Animal Behaviour 84 (2012) 293–294

Contents lists available at SciVerse ScienceDirect

Animal Behaviour

journal homepage: www.elsevier.com/locate/anbehav

In Focus

Featured Articles in This Month's *Animal Behaviour*

Birth Weight is Related to Learning Performance in Honeybee Foragers

The relationship between weight at birth and cognitive skills in later life is well established in humans. On average, lighter newborn babies score lower in cognitive skill tests as children or young adults than heavier babies. Surprisingly, the existence of such a relationship in nonhuman animals has hardly been investigated although it is likely to affect individual behavioural strategies and influence social and population dynamics.

Perhaps the first demonstration of a relationship between body weight at emergence and later cognitive skills in insects can be found in the present issue (pp. 305–308). Ricarda Scheiner (University of Potsdam, Germany) conducted experiments on honeybees because they are fast learners and typically live only for a few weeks. Earlier studies have demonstrated that honeybees emerging from their brood cells in the colony comb (Fig. 1) weigh between 81 and 151 mg. This variation is influenced by factors such as the queen's investment in the egg, brood care by nestmates, food availability, time of year and the presence of any diseases, to name a few. Scheiner investigated the relationship between this variation in birth weight and the variation in the learning performance of the same individuals 3 weeks later when a typical honeybee is a forager and at the peak of her learning performance.

The classic paradigm for measuring learning performance in honeybees is olfactory conditioning of the proboscis extension response. This reflex response is typically elicited when the antennae of a bee are touched with a droplet of sucrose solution whose concentration exceeds the individual's response threshold. Some bees (for example pollen foragers) are highly responsive and extend their proboscises when their antennae are touched with low sucrose solutions or even water. Others (for example nectar foragers) are more 'choosy' and only stick out their tongues when their antennae are stimulated with a high sucrose concentration.

Bees can be trained to extend their proboscises not only to sugar water but also to an odour when it is paired with a sucrose reward delivered to their proboscises. Earlier work has demonstrated that differences in olfactory learning abilities between bees from different genetic strains or different age groups could be ascribed reliably to differences in their responsiveness to sucrose. Highly responsive bees such as pollen foragers are much better learners than bees with a low responsiveness to sucrose, such as nectar foragers. Scheiner recorded the weight and the sucrose responsiveness at emergence for bees from the same colony and trained each of the 28 surviving bees to citral odour 3 weeks later. The sum of conditioned responses during the learning phase constituted the olfactory learning score for the bee.

Figure 1. A honeybee as she emerges from her brood cell. Photo: Ricarda Scheiner.

Scheiner found a significant positive correlation between the birth weight and the learning score of a bee 3 weeks later. Heavier newly emerged bees became better learners when they reached foraging age than lighter individuals. Sucrose responsiveness at emergence was also positively correlated with learning score in later life. Bees with a higher responsiveness at emergence were better at learning when they reached foraging age. Finally, sucrose responsiveness at emergence was positively correlated with birth weight. Bees with a higher sensory responsiveness tended to be heavier at emergence.

These results have important implications for the division of labour in honeybee societies because they suggest that heavier individuals would be better at foraging. Given earlier results that social insects are positively reinforced by the successful performance of a task, heavier workers are likely to exclude from foraging most of their lighter nestmates in the same age group at least for a while. More generally, if a similar relationship between birth weight and learning performance holds for other animals, it would facilitate the development of different behavioural strategies and specialization within collective behaviour such as foraging and group movement. This in turn suggests that any factor that influences the distribution of birth weight could have implications for social dynamics.

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0003-3472/$38.00
http://dx.doi.org/10.1016/j.anbehav.2012.06.020

Birdsong and Music

That birdsong is in some respects musical has long provided a rare point of agreement between the two cultures of the sciences and humanities. On the humanities side, composers from Mozart to Messiaen have responded to the perception that birdsong is musical by incorporating themes borrowed from birdsong in their compositions. On the scientific side, animal behaviourists, while agreeing with the general thesis, have laboured to specify the ways in which it is true: how exactly is birdsong similar to human music? A paper in this issue (pp. 309–313), by Marcelo Araya-Salas of the Universidad de Costa Rica, provides a noteworthy advance in the methods available for addressing this question.

The approach taken by Araya-Salas is to examine the intervals between the frequencies of successive notes in the songs of birds. In many cultures, including in the West, music is organized around scales, which are theoretical collections of notes, arranged in ascending or descending order that define a mode or tonality. Organization around a scale means that out of the continuous range of possible frequencies, musicians choose a defined small set of frequencies to use in a given piece. Three common scales in Western practice are the chromatic scale, which has 12 notes in one octave (or doubling of frequency), the diatonic, which has seven notes, and the pentatonic, which has five. Araya-Salas compares the intervals in songs of birds to the intervals in all three of these scales.

To make the test, songs are needed in which the elements are principally pure tones, so that a single frequency can be assigned to each. Araya-Salas found such songs (Fig. 2) in the nightingale wren, a denizen of Central America and Mexico. For a large sample of the songs of this species, Araya-Salas measured the fundamental frequency of each note, and calculated the ratio of the frequencies of successive notes. Then for each of the three musical scales, he estimated the distance between each observed ratio and the harmonic interval ratio to which it was closest. These distances were then compared to a uniform distribution around harmonic intervals. If the observed distances from the wren songs were consistently lower than the uniform distributions, this would be evidence that nightingale wrens conform to human musical scales.

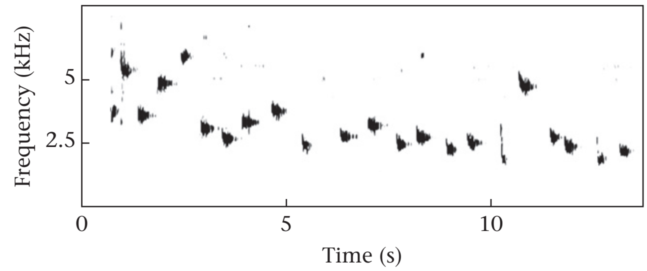

Figure 2. A spectrogram of a nightingale wren song. Musicality of such a song can be assessed by comparing the intervals between successive elements to the intervals between notes in Western scales. Figure courtesy of M. Araya-Salas.

In the event, only five of 81 nightingale wrens had distances to harmonic intervals that were significantly smaller than expected from a uniform distribution. Three of these birds conformed to the pentatonic scale, two to the chromatic scale and one to the diatonic scale. The great majority of the wrens, 76 of 81, conformed to none of the musical scales. By contrast, when the same method was applied to 24 melodies from Western classical, jazz and popular music played on continuous pitch instruments such as cello or trombone, all 24 had distances that were significantly closer than expected to the chromatic scale; 21 were also significantly closer than expected to the pentatonic and diatonic scales.

The conclusion that the songs of nightingale wrens are not musical by this measure may be viewed as disappointing, but perhaps would not be surprising to anyone who has listened to the songs of this species. The great contribution of Araya-Salas's study is in providing an objective method for examining musicality that can be applied to any bird species whose songs contain series of pure tones. Once the method has been applied to many species, we may arrive at a conclusion already suspected by those who have listened to nightingales and wood thrushes on the one hand and to yellow-headed blackbirds and common grackles on the other: that birdsong is musical except when it is not.

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