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Chickens' brains, like ours, are lateralized

Commentary on **Marino** on *Thinking Chickens*

Lesley J. Rogers
School of Science and Technology
University of New England, Armidale

Abstract: This commentary draws attention to yet another attribute that has been instrumental in demonstrating the cognitive abilities of domestic chicks: lateralization of brain function. The discovery of lateralization in domestic chicks was part of the first evidence showing that humans are not unique in this respect. The effects on cognitive ability of sensory stimulation in critical stages of development have implications for the welfare of chicks, as well as other species.

Lesley J. Rogers is Professor Emeritus at the University of New England, Australia, and a Fellow of the Australian Academy of Science. She has studied animal behaviour for many years and is well-known for her research on development and lateralized behaviour in the chicken. She has also published on welfare in domestic chickens and other species. **http://www.une.edu.au/staff-profiles/science-and-technology/lrogers**

More than twenty years ago, I concluded a book on the development of brain and behaviour in the domestic chicken with, "In my opinion, there is a demand to understand the cognitive abilities of the domestic chicken above all avian species, because this bird is the one we have singled out for intensive farming. *Gallus gallus domesticus* is indeed the avian species most exploited and least respected" (Rogers, 1995, p. 221). Since then there has been much fascinating research on the cognitive abilities of chicks, and also other avian species. Marino's (2017a,b) review covers much of the recent evidence. I agree with the target article's plea for recognition that chickens are no less cognitively complex than many other avian or mammalian species. However, no mention was made of the fact that chicks have lateralized brains, referring to the fact that they process information differently in each brain hemisphere and respond in different ways to the same stimulus depending on whether they see it with their left or right eye, hear it with their left or right ear, or smell it via their left or right nostril.

Brain lateralization was once thought to be a unique characteristic of humans and an attribute contributing to our cognitive superiority (Corballis, 2014) but that idea was overthrown by the discovery of lateralization in nonhuman species, the chick being one of three species in which this was first discovered (Rogers and Anson, 1979, and see summary in Rogers et al., 2013, and MacNeilage et al., 2009). Now we know that brain lateralization is present in a wide range of vertebrate species and it has even been found in some invertebrates (Frasnelli et al., 2012). Its ubiquity shows that it is not the defining characteristic of human, or indeed mammalian, superiority. Domestic chicks have held a paramount place in the research showing this. They have also given us some evidence for the function of brain lateralization: chicks with lateralized brains can attend to at least two visual tasks simultaneously, whereas chicks not lateralized for processing visual information are unable to do this (Rogers et al., 2004). The tasks used in these tests were searching for food grains scattered on a background of small pebbles and detecting a predator moving overhead. In lateralized chicks, the left hemisphere is specialized to carry out the former task and the right hemisphere to carry out the latter task. Chicks lacking this lateralization are slow to detect the predator while they are searching for food and, once they have seen it, they become so distracted that they are unable to find the food grains and avoid pecking at the pebbles. Subsequent studies on fish have found similar results (Dadda and Bisazza, 2006; see also Güntürkün and Ocklenburg, 2017). This is but one example of the important role of the domestic chick in research on lateralization and cognition (see also Vallortigara, 2000, and Vallortigara and Rogers, 2005).

Experience during development has important effects on lateralization and cognition. In fact, lateralization of visual processing depends on the exposure of chick embryos to light for a short period during the final days of incubation: Chicks hatched from eggs incubated in the dark are not lateralized for the tasks mentioned above, or for attack and copulation responses (Rogers, 1982). They are also more fearful and form less stable social hierarchies (summarised in Rogers, 2008, 2012). This demonstrates that sensory stimulation during critical stages of development has major effects on cognitive ability. It also contributes to our understanding of individual differences in cognition and has important implications for the welfare of *Gallus gallus domesticus* (discussed further in Rogers, 2010).

Depending on early experience, as well as on the levels of sex and stress hormones circulating before hatching (see Rogers et al., 2013), the chicken's brain subdivides its cognitive processing so that the right hemisphere (left eye) is specialised to detect unexpected stimuli and the left hemisphere (right eye) to categorise stimuli depending on past experience. The right hemisphere has broad spatial attention and the left hemisphere focussed attention (Tommasi and Vallortigara, 2007). Not only are these asymmetries essential to cognition in chicks but also, they are similar to the asymmetries found in other avian and mammalian species.

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