Hive minded: like neurons, honeybees collectively integrate inhibitory stop signals to efficiently regulate forager recruitment

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Social insects, such as ants and honeybees, and neurons in the brain, display collective decision-making, whereby groups of individuals or neurons collectively determine which stimuli to respond to and how to respond, yet crucially, no individual is aware that a decision is taking place. Honey bees rely on collective decision making when allocating foragers to the most profitable food source, based on positive reinforcement of the waggle dance. Here we examined whether negative feedback, via the audible stop signal, is being used at a collective level to more efficiently allocate of foragers to profitable food sources. We recorded feeder visits, waggle dances, waggle dance pheromones, and stop signals for bees that were marked and trained to a high 2.5 M sucrose solution feeder that was then switched to a poor food quality of 0.75 M sucrose solution. There was a burst of stop signals directed towards waggle dancing bees mostly from untrained individuals (contra signaling) right after the feeder switch, which then quickly returned back to baseline levels. Following this burst, waggle dancing (recruitment) and waggle dance pheromones continually decreased, but surprisingly previously trained bees visited the poor quality feeder more frequently. We then adjusted a neuron firing rate model with a sigmoidal gain-curve in order to model the dynamics of foragers waggle dancing for one of two potential food sites. We found that the addition of a brief spike of stop signals was enough to reproduce the dynamics of the focal population shown in the experiment. Our results suggest that: (1) honey bees can regulate foraging recruitment on a collective level independent from foraging frequency that appears to be regulated at an individual level and the two are not necessarily correlated, and (2) neural networks and honeybee colonies utilize similar network properties when making a decision.