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Animals and music: Between cultural definitions and sensory evidence

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Abstract. It was once thought that solely humans were capable of complex cognition but research has produced substantial evidence to the contrary. Art and music, however, are largely seen as unique to humans and the evidence seems to be overwhelming, or is it? Art indicates the creation of something novel, not naturally occurring in the environment. To prove its presence or absence in animals is difficult. Moreover, connections between music and language at a neuroscientific as well as a behavioural level are not fully explored to date. Even more problematic is the notion of an aesthetic sense. Music, so it is said, can be mimetic, whereas birdsong is not commonly thought of as being mimetic but as either imitation or mimicry and, in the latter case, as a 'mindless' act (parrots parroting). This paper will present a number of examples in which animals show signs of responsiveness to music and even engage in musical activity and this will be discussed from an ethological perspective. A growing body of research now reports that auditory memory and auditory mechanisms in animals are not as simplistic as once thought and evidence suggests, in some cases, the presence of musical abilities in animals.

1. Introduction

Music and other art forms are regularly regarded as a pinnacle of human achievement and an enduring testament to human culture (Mithen 2006). The very idea of considering a sense of music to be present in animals (in the broadest sense of perception and even rudiments of its production) seemed out of the question for a long time. The same was said of complex cognition but it is now well recognized and documented that animals, from different classes and orders, may possess complex cognitive abilities including the ability to use tools, solve problems, recall memories of past events and plan their future (summarized in Rogers, Kaplan 2004). From an evolutionary point of view it is also important to ask at least when aspects known to be part of human musical abilities first appeared in hominids or non-human animals. Studies of goldfish (Fay 1995) suggest that music discrimination may have existed even in species of great evolutionary distance from humans. Of course, discriminating sounds may be vital to survival for any species in any acoustically rich environment and it seems a major leap from this to the ability to learn and remember, let alone reproduce and vocalize, sequences of sounds as well. Yet one notes that studies such as those on carp (Chase 2001) and Java sparrows (Yamamoto, Watanabe 2008; Watanabe *et al.* 2005; Watanabe, Sato 1999) have shown that the discrimination of music, even specific styles and rhythms, is sophisticated rather than rudimentary. Being able to generalize between classical music and modern western music and apply the principles to other tunes seems a remarkably advanced ability in fish and songbirds. Likewise, the ability of rhesus monkeys to listen to melodies in transposed octaves and still recognize a melody as the same even when transposed by one or two octaves, but not by half octaves is comparable to the musical ability of children to recognize a melody as a whole and not its parts and to do so in different octaves (Wright, Rivera 2000).

Despite an increasing interest in the musical perception and abilities of animals, various publications have hastened to add that animals usually lack a key ingredient to appreciate, recognize, memorize, let alone reproduce music. It is said to be uniquely human to combine in music phonatory imitation with metric entrainment (Brown 2007) and an exclusively human prerogative to have a "natural inclination to engage with music", a view attributed to one of Canada's leading neuropsychologists of music (see Gess 2007). There may also be an implicit assumption that only humans practise music on their own (Kenneally 2008), while others have emphasized the alleged human uniqueness to perceive and synchronize rhythm because the latter involves a tight integration and coordination between the auditory and motor system. Such statements seem highly premature given the recency of research into this area and the very few species that have been investigated in any depth.

More or less all these orthodoxies are beginning to be dented already, however, by new studies that show some, often even compelling, evidence to the contrary. "Snowball", the sulphur-crested cockatoo (*Cacatua galerita eleanora*) may have been an amusing sideshow on YouTube but, when researchers investigated the rhythmic movements that the bird performed to the music to see whether changes in beat, but not in pitch, would result in the bird's adaptation to the changed rhythm (Patel *et al.* 2008), they found that was largely the case. This bird's performance may well meet the definitions of musical rhythmic behaviour that Bispham (2006) described and analysed in humans. A paper delivered at the 9th International Conference on Music Perception and Cognition in Bologna in 2006 (Patel, Iversen 2006) presented evidence that Asian elephants handling mallets on base drums maintained a regular and stable drumming tempo over periods of half an hour and over several days and it has been found that some African apes use percussions in their natural environment (Fitch 2005). Male palm cockatoos use a stick, and, together with some woeful screeching (cockatoos are obviously not songbirds but "sing" all the same), they drum a steady beat. With such acts Palm cockatoos are said to defend their territory but also advertise themselves to attract a mate. Here is thus an example of tool use and music making not in any shape or form influenced by humans. Whales and dolphins may have complex song sequences and some of these appear to be sung when an individual is alone. Many songbirds sing by themselves and practise (and not just in subsong) and quite a number of them also appear to appreciate species-foreign sounds and even melodies well enough to integrate them into their own song (Mathews, Schuyler 2004; Chisholm 1948) (more of this later).

