More than nothing: Behavioural and neuronal correlates of numerosity zero in the carrion crow

Maximilian Kirschhock
Institute of Neurobiology, University of Tübingen, Tübingen, Germany

Helen M Ditz
Institute of Neurobiology, University of Tübingen, Tübingen, Germany

Andreas Nieder
Institute of Neurobiology, University of Tübingen, Tübingen, Germany

Abstract

Although representations of countable numerosities, i.e., number of elements in a set, have been deciphered down to single neurons, the neuronal representations of numerosity zero (empty set, ES) remain largely unknown. We probed the behavioural and neuronal markers of numerosity zero in carrion crows. Crows were trained on a numerosity discrimination task with small numerosities including the ES. Behavioural performance functions exhibited a numerical distance effect in one crow, suggesting the quantitative handling of empty set alongside countable numerosities. Single-cell recordings in the nidopallium caudolaterale (NCL) revealed a great proportion of neurons tuned to the ES. NCL neurons integrated the empty set in the neural number line, shown by neuronal distance and size effects. Neuronal representations were behaviourally relevant. These findings mark the first account of neuronal ES representations outside the mammalian taxon. They underline the pivotal role of the NCL not only for numerical-, but general cognition.