

Sound information travels here along the auditory nerve from the ear. This is the most complex of the sensory systems in the brain. It makes sense of sounds and analyses their qualities, such as volume and location.

VISUAL CORTEX

Processes visual information, for example reading music or watching a performance.

SENSORY CORTEX

Receives and interprets feedback from sensations while dancing or playing an instrument.

ASSOCIATION AREAS

Association areas are involved in perception and recognition. The limbic association areas link emotion with information from the senses and the strength of an emotion associated with an event influences how long it is remembered.

HIPPOCAMPUS

Plays an important role in bringing together sensory details from an event to form episodic memory, as well as spatial, verbal and long-term memory. Helps the recall of context and musical experiences.

CEREBELLUM

Another location involved in auditory processing of music. It regulates the timing and sequence of muscle action that make up physical actions, such as dancing or singing.

ILLUSTRATION: LEVENT EFE

Fine tuning. Sarah adjusts an electrode on Krysta, her research assistant. Science shows the study of music improves brain function.

"Our auditory system is the most complex of all our sensory systems, even more complex than vision," Sarah says. "It has more way stations – or groups of nuclei – that process the sound signal, than happens for the visual signal. After it leaves our ears and travels via the auditory nerve up through the brain stem, the signal is already undergoing quite significant processing in the brain stem.

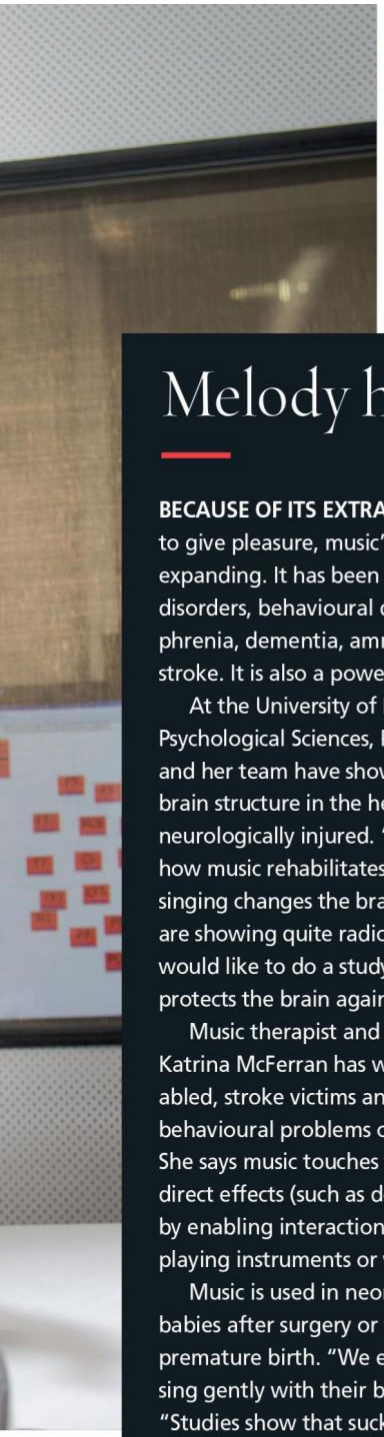
"So by the time it gets to the primary auditory cortex, which we know does a lot of cortical processing of the sound signal, we already have quite significant and sophisticated representations of the sound and its specific attributes – loudness, location, pitch height."

From the primary auditory cortex, the signal flows to the secondary auditory cortex surrounding it, then on to other parts of the brain behind the temporal lobes, including the association cortex, which "integrates sound with vision and other body representations," Sarah explains. "This may trigger certain images or senses... So we know that music is a very powerful trigger for other sensory experiences because it brings together an emotional tone, often with an autobiographical event in our life."

Which is why music so readily arouses memories that are happy or sad and may prompt inexplicable and inexpressible nostalgia. The sound signals also hit the mesolimbic system (the hippocampus, amygdala and nucleus accumbens), which is involved in the production of dopamine, the pleasure chemical. If the music really strikes a chord, dopamine floods into the brain (see page 45).