Songs of animals of a number of orders are largely discoveries only of the last five or so decades and so is the discovery that the brains of songbirds possess an entire neuronal network, including a high vocal centre, dedicated specifically to the task of learning songs, including the abilities to memorize, produce and even improve and improvise on songs. Many songbirds retain lifelong plasticity, that is, retain the ability to learn new sounds throughout life, and many can mimic speech of humans as well as sounds of other birds, mammals and even inanimate objects (Robinson, Curtis 1996; Kaplan 2000). Obviously, reproduction of sounds, particularly of those that are not species-specific, depends on the ability to form a memory of sound and have that memory transfigured into production of sound.

Neuroscientists use the avian vocal system instead of nonhuman primates as a model for human vocal learning (Zeigler, Marler 2004; 2007) because primates are not vocal specialists and learners. Indeed, research on zebra finches (Arnold *et al.* 1976; Konishi, Akutagawa 1985; Margoliash, Fortune 1992; Vicario, Yohay 1993), canaries (Nottebohm 1977), sparrows (Konishi 1965) and a range of other songbirds (Nottebohm 1980) has assumed model status for the study of memory formation and for the complex interaction between neural activity, auditory feedback, plasticity, attrition and development of song. Hence, the neocortex, once thought to be an indispensable precondition for vocal learning, and as such a mammalian innovation *de novo* in evolution, is being dramatically replaced by attention to the song control system of birds as a way of understanding how vocal learning occurs.

2. Animal song: speech or music

As many of these hallmarks of human uniqueness begin to crumble under the weight of emerging evidence of the abilities of animals, art, and specifically music, is among the last vestiges of human uniqueness. However, even in human cultures there appears to be no easy and totally satisfying explanation for musicality or an aesthetic sense of music. Many have called music the most unique of human behaviours and the most intrinsic and defining feature of human culture (McDermott, Hauser 2004), others have called music a mere useless adjunct, a 'cheese cake' in culture (Pinker 1997) that has little to offer by way of explanations of evolution and culture whereas language is invariably considered an essential human trait.

There are writers who claim that human music has converged, quite coincidentally, to share properties with birdsong and whale song (Mithen 2006), whereas the position of neuroscientists is that birdsong production helps us understand human language, not music. Debates on human language origins, as is well known, have been acrimonious at times, because of a failure to distinguish between language as a communication system and the computations underlying the system (Hauser 1997). In so far as human language is premised on acoustic memory and vocal learning, there are at least a number of classes and orders of animals, select though they may be, that share this trait with humans. These include songbirds, cetaceans and bats (Pettigrew 1986). Complex vocal learning has been shown also in parrots (Ball 1994; Dooling *et al.* 1995), and in hummingbird species (Baptista, Schuchmann 1990), that is, in species that are not closely related taxonomically (Sibley, Ahlquist 1990). This suggests that the ability to learn vocalisations may have evolved independently at least three times among birds alone (Gahr 2000).

Non-human primates do not feature greatly in this comparative exercise of vocal learning among species, with some recent corrections, and the emphasis on studies of songbird mechanisms has become the dominant model. For anthropologists and evolutionary biologists, however, the link of primates to humans remains of strong interest (Owren, Rendall 2001) and the last few years have seen a strong interest in auditory and vocal performance of primates (see below).

Music cannot be shown to be adaptive because any empirical evidence is scant or lacking altogether. The latter is true enough because music is ephemeral, fleeting, and early oral traditions of song and dance have apparently not left as many clues as have paintings or architecture. Arguing that music may have been adaptive (that is, hominids sang rather than spoke and the best (male) singers had a reproductive advantage over less competent singers) has been based on no more than conjecture, as also is the view that music never mattered in the evolution of Homo sapiens. Neuroscientific studies have begun to research the underlying mechanisms and neural coding of sounds found in the human brain during the perception and production of music (for example, Zatorre, Peretz 2003) but the evolutionary path and any precursors of language and music (and their relationship to each other in terms of brain function, see Koelsch 2005 or cultural themes, Merker 2005) in non-human animals will require far more research, of course, before music can be deemed a uniquely human trait.

