

A CARNIVAL IN RIO - SOUND, RHYTHM AND THE BODY

Imagine you are in Rio de Janeiro at Carnival time. It is late at night, but you are walking through streets full of people. You are relaxed, and happy to feel aware of yourself, or your body and of the present moment. Sounds, scents, shapes and colours drift through your senses, seeming to arise, mingle and disappear in an almost "timeless" flow.

All of this is suddenly interrupted by a short, loud and deep sound behind you. You are not afraid of the sound, in fact it interests and pleases you, but the surprise makes you blink; your body even reacts with a small, involuntary "jump". It is the sound of a surdo, a low tom-tom, the rhythmic bass of the street bands of samba batucada. It has been hit with a single, powerful stroke of a large, soft-headed stick. But why have you jumped? How did you know, without apparently thinking about it, that this sudden sound was pleasing rather than a threat to you?

Already, in a single sound you have encountered some of the central mysteries of music, the mind and the body. These are mysteries which begin in the slow and easily perceived mechanical energy of sound, pass through the miraculous sensing system of the ear on to the fastest-firing neuronal system of the human brain, and finally to human consciousness and action.

The powerful stroke of the beater (which started off this surprise) has set the skin or synthetic membrane stretched across the head of the drum into brief but equally powerful vibration. This powerful burst of vibration has caused pressure changes in the air around the drum, rather like the ripples when a stone is thrown into water. Here the ripples are deep, because the sound is loud, and the main ripple movement is relatively slow, because the frequency (or pitch) of the drum is low. Importantly there are subtle ripple movements of different speeds within the slow, main ripples. These form the character of the sounds of the drum: they include additional vibrations across the surface of the skin, the resonances of air in the hollow of the drum and "formants" or resonances from the wood or metal of the body of the instrument.

This powerful burst of richly detailed vibration has reached your pinna, or outer ear, which because of its elegant shape has caught the sound coming from behind and helped reflect it into your auditory canal. Through the auditory canal the vibration has been communicated to your eardrum, or tympanic membrane. The eardrum behaves very much like the skin or membrane of the surdo itself, and begins to vibrate in the same powerful and rich pattern as the original sound.

Behind the eardrum lie the three smallest bones in the body, the ossicles, which have amplified the vibration, through lever action and concentration of energy (like a combination of David balancing Goliath on a seesaw and an elephant balancing on a ball) and transmitted it to the oval window of your cochlea. This is an organ the size of a small pea, shaped like a spiral seashell, filled with liquid and containing, among other structures, the basilar membrane. As the liquid vibrates in the pattern of the sound, the spirally-wound basilar membrane "flexes" as vibrational impulses travel along it. Because it is narrower and stiffer at its beginning than at its end, every vibration with differing speed and energy peaks at a different point or points. Along the surface of the membrane are cilia or hair cells – literally like hairs on a closely-shaven head – which are "opened" by the flexing action at the point or points of peaking. As your hair cells have opened, the liquid in the cochlea, consisting of positively charged potassium or sodium ions, has entered the cell bodies beneath and "hyperpolarized" them, like car batteries. The system is miraculously sensitive: your hair cells may have hyperpolarized by moving as little as the equivalent of the Eiffel Tower swaying 10 millimeters in the wind – and this many hundreds of times a second. The message has then been passed on to other cells, or neurons, by chemical neurotransmitters, which communicate across the synapses where the axons of cells meet, and into the electrochemical firing of neurons. The positions of the cells on the basilar membrane and the speeds of their firing have provided your brain with detailed neural information about the rich vibration of the drum in "real time".

Here may be part of the answer to the first of the mysteries. It appears that strong neural impulses from the ear may travel, by way of the spiral ganglion and superior olivary nucleus behind the ear, and possibly by way of the inferior colliculus (a neural meeting point in the midbrain), directly to the spinal motor systems that make you jump. In other words there may be a direct, "hard-wired" connection between sound and movement that does not require thinking about – a phenomenon described in the world of biology and medicine as the acoustic startle response.

The answer to the mystery of recognition may also lie quite low and early in the auditory cortex. It is likely that there are neurons which we have inherited or trained to recognise patterns of neural activity associated with certain sounds before we consciously compare or remember them. These neurons are connected, among many other things, to the amygdala, an organ deep in the brain which may set in motion reactions of fear or stress if threatening sounds are identified.

