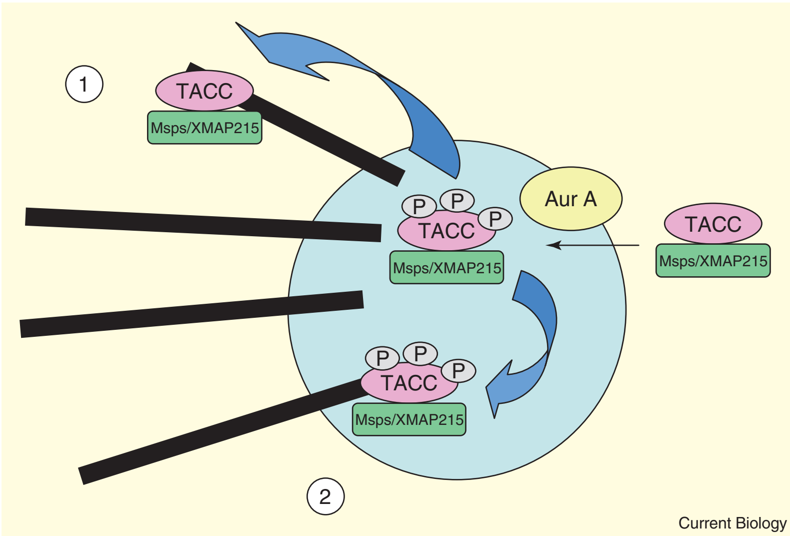

Figure 2. The function of Aurora A phosphorylation of TACC.

Microtubules (black lines) with minus ends focused at the centrosome (blue) and plus ends extending away. Phosphorylation by Aurora A (Aur A) recruits TACC, and consequentially its binding partner Msps/XMAP215 to the centrosome in mitosis. What is the function of the complex once at the centrosome? Targeting of TACC–Msps/XMAP215 to the centrosome may enhance the activity of Msps/XMAP215 in stabilising microtubule plus ends (1). In another model, the phosphorylation at serine 863/626 is proposed to allow the complex to stabilise the minus ends of microtubules nucleated at the centrosome (2).

shown to play a role in centrosome maturation [19]. Identifying other targets of mitotic kinases and evaluating their role in centrosome maturation remains a future challenge.

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Infant Learning: Music and the Baby Brain

When it comes to listening to music, infants literally have a more open mind than their parents. Studies which investigate listening behaviour of babies and adults have shown that, as we learn to discriminate the musical sounds in our own environment, we become less sensitive to those of other cultures.

Lauren Stewart[1] and Vincent Walsh[2]

The extent to which perceptual and cognitive capacities are innate and the extent to which they are shaped by the environment has long been a matter of debate. Two of the major test beds for establishing where the line between nature and nurture should lie have been studies of the effects of deprivation on the development of perceptual abilities in animals [1], and of language learning abilities in humans [2–4].

Perhaps one of the most extreme positions on this matter was held by the German Emperor, Frederick II (1194–1250). He believed that children raised in silence would grow up speaking German. Intent on proving that German was God's natural language, he tested this theory by raising children in silence, but found that the children did not acquire any language at all. In his defence, he did have a hypothesis, but his error was in employing a total rather than a partial deprivation design.

Fortunately, nature abounds with partial deprivation experiments which provide a more ethically constrained approach for asking questions concerning the extent to which our perceptual abilities are shaped by the environment. For instance, all children grow up hearing the sounds of the dominant language from their own environment rather than the sounds of any other of the world's languages. The work of Werker and colleagues [3,4] has shown that infants start life with the potential to acquire any language. They showed that up to the age of six months, Canadian infants raised in their English speaking homes can discriminate between different sounds within the Hindi language, even though these same differences are imperceptible to Canadian adults. By the end of the child's first year, however, the speech sounds in their own environment have begun to shape their perceptual abilities and their phonetic perception is transformed from 'universal' to 'language-specific' [3,4]. They are now better at discriminating between the sounds of their own language than those of another tongue. This is the first stage of becoming a native speaker — accurate perception of speech sounds precedes learning to produce them.

Just as different languages have both universal and culturally specific features, so too does music. Even in this world of musical pluralism one can experience music of different cultures as alien. While different languages use different sets of phonemes, the music of different cultures uses different musical scales and different ways of grouping events in time. Evidence has recently emerged that perceptual abilities are shaped by regularities in one's musical, as well as one's linguistic environment. By measuring perceptual discrimination of native and non-native sounds, in both infants and in adults, Lynch *et al.* [5] showed that infants have comparable pitch discrimination abilities in native and foreign melodic contexts, whereas adults exhibit superior skills when the melodic context is drawn from their own culture. Hannon and Trehub [6,7] have now examined perception of musical rhythm in infants and adults.