For most modern humans, music is an essential art. Birdsong is certainly music to us, but it has been a matter of debate whether the songs that birds or other animals produce are music to the animals themselves. There is little argument, however, that birdsong can be very close to music and the evidence for such parallels is overwhelming (Rothenberg 2005). The question is whether the birds so praised for their music by human admirers (that is, by the many composers who have actively incorporated birdsong into their own compositions) actually share a sense of pleasure in their own song (*Figure* 1).

Figure. 1. Birdsong can function as advertising territory but it still sounds musical.

3. Auditory perception

In the 1930s, hearing of birds was examined in the context of musical sounds and musical ability. These studies, published in scholarly musicology journals, tested whether birds could distinguish between pure and noisy tones and whether their "musicality" allowed humans to classify bird song in music annotation. For instance, are birds capable of distinguishing intervals of a third, fourth and fifth and can they memorise a tune and transpose it to another key? This was tested in budgerigars (*Melopsittacus undulates*; Knecht 1939), the small nomadic parakeets of inland Australia, and now one of the most commonly available pet birds worldwide, and these are not even songbirds. They also used crossbills, that are songbirds, and it was found that these two species, despite their differences in song production, were capable of distinguishing between intervals that were considerably smaller than full tone steps and they had no difficulty in transposing a song within four octaves (Knecht 1939). The same was found to be true of pigeons, *Columba tartus* (Wassiljew 1933). Memory of auditory cues was ascertained for a difference as small as 1 to 2 Hz showing that this ability is as well developed in some birds as it is in human hearing. In another experiment budgerigars were conditioned to recognise one specific call as a food call. On completion of this training the birds were meant to be confused by being presented with sounds that embedded the specific food call in a series of known and unknown sequences of sounds and songs. The birds were able to identify the food call every time despite the scramble (Knecht 1939). These findings suggest that auditory communication in birds may well be extremely subtle and complex and that the avian ear (not necessarily of all species) may well be capable of very fine discriminations. Modern studies have confirmed this in budgerigars (Dooling *et al.* 1995; Farabaugh *et al.* 1994, 1998) and in many songbird species (Marler, Slabbekoorn 2004).

4. Sound distortion

Most research on avian auditory perception is of a relatively recent date. One of the first tasks arising in this new subfield of neurobiology was to map the avian brain and to understand its auditory feedback mechanisms. The avian auditory pathways were mapped out in the 1960s, including the regions of the forebrain involved in processing auditory inputs. It was found that, despite a lack of peripheral specialisation in the avian ear, higher auditory centres process information that is biologically relevant to each particular species (Konishi 1974). It also needed to be explained how the avian hearing organ can deal with identification of sound location and even with sound distortion (Taschenberger *et al.* 1995), how the sounds irrelevant to the messages are filtered out and how the auditory pathways function in this process of deciphering (Dooling 1982; Klinke *et al.* 1994).

In the 1990s it was discovered that budgerigars are capable of distinguishing sounds stimulating one ear from sounds stimulating the other ear (called large free-field binaural unmasking), an ability that had been documented before only in animals with much larger heads (Dent *et al.* 1997), and they show an unusually small signal-to-noise ratio around 3 kHz (Farabaugh *et al.* 1998; Okanoya, Dooling 1987). They are also able to classify a large number of types of contact calls and can remember these for up to several months (Park, Dooling 1986). This occurs even when the calls are degraded, as by filtering or truncating them (Park, Dooling 1986). The best signal-to-noise ratio attained by the budgerigar auditory system is in a narrow spectral region of 2 to 4 kHz. The unusually sensitive hearing of budgerigars (called critical ratio function), compared to that of other birds and mammals, is characteristic of the species and not a result of domestication or selective breeding (Farabaugh *et al.* 1998). Great tits (*Parus major*) also show an unusual critical ratio function, which may have been an adaptation to coping with broadband background noise of leaves and branches generated by wind in the canopy (Langemann *et al.* 1998; Boncoraglio, Saino 2007). Budgerigars do not naturally have many trees in their arid Australian inland environment yet they have hearing comparable to that of the great tits. The reason is probably that they also have to hear against the constant sound of wind that generates broadband background noise.

