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ARBEITSVORHABEN

Hive Mind: the Intelligence of Honeybees, Bumblebees and Their Relatives

My main goal is to write a book entitled as above.

People have long been fascinated by the immense variety of instinctual behaviours that are required so that a 60,000-individual-strong beehive can operate like a smoothly oiled machine. While people accept that the neural templates for dozens of complex instinctual behaviours can be instantiated in a miniature brain such as a bee's, the common perspective is that there is insufficient room for intelligence in an insect head.

It is now clear that this notion is no longer tenable. Foraging bees navigate successfully over miles, recalling the location of their hive and multiple foraging destinations. In visiting flowers, they remember the most profitable species by their colours, patterns and scents, but studies of the cognition of bees in the past 20 years have substantially challenged the notion that simple associations explain how a bee interacts with its environment. Bees can count landmarks, recognise human faces and solve basic versions of the travelling salesman problem. Just last year, it was discovered that bees can solve cognitive problems once thought to be the domain of primates, e.g. pulling a string to gain access to reward and simple tool-use problems. An important shift in perspective has been generated by the observation that bees' intelligence is highly individually variable. The existence of such "personality"-like phenomena has important consequences for the organisation of labour in the hive, and variance between hive "personalities" directly affects fitness in the economy of nature.

The core of the book will be to describe these recent research breakthroughs and their significance across disciplines, and in a manner that is intelligible not just to scientists, but also to the scientifically interested layman. The findings above have wide-ranging implications for understanding cognition in animals more generally, its evolution and its neural-computational underpinnings. They call into question the notion that large brains are required for intelligent behaviour and open future avenues of research exploring the neural hardware mediating cognition in relatively small nervous systems. Insect nervous systems have several orders of magnitude fewer neurons than vertebrates, meaning that we can give crisp mechanistic explanations for relatively complex behaviour. Recent neurobiological research and modelling has shown that advanced cognitive capacities naturally emerge from exceptionally small neural circuits. This raises the question of what big brains are for - and the answer might well be that they do not necessarily mediate higher intelligence - but just more memory storage space, rather than more complex or faster computations. The microcomputer that is the bee brain thus offers potentially extremely efficient and elegant biological inspirations for information-processing in real computers.

Recommended Reading

Chittka, L. and Niven, J. (2009). Are bigger brains better?" Current Biology 19: R995-R1008.
Perry, C. J., Baciadonna, L. and Chittka, L. (2016). "Unexpected rewards induce dopamine-dependent positive emotion-like state changes in bumblebees." Science 353 (6307): 1529-1531. doi: 10.1126/science.aaf4454.
Loukola, O. J., Perry, C. J., Coscos, L. and Chittka, L. (2017). "Bumblebees show cognitive flexibility by improving on an observed complex behavior." Science 355 (6327): 833-836. doi: 10.1126/science.aag2360.

DIENSTAGSKOLLOQUIUM, 12.12.2017

Der Verstand der Bienen

Bienen haben ein vielfältiges Triebrepertoire, das dem der meisten Wirbeltiere an Komplexität überlegen ist. Dieses Repertoire ermöglicht die soziale Organisation von Leistungen wie der Konstruktion von sechseckigen Waben, eines genauen Klimaregelungssystems in ihrer Behausung, der Bereitstellung von Rohstoffen, die auf einem großen Gebiet geerntet werden müssen (Nektar, Pollen, Harz und Wasser), sowie ein symbolisches Kommunikationssystem, das ihnen ermöglicht, Stockgenossinnen über den Standort dieser Rohstoffe zu informieren. Die Vielfalt der Bieneninstinkte stand jedoch traditionell im Widerspruch zur Vorstellung, dass die kleinen Gehirne der Bienen wenig Verhaltensflexibilität und Lernverhalten zulassen. Diese Ansicht wurde in den letzten Jahren jedoch gekippt, als man entdeckte, dass Bienen Fähigkeiten wie Zählen, Aufmerksamkeit, einfachen Werkzeuggebrauch, Lernen durch Beobachtung und Metakognition (das Wissen ihres eigenen Wissens) zeigen. So diskutieren nun einige Wissenschaftler, ob es möglich ist, dass Bienen ein Bewusstsein haben. Diese Beobachtungen werfen die naheliegende Frage auf, wie solche Fähigkeiten auf neuronaler Ebene in den Miniaturgehirnen von Insekten implementiert werden können. Wir müssen die neuronalen Schaltkreise verstehen, nicht nur die Größe der Gehirnregionen, die diesen Fähigkeiten zugrunde liegen. Neuronale Netzwerkanalysen zeigen, dass kognitive Merkmale, die man bei Insekten findet - wie beispielsweise Prozesse, die Zahlenverständnis, Aufmerksamkeits- und Kategorisierungsfähigkeit ähneln - möglicherweise nur eine sehr begrenzte Zahl an Neuronen erfordern. Mit computergestützten Modellen des visuellen Systems der Bienen untersuchen wir, ob sich scheinbar fortgeschrittene kognitive Fähigkeiten automatisch aus den Eigenschaften relativ grundlegender neuraler Prozesse im visuellen Verarbeitungsbereich des Insektengehirns und ihrer Verbindung mit den Pilzkörpern, Lernzentren höherer Ordnung, ergeben könnten.

Chittka, Lars (Leiden,2020)

Selective interspecific information use in the nest choice of solitary bees

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1690247150

Chittka, Lars ([London],2019)

Randomly weighted receptor inputs can explain the large diversity of colour-coding neurons in the bee visual system

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1670524817

Chittka, Lars (2019)

Harmonic radar tracking reveals random dispersal pattern of bumblebee (Bombus terrestris) queens after hibernation

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1665058633

Chittka, Lars (2019)

How foresight might support the behavioral flexibility of arthropods

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1665057688

Chittka, Lars (2019)

A spatial network analysis of resource partitioning between bumblebees foraging on artificial flowers in a flight cage

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1665045892

Chittka, Lars (Lausanne,2018)

Bumblebees express consistent, but flexible, speed-accuracy tactics under different livels of predation threat

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1694306801

Chittka, Lars (Lausanne,2018)

Cognitive aspects of comb-building in the honeybee?

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=168851404X

Chittka, Lars (Lausanne,2018)

The importance of spatial visual scene parameters in predicting optimal cone sensitivities in routinely trichromatic frugivorous old-world primates

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1670760200

Chittka, Lars (2018)

Adaptive learning in non-social insects : from theory to field work, and back

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=166505459X

Chittka, Lars (2018)

Bee-brained

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1041167784