"We just love it," Sarah says. "That's why we get our favourite pieces of music and listen to them over and over. They give us that very beneficial effect without having to take any tablets or do anything invasive. It's a very natural way of getting pleasure, getting a high."

Alan Harvey adds: "Music gets right to the heart of the emotional brain. One of the key areas is the nucleus accumbens, the brain's pleasure centre, which is activated in addiction and things like that.



Melody heals

BECAUSE OF ITS EXTRAORDINARY capacity to give pleasure, music's role in medicine is expanding. It has been used to treat mood disorders, behavioural difficulties, schizophrenia, dementia, amnesia, epilepsy and stroke. It is also a powerful painkiller.

At the University of Melbourne's School of Psychological Sciences, Professor Sarah Wilson and her team have shown music can change brain structure in the healthy and in those neurologically injured. "We are looking at how music rehabilitates language and...how singing changes the brain," she says. "We are showing quite radical changes...and we would like to do a study showing how music protects the brain against ageing."

Music therapist and associate professor Katrina McFerran has worked with the disabled, stroke victims and young people with behavioural problems or who are grieving. She says music touches them either through direct effects (such as dopamine release) or by enabling interaction through singing, playing instruments or writing songs.

Music is used in neonatal units to soothe babies after surgery or those traumatised by premature birth. "We encourage parents to sing gently with their babies," Katrina says. "Studies show that sucking rates improve, there is weight gain, [and] hospital stays are shorter when music therapy has been used."

"Dopamine is one of the important chemicals involved. If you know a piece of music and...when there is going to be a climax, there is a burst of dopamine in the brain – not unlike the effect of an orgasm."

This expectation and reward nexus is at the heart of music pleasure. With a familiar piece of music, you know what's coming; you anticipate it. If you are enjoying an unfamiliar piece it probably contains elements you have heard and enjoyed before in other music. In both cases, when your expectation is fulfilled, you're rewarded with a hit of dopamine.

But it doesn't always have to be that way. Sometimes a piece exhilarates you by surprising you, by doing the unexpected.

MUSIC HAS LONG fascinated evolutionary scientists. It is practised in every human society and always has been. Humans are the only truly musical creatures. Music underpins much human interaction and plays a central role in traditional societies, usually involving everyone in the community.

Charles Darwin and many evolutionary scientists since have wondered why music is so important to us. Is our capacity for music an innate, inherited trait? If so, it must serve an evolutionary function and give us some kind of survival edge.

The origins of music are lost in deep history, but it is thought to have developed from a pitch-dependent protolanguage that scientists have dubbed 'musilanguage'. It was perhaps akin to the sing-song talk mothers use with babies and probably incorporated gesture and mime. In every culture, mothers sing naturally to their babies. In turn, babies babble and squeal in a naturally musical way. Music is a hardwired facet of human life.

At some point in our prehistory, language and music diverged and language was used primarily to convey ideas and music to express emotions. A single origin may explain the large number of brain parts that the two systems share. The human voice may have been the first musical instrument, perhaps accompanied by rhythmic sounds provided at first by hand-clapping or the beating of objects, which later became drums. The first song may have been a lullaby or perhaps a musical accompaniment to a ritual. Music, language and the brain have been evolving in unison ever since.

> A community that strengthens its bonds through collective song and dance has a better chance of survival.

"Why retain both music and language as two parallel communications streams?" Alan asks. "Was music just a leftover from some precursor to language, or did it also bring some very special evolutionary significance to the species?"

Darwin provided an answer in *The Descent of Man*. He suggested music was used for display in sexual courting. Most scientists take a Darwinian view, believing that music confers some unique survival advantages and has shaped the human brain over evolutionary time. A narrow interpretation of this is that, because a skilled and energetic performer is likely to be fit, strong and intelligent and therefore a good mate, he is more likely to win a partner and pass on his genes. Music, therefore, is sexy.

But a broader view claims group cohesion is music's great gift to humanity. "There is a really interesting body of literature that's emerging on that at the moment, which shows that people who do things together in time, who synchronise, tend to be altruistic and empathic, so it brings community benefits for the group that does that," Sarah says.