On this hot Brazilian night, however, you do not feel threatened. But of course you look behind you, and see a whole band of musicians and a group of dancers lining up. It is the beginning of a Carnival parade. The surdo drum is struck again....and yet again. By the third stroke you realise that this will be a regular pattern of beats: one...one...one...one....etc. As it progresses it begins to occupy your thoughts. The uninterrupted flow of sensations of the earlier evening is replaced by an attention-catching pulsation – like the peaks of a wave form – a much slower version of the waves that make up the sound itself, the nature of all matter around you, and indeed the entrained neural firing of your own thoughts. The beat makes a different kind of "here and now". It both measures and arrests time. In the progress of pulses you are conscious more than ever of the passage of time, but the more-or-less identical repetition creates, paradoxically, the sense of a timeless moment. You are in one of the rare experiences, that only music can provide, of homeostasis of consciousness in time – and perhaps, if you are of a spiritual

inclination, a “oneness” with the nature of energy itself.

Now the surdo player has begun to add character to the rhythm. He or she has begun to damp alternate beats with his left hand and flick the surface of the drum before a strong second beat: one...tWO...one...tWO. In the cognitive, reflective part of your mind, the beat has acquired three dimensions – the original pulse is still there but the ones and TWOs seem to set up their own frequencies at half the speed, and the flick guides the mind towards the powerful TWO. This is the point at which the sensation of pulse turns into both the sensation and the cognitive construct of “metre”: larger-scale repeated structures of stress and duration which are the equivalent of “bars” in Classical Western music and “feet” and lines in poetry.

But it is not only your mind that is guided to the strong beat. You have begun to want to move. Perhaps you are shy or self-conscious and prefer to keep this to yourself, and maybe just tap your foot. Perhaps you decide to join the dancers and bystanders and start to dance. Either way, the feeling is at some level irresistible, and this leads to another mystery: why and how does music make us want to move in this way? The hard-wired acoustic startle response opens up the possibility that there may be a direct biological link between musical rhythm and rhythmic movement. Certainly the body is full of numerous neural oscillators (literally rhythmically firing neurons) which regulate movement. When we dance or move to music, these oscillators are inevitably engaged and entrained by the beat of the music. But are they automatically engaged – is there a hard-wired hotline as in acoustic startle – or do we voluntarily activate them?

The answer is likely to be some combination of the two. Evidence from various forms of brain scanning suggests that the transformation of rhythms into movement involves a complex loop of functions including the pre-motor cortex in the upper, reflective part of the brain, the basal ganglia deep in the lower part of the brain (in the same assembly as the amygdala) and concerned with unconscious action, the cerebellum of the hindbrain which co-ordinates, regulates and “smoothes” muscular activity, and the vestibular system behind the ear, concerned with posture and balance. In addition, we know that the “higher” and cognitive processing of rhythm is located high in the brain in the auditory cortex of the temporal lobes, where more specialised tasks of rhythmic understanding and learning are carried out – like, for example, the retention of rhythmic patterns, which appears to take place in the right anterior secondary auditory cortex.

It is likely that moving to music is both voluntary and involuntary, and processed in both the upper cortical and lower subcortical parts of the brain. But an important role may also be played by mirror neurons in the pre-motor and parietal areas of the upper brain. If current theories are correct, these neurons may help us to understand and internalise the actions of others. It is possible that as you hear the surdo being played, your mirror neurons are reading the actions, intentions and energy of the player encoded in the sounds and “mirroring” her/his intentional and energetic state in your own body. If we hear the loud bang of a fist on a table, for example, we can all somehow feel both the power of the movement and the anger behind it in our own bodies. Whatever the case, the evidence that music may both trigger and attract human movement is overwhelming. The psychologist Colwyn Trevarthen discovered many years ago that the first coordinated movements of babies are either cued or attracted by the “musical” vocalisations of mothers. There is copious evidence of the usefulness of music in certain phases of Parkinsons Disease, where patients who have lost the ability to move in a co-ordinated way may regain control of movement through musical/rhythmic signals. There is also strong evidence that people with such diverse difficulties as cerebral palsy and chronic pain may extend their repertoire of movement through music, and indeed that everyone may potentiate physical action by supporting movement with appropriate musical/rhythmic stimuli. It is even conceivable that there is an “evolutionary” link between musical rhythm and movement. It is possible that music is in part a means by which human beings, in their early social evolution, sought to coordinate and synchronise movements, energies, intentionalities and significant ritual actions, both between individuals and within groups. If this is the case, there is certainly a substantial residue in the large repertoire of music for dance and ritual music which remains to this day, universally, in every world culture.