Primates, by contrast, have generally not fared well in the new scrutiny of sound production and reproduction, let alone in music as an art form, because they cannot acquire new sounds and are said to lack the capacity for vocal memory of anything novel (Zeigler, Marler 2004). To an extent, these claims of suggested inabilities of primates are exaggerated. Seyfarth *et al.* (1980) showed the learning of appropriate vocal responses in vervet monkeys. Although the calls were not modified, as birds modify sounds, the context in which they were made was. In other primates, it has been found that functionally referential signals exist even in lower primates, such as tamarins, *Saguinus* *fuscicollis* and *Saguinus mystax* (Kirchhof, Hammerschmidt 2006), and in alarm calls of sifaka, *Propithecus verreauxi* (Fichtel, van Schaik 2006). Recently it was demonstrated that langur monkeys can remember which group member had given alarm calls based on auditory cues alone (Wich, de Vries 2006). These findings may have little to do with music but they have to do with memory and auditory perception and both are vital preconditions for musical ability and perception of music. Such recent research shows that non-human primates may have finer auditory discrimination and memory than they were hitherto credited to possess (more below).

5. Memory of song

Song in avian species entails memory — a song that is sung in one breeding season needs to be remembered in the following breeding season — and poses complex questions related to how the song nuclei in the brain manage to lose neurons in the non-breeding season and retain full memory of the song next season (Nottebohm 1980; Konishi, Akutagawa 1985), why some aspects of song are discarded (or "over-learned"), why some song is spontaneous, and why other aspects of song are imitated or improvised and also why and how some elements of song are learned at all (Nottebohm *et al.* 1990; Nixdorf-Bergweiler 1995). Indeed, many factors may determine how long learning takes and how strong a memory will be formed (Clayton, Soha 1999). Age is important, and so are shaping events, such as approval or punishment. Hence song practice in these species includes times of learning but not reproducing all that has been learned in one season, as well as attrition of elements and crystallization of song during the subsequent breeding season (Marler, Peters 1982a; 1982b). The latter occurs either by selective memory or, as in cowbirds (*Molothrus ater*), as a result of shaping in social contexts (Freeberg *et al.* 2002).

In some species, in which only the male sings, crystallised song may not be entirely fixed because new syllables, phrases, indeed, a new repertoire, may be produced in each successive season, as is the case in lyrebirds (Robinson, Curtis 1996), nightingales (*Luscinia megarhynchos*) and canaries (*Serinus canaria*), and these may have been acquired via a process of improvisation, rather than by rote learning from a tutor, or they may be influenced by females, who may prefer certain elements over others. For instance, female canaries respond to higher trill rates in males with higher rates of solicitation displays and thus they shape the song of adult males (Vallet, Kreutzer 1995).

Relatively little is known of song acquisition, song production or memory formation and retention in passerines that are vocally monomorphic. In particular, rather little attention has been paid to the structure of the song control system in avian species in which both the males and females sing the same amount of time and behavioural dimorphism in song is minimal or absent (Kroodsma 1996). The Australian magpie (*Gymnorhina tibicen*) belongs into this category. Males and females both sing and there is no evidence to date to suggest that song plays any role at all during the breeding season (Kaplan 2008).

The magpie is thus an interesting case and one in which musical ability and "singing for joy" (an aesthetic sense of music?) may be tested. And here it may be useful to resurrect an anecdote, written in 1903 by Edgar R. Waite from the Australian Museum in Sydney (Waite 1903). He supplied a small note for the journal *Nature* in which he reported his musical experience with a magpie. He had acquired a nestling magpie (*Gymnorhina tibicen*), Bird A, and taught it by playing a flute to sing the following tune (Fig. 2):

Figure 2. The tune that the magpie learned from a flute play presented by E. R. Waite (1903).

How the song was taught, how much time it took before the bird acquired the tune and at what age it first gave a rendition of the tune is not reported. At any rate, this might not have been the most interesting aspect of the story. Many birds can mimic (Chisholm 1948) and such mimicry may include the sounds of animals and inanimate objects, car horns, telephone and other chimes and, presumably, this extends to mimicry of any composed piece of music that is within range of its own vocal abilities. The magpie is an excellent mimic, equally versatile in producing mimicry as often heard in the male lyrebird's vocal displays (Robinson, Curtis 1996; Kaplan 2000; 2003). However, when a second magpie (Bird B) was added to the aviary, it learned the same tune from the other magpie resulting in a duet in which both birds shared in a portion of the tune, each time in the same manner. Bird A started the tune and completed the first two bars. Bird B, according to the writer, sang the last two bars. Moreover, once Bird A had commenced the tune, Bird B adopted a vigilant posture and waited with half-open beak for its turn and promptly took over to finish the song. Bird B later died and thereafter Bird A resumed singing the entire song and did so in perfect pitch, in F major (Waite 1903).