Hannon and Trehub [6,7] used preferential looking to test whether infants could discriminate rhythmic changes in native (in this case Western) and foreign (in this case Balkan) contexts: if an infant is presented with a stimulus a number of times, a change in the stimulus will, if recognized, cause the infant to spend longer looking at the source of the stimulus (hence the term preferential looking). The authors measured looking behaviour when a change in metre was introduced, either to Balkan music or to Western music. In musical terms, metre is the underlying pulse that differentiates, for instance, a waltz (**one**, two, three, **one**, two, three) from a march (**one**, two, three, four, **one**, two, three, four). In Balkan music, the metre is more complex, commonly consisting of cycles of five or seven pulses which give the music a distinctly irregular feel. Hannon and Trehub [6,7] played rhythms with either Balkan or Western metres to infants at 6 months or 12 months old and to Canadian adults.

The question was whether infants would spot the introduction of a change in both types of metre or whether they would only notice the change in the metre of their native culture. Hannon and Trehub [6,7] found that, while six months old infants responded to the introduction of a change to either the Balkan or the Western metre, twelve month old infants could only spot the change in their native, Western, metre. However, after a limited amount of exposure to Balkan music — two hours per day for two weeks — the 12 month old infants started to exhibit the same perceptual abilities as the younger subjects. Adults, on the other hand, failed to achieve native-like perception of Balkan metre after two weeks of listening (but see experiment 3 of [7] for an intriguing twist).

Echoing the claims of Frederick II, several modern day composers and musicologists contest that the Western musical system is the most natural one. But this would predict that our nervous systems are, regardless of our musical environment, more attuned to this system than other alternative ones. The work of Hannon and Trehub [6,7] provides compelling evidence to the contrary: as far as the brain is concerned, the most natural musical system is that which you have grown up hearing [2,8].

It is worth considering *why* the brain loses the ability to discriminate sounds. What could be the possible value of losing an ability? We can gain an insight into this by considering what a brain is for. We do not merely react to the outside world, we predict the state of the outside world based on previous experience. And we can best predict the future state of the world by accurately sensing and encoding its present and past states. This leads to the development of specific perceptual and neural sensitivities. Kittens reared with exposure to, for instance, only vertical edges never learn to perceive horizontal edges, nor do neurons in their visual cortex acquire any sensitivity to horizontal lines [9]. A kitten in a vertical world has no need to make predictions about horizontal lines, just as children reared in an entirely English-speaking environment have no need to make predictions about the sounds that are unique to the Hindi language.

This view has been formalised by the work of Saffran and colleagues [10,11]. Using strings of words and tones with infants as young as 8 months, they asked how much of our abilities are hardwired and independent of the environment and how much they are dependent on incoming information. Infants are sophisticated learners and it seems that, in language and music, their perceptual abilities are driven by innate mechanisms and learning by experience [8]. In both domains their learning is driven by the ability to extract statistical regularity from stimuli. Their responses to strings of words and sounds depend on the probability that one element of a string will follow another based on previous experience. In other words, it seems that the infants are making statistical inferences regarding the external world. What we now need to know is the extent to which the algorithms for extracting these regularities and building predictions are similar or even shared at some stages of development across domains such as music and language.

The issue is a deep one: We make predictions about visual objects, about others' emotional responses, about speech, music and the movement of objects in the world. The ground has shifted, then, from thinking about hardwired knowledge to thinking about hardwired ways of acquiring knowledge. Whether adults can recapture the early power of these learning mechanisms or whether more developed mechanisms can be adapted to learn things in different ways is also a question opened by this line of work.

What of the adults in Hannon and Trehub's experiment [7]? Would they have learned like the 12 month olds if they just had more time, or had they missed a critical time window after which they could not use the same learning mechanism? Again a halfway house might be the right place to stop: it may not be that the window is slammed shut, but that the adults continue to use predictive learning mechanisms only on a different, usually less rich and more fixed body of neural representations than are available to children. Adults can learn, of course, but they have to overcome the limitations set by their early experience and subsequent neural sensitivities. Balkan dance classes are now open for enrolment.

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Language Evolution: What Do Chimpanzees Have to Say?

Although unique in important ways, language shares some properties with other animal communication systems. Comparative analyses of nonhuman primate vocalizations can shed light on the evolution of language's special features.

Adam Clark Arcadi

Human language exhibits many unique features compared with the communication systems of other animals. The most obvious of these is its expressive power — the grammatical structure of language permits an infinite number of meaningful utterances [1]. Language behavior depends on the ability to model the mental states of conspecifics [2]. And the ability to produce and process speech involves specialized oro-facial, respiratory and perceptual abilities [3]. But these potentially unique features are also supported by capacities that show continuities with other species. For example, members of some species partition continuous acoustic variation categorically, exhibit lateralization in perceptual processing, require auditory feedback to learn species-specific vocalizations, engage in timed vocal interactions, vary call production depending on their audience, and encode information about external events in their calls [4].

Tracing the evolution of language requires clarifying the nature of continuities between human and nonhuman cognitive structures and communication systems in order to specify likely pathways by which language's unique features could have emerged [5]. One intriguing research area, explored by Slocombe and Zuberbühler [6] in a recent issue of *Current Biology*, concerns the possibility that some animal signals refer to objects or events external to the signaler, and may therefore be similar to words. The first evidence of such referential potential came from the observation that wild vervet monkeys (*Cercopithecus aethiops*) produce acoustically distinct alarm calls in response to their three most important predators —