In short, a group – a community, tribe or family, for example – that strengthens its internal bonds through collective song and dance has a better chance of survival, in evolutionary terms, than one that doesn't. A united community may work better together when hunting, harvesting crops, digging irrigation ditches or defending a settlement against raiders. It may also be in better shape to face hardships such as drought and famine. ▸

Early start. Composer Mary Finsterer (top) helps her children Wil and Eve Golja practise violin and cello. Early childhood music specialist Jane Boyd (bottom) teaches singing and rhythmic movement to toddlers in Sydney.

The Mozart effect

PLAYING MOZART TO children was once said to boost their intelligence and led to the term 'Mozart effect'. It was a misconception but, while listening to Mozart may not boost IQ, learning music when young may.

Conductor Richard Gill is convinced of its power. "Children's involvement in musical activity has a profound effect on the development of the child's general learning," Richard says. "It is now proven beyond doubt that children who are engaged in arts activities, especially music, have advantages in all areas of learning."

The University of Melbourne's Sarah Wilson agrees. "There is clear evidence that music can alter your mental state. It may not achieve a change in the short term but over the long term, if you compare musicians with non-musicians, there are down-the-track benefits for cognition, probably more in those fluid or problem-solving-type tasks that require adaptable thinking and sustained, focused attention and concentration."

Some experts say the Mozart effect is not limited to music – almost any activity practised intensely for many years will change the brain. Others say the evidence is insufficient to prove a direct link between music performance and general cognitive improvement.

Music-based ceremony is and was not simply a feel-good issue but also a means of passing on information.

Moreover, in a traditional society, especially a non-literate one, music-based ceremony is and was not simply a feel-good issue but also a means of passing on information – about tribal law, kinship ties, environmental issues, food sources, myths and religion – crucial to the group's functioning.

Humanity has countless subdivisions – nations, tribes, religions, military units, migrant minorities and football teams, not to mention One Direction and Justin Bieber fan groups – and members of a subculture may identify and define themselves by the music they enjoy as much as by anything. Music remains as strong a social glue as it has been over many millennia.

"Music is very much part of social identity," Sarah says. "It plays a huge role in helping people define what they stand for, their values, what they pledged their soul to at the age of 15 or 16. It has that huge socio-cultural shaping role."

Professor Rob Brooks, an evolutionary biologist at the University of New South Wales (UNSW) in Sydney, is interested in the evolution of mate selection and sexual advertisement in humans. Music is "one of the living world's greatest sexual displays," he says in the chapter "Blame it on The Stones", of his 2011 book, *Sex, Genes & Rock 'n' Roll*. It's a telling title, speaking as it does of the sexual charms of male rock stars. But Rob points out a seeming contradiction in the notion that music used as a sexual lure works for the good of a group.

"There is stuff that is good for the group but within the group there is all sorts of conflict," he says. "What it really is about is outcompeting your rivals. People that are here now are the consequence of genes that have succeeded in that *Continued page 54* ▸

Street strings. Busker Emily Sheppard performs with fellow students at the National Academy of Music, outside Flinders Street Station in Melbourne.

competition in the past. So there is always a tension between cooperation and conflict, and very little evolution is about anything to do with the good of the species or the group at all. The interests of the group and the individual may be aligned at certain times but at others they would be at complete right angles to each other."

Rob believes both music and language are about getting noticed, and getting noticed may lead to more than finding a mate; it may bring fame, status and even power – within the system or by subverting it.

"One way in which men have always got noticed has been through feats of musical and verbal gymnastics. And those capacities are very closely related, I believe. The great voices – the Richard Burtons, the Orson Welleses and others – they are very musical, too."

The strictly Darwinian view of music's place in human life has been challenged by neuroscientist Steven Pinker, of Harvard University in the USA. He says humanity's capacity for music is not an evolutionary adaptation, but that music is simply "auditory cheesecake, an exquisite confection crafted to tickle the sensitive spots of...our mental faculties".