It is puzzling, if one presumes the story to be true, that Bird B was attending to the commencement of the song and did so in the specific manner of vigilance. Further, it is noteworthy that Bird A resumed singing the entire song and in the correct sequence (and in pitch of F major). There is no reason to presume that mimicry involves having to copy sounds of this complexity in its entirety and in sequence. Since the song had been divided into two by the birds themselves, the units had been broken into two and could have been sung as part 2 first and then part 1, interspersed with the magpie's own vocalisations but, apparently, that did not happen. Such anecdotes tend to raise more questions than they answer. However, the experience described by Edgar Waite may also suggest that the magpie had a musical sense (if not aesthetic appreciation) of the tune having a certain internal integrity.

My own research on magpie (Fig. 3) mimicry (Kaplan 2005) suggests that mimicry is not random. In a hand-raised magpie, over months of testing and recording, the bird reproduced and practised specific sounds that had to do with the sound scape of its own environment. Magpies are territorial and the sounds reproduced were specific to those sounds that resided permanently within the bird's own "territory". In its case, these consisted of human speech sounds and a variety of vocalisations of other species (birds and dogs). Its mimicry practice consisted to 73 per cent of practice of human speech, and then, in various degrees, of other species that it had heard. Moreover, the focal magpie managed to improve its performance of mimicked sounds substantially over time (Kaplan 2000[1]).

This behaviour perhaps undermines the conclusion that could have been drawn from Edgar Waite's description. If another magpie practises speech with the same earnest application as his magpie practised the tune, it is perhaps not so much a case of musical appreciation as the fact that they need to learn and understand whatever is relevant and important in their territory. The latter hints at a function for survival and thus follows scientific principles that a behaviour that has been preserved in a species ought to constitute an advantage for its survival. By contrast, the conclusion that magpies may have musical appreciation does not. Having said so, however, music has not been explicable functionally in humans either. That is why Pinker (1997) could be so provocative and call it a mere 'cheese cake' in human culture.

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[1] The results have also been presented in a paper titled *Higher cognition and communication in apes and birds, with special reference to the vocal repertoire of Australian magpies (Gymnorhina tibicen)* at Symposium, Development and Evolution of Higher Cognition in Animals at Australian Academy of Science in Canberra, ACT, 4 May 2007. www.science.org.au/sat2007/symposium.htm

Figure 3. An Australian magpie vocalising and presenting tuneful 'warbles', often performed for hours. Note that a bird performs on its own, usually away from the group and may sing all year round, male and female alike. The species has specific territorial calls (carolling) and song plays no role in the breeding season.

6. Effect of music

Birdsong in male seasonal singers has a clearly identified function. It has evolved either to attract a mate on the basis of vocal performance or to secure and maintain a territory (Catchpole, Slater 2008). The question here is one beyond these functions, namely, whether music (composed music) has any effect on animals. We do not know, of course, what precisely animals perceive when we play music to them but we can measure behavioural changes. The number of research papers reporting effects of music (and specific kinds of music) on animals has steadily increased and, perhaps not surprisingly, these have come from researchers particularly interested in animal welfare.

In animal welfare it is now believed that music may have a role to play not so much as a cognitive process (Dowling, Harwood 1986; Krumhansl 1990) but as enrichment and as leading to beneficial physiological responses. One such study was conducted at the Coulston Foundation where singly housed chimpanzees were exposed to high beat and low beat music. Results of the study showed an increase in activity on presentation of high beat music (Harvey *et al.* 2000). Another study of chimpanzees (Howell *et al.* 2002) in Arizona revealed a therapeutic effect of music, showing a decrease in agitation and aggression and promoting relaxation, confirming an effect that has repeatedly also been found in humans. As a result, the Arizona Primate Foundation promoted a stereo music system as environmental enrichment for captive chimpanzees (Howell *et al.* 2003). Sutoo and Akiyama (2004) found that music (specifically Mozart) decreased blood pressure in SHR rats and a similar effect was found in Asian elephants (Wells, Irwin 2008).