But now the ritual of the samba batucada is in full swing. The chocolo shaker divides the beat into four – its rhythms combine influences from both West Africa and South America – but it is elegantly uneven: the action of distal muscles means that the player’s hand takes longer to move forward than pull back, and this creates a beautiful, biomechanical fluidity. The agogo, like two small cowbells joined together, plays a spacious “syncopated” rhythm where accents and rests are unexpected; now two agogos play the pattern so that it becomes interlocked, like the fingers of two hands clasped together. The tamborim, a small hand-held drum with a stick beater, probably derived from Portugese/Andalus/Berber traditions plays the fastest and most syncopated rhythm of all, distantly descended from the complex “time lines” of West African music, where several metres may be implied simultaneously, like the aural equivalent of an Escher staircase. If you have decided to dance, you will discover the the batucada has become a map of your body and its movements – from the surdo linked to the spiral and hip movement of the centre of your body outwards towards movements of arms, legs, hands and feet mapped on to rhythms of the cholcolo and tamborim. In the movements of the dance the body has recruited an “orchestra” of neural oscillators as complex and polyphonic as the multi-cultural rhythmic layering of the batucada itself.

Who knows how long you dance or stand and watch? Perhaps you follow the Carnival parade up and down the hills and through the favellas of Rio de Janeiro, crossing over and meeting up with other bands, Carnival floats, Samba Schools. Perhaps you are lucky enough to be handed an instrument and invited to play. If you are, then you may find yourself caught happily in the loop of this all-embracing sound, both responding to it and generating it – in an exhilarating synchronisation and sympathy with other players, thinking your rhythm, feeling theirs, sharing the speed of their thoughts and the time of their bodies, joining in a

profound mental and biological communication, a powerful musical-cognitive-corporeal clarity and an irresistible force field of joy, empathy and trust.

Perhaps you continue to wander alone through the city as you did before. Whatever happens, this encounter with movement and rhythm has, in a modest way, transformed you both mentally and physically. The rhythmic excitement of the music and the relaxed feel of the atmosphere will have at times both increased and decreased tone in the sympathetic and parasympathetic divisions of your autonomic nervous system, exercising your heart and aspects of your metabolism in healthy ways, both speeding them up and slowing them down. If the rhythmic pulse has really slowed down, it may have entrained your heart to synchronise with it. Whatever the case, through your responses to the music, the way is prepared for "parasympathetic" relaxation. The experience will have exercised and helped regulate patterns of respiration, and the healthy irregularities of the heart related to breath. While the musical rhythm was at its most exciting, it will have speeded up both automatic and voluntary breathing. Now it is probably steady and slow.

The music will also have exercised systems secreting hormones and releasing neurotransmitters relating to stress and relaxation. It is likely that at the most exciting moments, secretions of hormones such as cortisol, associated with stress reactions, may have temporarily and marginally increased. Now the levels are almost certainly lower than before the experience. According to recent research, it is likely that the musical experience will have had a regulating affect on dopamine, a neurotransmitter associated with motivation, reward and avoidance of threat, on noradrenaline a neurotransmitter synthesised from dopamine and associated with attention, working memory and arousal, on serotonin associated with sleep, appetite and control of aggression, and on the opioids associated with hedonic responses and blocking pain. It is likely that the experience has also increased concentrations of the peptide hormone oxytocin which appears to have a role beyond its traditional association with childbirth and lactation and be linked to more general feelings of well-being and indeed to the modulation of feelings of fear and stress in women, men and children.

This brief hypothetical journey is an extremely "rough"-guide encounter with the infectious world rhythms of the samba batucada. But it is also a short, virtual adventure in rhythm, movement, the mind and the body. And perhaps it is in the latter that the more exciting and interesting geography lies: in the mysterious map of music and physical movement – tracing journeys from the physical nature of sound to perception and cognition, from mechanical energy to electrochemical firing, from subcortical to cortical processes, from the motor cortex to physical action – and in the way in which this extraordinary geography may be explored in adventures in rhythm and humble transformations of human minds and bodies.