A less extreme view is that of Aniruddh Patel, an associate professor of psychology at Tufts University in Massachusetts, who says music is a "transformative technology of the mind", a powerful human invention on a par with fire-making and reading. He claims no evolutionary adaptation of the brain has occurred to specifically support musical behaviour. All the parts of the brain that music coopts are also used for other functions. But he does not deny that music is biologically powerful and can shape an individual's brain over a lifetime.

TO APPRECIATE HOW fundamental music might have been in ancient human societies, you need look no further than Australia's traditional Aboriginal culture. In many of its communities, music (usually in the form of ceremony) is pre-eminent. Ceremony is everything. Yet whatever collective benefits it may bestow, the potential friction between the group's and individual's benefits is an ever-present subtext.

Aaron Corn, an associate professor of music at

Listened lessons. Harley Hall, at left, belongs to the Kuma Karro (one blood) dance group from the Adelaide Plains. The group uses music and dance to tell traditional stories to the community.

the Australian National University in Canberra, is an ethnomusicologist with an interest in Aboriginal music, particularly that of contemporary bands such as Yothu Yindi.

"In the culture that I grew up in, learning about music teaches you about music and maybe some of the other arts. In classical Australian [Aboriginal] societies, learning about music teaches you about everything else in the natural order. So it's history, it's law, it's tradition, it's myth, it's survival, it's behaviour," Aaron explains.

A ceremony is a spiritual event that purifies community members, releases tensions and rebalances not only the elements within the group but also the group within its environment.

"The whole ceremonial framework, from the music and the words upwards, is designed to keep balance between parts of society, between people and the environment they are in, between the living and the dead, and between a lot of other things," Aaron says. "It reminds people of what they do in this world and why they do it."

> "Being able to sing, to sing a lot of songs and to sing them well, to lead performances, gives power."

Ethnomusicologist Jill Stubington, formerly of UNSW, has spent more than 45 years studying Aboriginal music. She has witnessed ceremonies in the Northern Territory that had a variety of purposes. Some might have been specifically for reconciliation, grieving, healing, fertility, care of the land, diplomacy, initiation or invoking the ancestors and the Dreaming, while others had multiple objectives.

And in each case, as the group's collective spirit was being healed or instructed, participants were undoubtedly following their individual evolutionary destinies, pursuing status or reproductive success.

"Music is at the absolute centre of Aboriginal life," Jill tells me. "And for men, singing is a crucial part of their progression through life... Being able to sing, to sing a lot of songs and to sing them well, to lead performances, gives power to Aboriginal men in society. Music has everything to do with status, power and prestige."

As for catching the eye of the opposite sex, not only the men used music: the women, too, attracted attention to themselves through their dancing, Jill says. Yet for all the individual crosscurrents at play during them, ceremonies were, and are, inclusive events, even if most participants' contribution may be limited to moving in time with the music – dancing. Everyone who is qualified to do so is expected to take part, although parts of ceremonies may be off limits to some, depending on gender or age, or another social criterion.

Today's globalised music culture can appear very different from that in traditional societies. Music seems to be created and performed by elite musicians for audiences who just sit, watch and listen. But even for a non-participatory audience there is more exchange with the musicians than might be thought possible. And across Australia, music performance is thriving – in country sheds, backyard garages, suburban dance halls, CBD nightclubs, school halls and churches.

IN THE PITT STREET Uniting Church I'm floundering. For some reason I'm finding it hard to read the words on the song sheet and sing in tune at the same time. That's worrying. Maybe I'm standing too close to the piano and it's overwhelming our voices, so I have none to guide me.

I sidle around the piano and position myself close to three men who seem to know what they're doing. The piano still rings out, but the voices of the others are discernible. I open my mouth to contribute mine. Immediately I sense it being drawn from me and lifted to join the collective chorus. That's when a strange thing happens. Instead of the thin, reedy wail that emerged from my throat earlier, I hear a tenor so unexpected that for a moment I wonder if it's mine. It seems to come from me but at the same time from everyone around me. It's one and it's all. AG

SEE more of Michael's evocative images of people interacting with music across Australia at: **www.australiangeographic.com.au/issue119**