Similar programs have been run for humans and the value and efficacy of specific types of music on regulating heart beat in cardiac patients and reduction of stress in Alzheimers patients have been tested and examined, apparently with great success, according to an interview with Arthur Harvey, music professor of the University of

Hawai. He is quoted as saying, on the basis of his own music intervention programs, that "music can be a tremendous intervention. It can relieve pain and stress, calm the heart rate and blood pressure, affect physical responses for healing and growth, and stimulate creative thinking"[2]. The songs and rhythms used correspond to near resting heart rate (62 beats a minute) in the lower frequency. There are now also CDs of lullabies available for pets, but to my knowledge, there are no scientific studies supporting or rejecting the claimed soothing effects of specific heartbeat music for dogs and cats.

However, the results of experiments testing whether chimpanzees can appreciate music of one type over another have been mixed and often contradictory. Partly, this might have been so because music is a summary description for a vast variety of sounds and rhythms but this was not always considered across experiments. Hence, more recent studies began to look at types of sound and rhythm. Videan *et al.* (2007) selected vocal versus instrumental music and, within these two categories, classic versus 'easy-listening'. Results showed that instrumental music increased affiliative behaviour in male and female chimpanzees. Slow tempo 'easy listening' music decreased agonistic behaviour in males more so than fast tempo classical music but had no effect on females (Videan *et al.* 2007), suggesting that chimpanzees respond differently to different types of music. In another study by McDermont and Hauser (2007) their chimpanzees were found to prefer silence over any offering of music and similar differences were found in studies of the music interests of gorillas (Wells *et al.* 2006). In one case, at Melbourne Zoo, a gorilla was accidentally found to be interested in television and he shunned any music offerings, played as enrichment to the apes in favour of a television program depicting parliamentary debates in Canberra. He shunned auditory information

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[2] Altonn, H. 2004. Music, especially by Bach, helps reduce stress: heartbeat music calms chimps. Starbulletin.com

for the rich gestural and facial communication in Australian parliamentary politics (personal communication 2009).

Choosing music on their own was one of the innovative ideas tested at the Primate Foundation of Arizona. In the study already mentioned above (Howell *et al.* 2003) chimpanzees were given their own juke box with choices from Pavarotti singing to Indian flute playing. At the same time, they were also given little plastic pianos with four keys and it was found that they preferred to make their own music and totally ignored the music they could call up (Fritz 2004). The fact that they never seemed to tire of producing sounds themselves, in preference to listening to music, even of their own choosing, may also mean that chimpanzees like pushing buttons, just as children do or that a toy that is partially interactive retains a certain fascination.

Hence the evidence about the musical interests and capabilities of primates is by no means clear and, at times, contradictory. As far as the experiments explored it, any demonstrated interest need have nothing to do with aesthetic appreciation but with experience of sounds of the uterus and with particular frequencies and rhythms for which the auditory and perceptual apparatus of apes may be equipped, (that is, these may belong to the psychoacoustical auditory perception of animals and humans). Moreover, in attempts to assess the effect of music on animals it would also seem important to revisit the methods used. In quite a number of designs concerned with animal studies and music, 'music' is defined into broad categories (such as 'classical', 'easy listening', or 'modern') and one is therefore at a loss to assess to which of the many aspects of any type of music an animal or a group of animals may have responded. Finally, if an animal is to be tested for musical "interest" it is paramount, of course, to establish first its own hearing range and, more importantly, establish in which frequency range that species' own communication naturally occurs. For instance, testing music perception and music choices in marmosets (a New World Monkey) and in rats would be constrained by the fact that their own communication is largely in a range of frequencies well above those in which music is composed for humans, even though some important effects of classical music were recorded in rats (Lemmer 2008). Marmosets often communicate in a frequency range of 15–24 kHz (usually no longer audible to the human ear above 18kHZ) while most human music is located in frequency bands well below that (1–8kHz). It would also be important to consider structure and variability of their own vocalisations so that the presentation of human-specific/composed sounds fall at least within a range of sounds that are recognisable in specific contexts to the animals being studied. I would not yet judge primates as lacking an interest in music (McDermott, Hauser 2007) without a great deal of further testing, simply because even a supposedly soothing lullaby composed for humans, played, however, at a frequency range in which, for instance, marmosets may only express fear (such as low level "egg" calls; cf. Epple 1968) may well be very unattractive to the primate listeners and thus tell us little about the primate's ability to appreciate music.

Neuroaudiological research on a variety of mammals, such as gerbils (Schultze, Langner 1997), monkeys (Steinschneider *et al.* 1998; Fishman *et al.* 2001) and cats (Schreiner, Urbas 1986; Wallace *et al.* 1991) has long since established that the auditory cortex of mammals may contain representations of amplitude modulation, be capable of periodicity coding with different coding strategies for pitch and rhythm and, in monkeys, have different mechanisms subserving pitch perception.

However, in birds, a vital component is added and that is a feedback enabling auditory memory formation but also the capability of reproducing sounds, even if these may not be part of its own species-specific repertoire. It is the latter ability, shared with humans and some cetaceans, which would appear to be a vital precondition for complex music appreciation.

7. Music appreciation by animals?

Despite the substantial agreement by musicians that many songbirds have a musically pleasing song, it is more difficult to turn the argument around and ask whether birds themselves have a musical sense or whether the genetically fixed abilities serve specific functions and are not at all appreciated as song and music by the birds themselves. The memorising of song as mimicry, as described above for the magpie or in the example described by Erwin Tretzel (1998), suggest that part of some songbird's endowment is a sense of music or it could not even be reproduced. For instance, Tretzel described a case of a crested lark (*Galerida cristata*) in Bavaria that had imitated the whistled commands of a shepherd, which it then arranged in C major with "definite metric construction that revealed a sense for musical form and proportion" (Tretzel 1998). Humans that lack musical ability are not able to reproduce tunes accurately, let alone arrange them in a composition. Hence, expressed positively, the ability to do so should be regarded as evidence of musicality. We would certainly not hesitate to call the ability to produce a song in pitch musical ability if a human had done so.

Secondly, in some songbirds there arises the question why they continue to sing once the function of song has been fulfilled (such as attracting a mate). The point was recently made (Sound Archive British Library) that black birds (*Turdus merula*) and willow warblers (*Phylloscopus trochilus*) develop their song musically long after a mate has been secured and it was therefore not easy to argue other than to say that song was developed and sung for its own sake.

Moreover, there are songbirds that continue improvising and some of them, among them outstanding singers like the Australian magpie, continue to improve and find new ways of producing song they had never sung before. Normally, we would call this creativity if it applied to humans. The magpies I have recorded could sing over four octaves, use crescendos and decrescendos, use the style of cadenza in accelerated and retarded form (accelerando and ritardando) and have transitions of phrases and resolution of sounds that seem to have a musical logic which cannot be explained merely as accidents or faulty copying of a species' own template of species-specific calls. In other words, the question is whether birds and other vertebrates might have evolved an aesthetic appreciation of art or, specifically of music (Rogers, Kaplan 2006). There has been qualified support for this view from some scientists of birdsong from as long ago as the 1950s. William H. Thorpe, respected for his extensive work on birdsong, said in print (Thorpe 1958):

> The idea that bird song is often an expression of irrepressible joy can be supported with some plausible arguments, and is certainly not without some scientific justification. In so far as this may be true, the song of birds can be regarded as a first step towards true artistic creation and expression.

Such conclusions voiced by a scientist are warranted because a musical sense has been relatively difficult to assess. However, there is now some evidence from neuroscientific studies that singing may indeed be pleasurable to the singer by increasing dopamine levels in the brain and perhaps even inducing a state of euphoria (Sasaki *et al.* 2006; Feduccia, Duvauchelle 2008).

To test whether animals have an aesthetic appreciation of music might seem impossible but very basic tests have actually been conducted on human infants (Zentner, Kagan 1996, 1998; Trainor, Heinmiller 1998) and these designs can be translated into testing animals because they involve simple choice tests. Playback experiments can be instated and, in the case of music, alternative tunes be provided in different, but freely accessible locations. This is precisely what McDermott and Hauser (2004) did in a set of experiments with 6 adult cotton-top tamarins (*Saguinus Oedipus*). The researchers allowed the tamarins to choose between a number of sounds, paired for a) familiar/unfamiliar sounds b) loud noise/soft noise and c) consonant and dissonant sounds. The fist two sets of experiments (a-b) were conducted simply to establish whether the tamarins responded to auditory signals and whether their choices conformed to researcher expectations. They did. The main set of experiments, however, tested origins of musical preferences by choosing basic components such as consonant and dissonant sounds. Consonant sounds are pairs of tones (counting the fundamental frequencies) and these are related by simple integer ratios (such as perfect 5^{th}-c and g- interval ratio 3:2; or an octave - c and c - interval ratio 2:1). Results showed that the tamarins had no spontaneous preference for either pair of sounds, unlike their human counterparts, and they concluded that this discriminatory ability may well be unique to humans. The conclusion appears rather unjustified however, for reasons of differences in cultural appreciation of music even within human cultures and sensory perception.

Although it will be impossible here to go into the complexities of the theories of consonance and dissonance as developed by Pythagoras and, in modern times, by Helmholtz (1863) it is important to indicate that there are two ways of examining consonance/dissonance, one in a musical sense and the other in a sensory, psychoacoustic sense. The former is culturally determined and nurtured and thus depends on learning and exposure. The latter is culturally invariant, concerns isolated cords and is a sensory ability shared by humans and a wide variety of animals (rats: Fannin, Braud 1971; starlings: Hulse *et al.* 1995; Japanese macaques: Izumi 2000). In other words, as Fishman *et al.* (2001) found, sensory consonance/dissonance is likely to be shaped by relatively basic auditory processing mechanisms that are not music specific. Hence, testing these in isolation may not have told us all that much, certainly not about musical perception.

In summary, whatever the speculations might be, it seems relatively clear that auditory, psychoacoustic perceptual capabilities are more sophisticated in non-human mammals than once thought and that the musical abilities of songbirds and vocal learners, including parrots and parakeets, have been underrated because human culture had predefined such capabilities as uniquely human. This is circular thinking. A growing number of studies has begun to show that auditory discrimination of animals can be very complex and, that in some species, notably birds, discriminatory abilities of hearing are matched by output. Relating this to timing and melody is yet another daunting task awaiting researchers (Janata, Grafton 2003). Such musical production and musical talent, in some instances, may be suggestive of creativity and of an aesthetic sense of appreciation of music.

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Животные и музыка: культурные определения и сенсорные доказательства

Ранее считалось, что только у людей имеется способность к комплексной перцепции, но к настоящему времени научные исследования представили достаточно доказательств об обратном. Так, например, искусство и музыка считаются чем-то исконно человеческим, и научные доказательства также это подтверждают. Но так ли это? Искусство означает создание чего-то нового, и его наличие или отсутствие у животных очень трудно доказать. Более того, взаимоотношения между музыкой и языком до сих пор недостаточно исследованы на неврологическом и этологическом уровнях. Понятие «эстетической перцепции» еще более проблематично. Утверждается, что музыка может быть и миметической, но, тем не менее, птичье пение считается или чистым подражанием или мимикрией, т.е. в данном случае мы якобы имеем дело с так наз. «неосмысленным» действием (напр. попугаи, которые автоматически повторяют сказанное). В данной статье я привожу несколько примеров, где животные выказывают определенную восприимчивость к музыке и даже совершают музыкальные действия, и анализирую их поведение с этологической точки зрения. Все большее число научных исследований свидетельствует, что слуховая память и слуховые механизмы у животных не столь примитивны, как считалось ранее, и есть свидетельства, что у некоторых животных даже могут быть музыкальные способности.

Loomad ja muusika: kultuurilised määratlused ja sensoorne tõendusmaterjal

Varem arvati, et vaid inimestel on komplekse taju võime, kuid teaduslikud uurimused on praeguseks esitanud küllaldaselt tõendeid vastupidisest. Siiski peetakse kunsti ja muusikat enamasti millekski vaid inimestele eriomaseks ning tundub, et ka teaduslikud tõendid selle kohta on veenvad. Kuid on nad seda? Kunst tähendab millegi uudse loomist, mida

keskkonnas niisama ei sünniks, ja selle puudumist või olemasolu loomadel on väga raske tõestada. Veelgi enam, muusika ja keele soesed ei ole tänaseni ei neuroteaduslikul ega käitumuslikul tasemel veel piisavalt läbi uuritud. “Esteetilise tunnetuse” mõiste on aga veel problemaatilisem. Väidetavalt võib muusika mimeetiline olla, kuid linnulaulu kohta seda tavaliselt ei arvata ning seda peetakse kas pelgaks jäljendamiseks või mimikriks, misjuhul on tegemist “mõttevaba aktiga” (nt automaatselt öeldut järele korrutavad papagoid). Käesolevas artiklis esitan mitu näidet, kus loomad näitavad üles teatud vastuvõtlikkust muusika suhtes ning sooritavad isegi muusikalisi tegevusi, ning analüüsin neid näiteid etoloogilisest vaatevinklist. Järjest suurem hulk teaduslikke uurimusi tõendab, et loomade kuulmismälu ja kuulmismehhanismid ei ole nii lihtsakoelised, kui varem arvati, ning tõendusmaterjal osutab mõnel juhul isegi musikaalsete võimete olemasolule mõnedel loomadel.