
《自然》（20250918出版）一周论文导读

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Experimental demonstration of logical magic state distillation

逻辑魔态蒸馏的实验演示

▲ 作者：Pedro Sales Rodriguez, John M. Robinson et al.

▲ 链接：

<https://www.nature.com/articles/s41586-025-09367-3>

▲ 摘要：

在此，我们在中性原子量子计算机上实现了逻辑量子比特的魔态蒸馏实验。我们采用动态可重构架构对多个逻辑量子比特的并行编码与量子操作。

通过基于d=3和d=5色码的编码方案，实验观察到输出魔态的逻辑保真度较输入逻辑魔态显著提升。这些实验证明了通用容错量子计算的关键核心组件，标志着向大规模逻辑量子处理器迈出重要一步。

▲ Abstract：

Here we present the experimental realization of magic state distillation with logical qubits on a neutral-atom quantum computer. Our approach uses a dynamically reconfigurable architecture to encode and perform quantum operations on many logical qubits in parallel. We demonstrate the distillation of magic states encoded in d=3 and d=5 colour codes, observing improvements in the logical fidelity of the output magic states compared with the input logical magic states. These experiments demonstrate a key building block of universal fault-tolerant quantum computation and represent an important step towards large-scale logical quantum processors.

生物学Biology

Supervised learning in DNA neural networks

DNA神经网络中的监督学习

▲ 作者：Kevin M. Cherry Lulu Qian

▲ 链接：

<https://www.nature.com/articles/s41586-025-09479-w>

▲ 摘要：

在此，我们首次实现DNA分子在体外自主执行监督学习的功能，该系统能够通过输入分子与预期响应分子的示例完成模式分类学习。我们展示了一个经过训练的DNA神经网络，成功实现对

三组不同100位模式的分类任务——该网络将训练数据直接整合为分子浓度记忆，并利用这些记忆处理后续测试数据。

我们的研究表明分子电路能够学习比简单自适应行为更复杂的任务，为在生物医学和软材料等众多物理系统中开发具有嵌入式学习与决策能力的分子机器开辟了新途径。

▲ Abstract :

Here we show that DNA molecules can be programmed to autonomously carry out supervised learning in vitro, with the system learning to perform pattern classification from molecular examples of inputs and desired responses. We demonstrate a DNA neural network trained to classify three different sets of 100-bit patterns, integrating training data directly into memories of molecular concentrations and using these memories to process subsequent test data. Our work suggests that molecular circuits can learn tasks more complex than simple adaptive behaviours. This opens the door to molecular machines capable of embedded learning and decision-making in a wide range of physical systems, from biomedicine to soft materials.

A gut sense for a microbial pattern regulates feeding

肠道对微生物模式的感知调控摄食行为

▲ 作者 : Winston W. Liu, Naama Reicher et al.

▲ 链接 :

<https://www.nature.com/articles/s41586-025-09301-7>

▲ 摘要 :

在此，我们展示了在小鼠结肠中，微生物界普遍存在的鞭毛——这一跨菌门统一特征——能刺激PYY标记的结肠神经鞘细胞中的Toll样受体5（TLR5）。这种刺激促使PYY释放至表达NPY2R的迷走神经结状神经元，从而调控摄食行为。

敲除该类细胞TLR5的小鼠相较于对照组摄食量增加，且体重增长更显著。我们发现鞭毛蛋白并不直接作用于神经，而是通过刺激结肠腔内的神经鞘细胞，经由肠—脑感觉神经环路抑制进食。

此外，鞭毛蛋白的摄食调控作用独立于免疫应答、代谢变化或肠道菌群存在。这种感知机制使宿主能根据常驻微生物的分子模式调整行为，我们将这种介于生物群与大脑之间的感知系统称为神经生物感应。。

▲ Abstract :

Here we show that in the mouse colon, the ubiquitous microbial pattern flagellin—a unifying feature across phyla—stimulates Toll-like receptor 5 (TLR5) in peptide YY (PYY)-labelled colonic neuropod cells. This stimulation leads to PYY release onto NPY2R vagal nodose neurons to regulate feeding. Mice lacking TLR5 in these cells eat more and gain more weight than controls. We found that flagellin does not act on the nerve directly. Instead, flagellin stimulates neuropod cells from the colonic lumen to reduce feeding through a

gut – brain sensory neural circuit. Moreover, flagellin reduces feeding independent of immune responses, metabolic changes or the presence of gut microbiota. This sense enables the host to adjust its behaviour in response to a molecular pattern from its resident microorganisms. We call this sense at the interface of the biota and the brain the neurobiotic sense.

动物学Zoology

Flourishing chemosynthetic life at the greatest depths of hadal trenches

在海沟最深处蓬勃生长的化能合成生命

▲ 作者：Xiaotong Peng, Mengran Du et al.

▲ 链接：

<https://www.nature.com/articles/s41586-025-09317-z>

▲ 摘要：

在此，我们报告了在“奋斗者”号载人深潜器对千岛—堪察加海沟和阿留申海沟西部的科考中，发现的目前已知地球上分布最深、规模最大的化能合成生命群落。这些以管栖多毛类和双壳类生物为主导的群落绵延2500公里，分布于5800米至9533米的深渊带。

同位素分析表明，富含硫化氢和甲烷的流体沿海沟沉积层深处的断层上涌，其中甲烷由沉积有机质经微生物作用产生，为这些群落提供了能量来源。鉴于其他超深渊海沟具有类似地质特征，此类化能合成群落的分布范围可能远超既往认知。这些发现对现有极端环境生命模型和深海碳循环理论提出了重要挑战。

▲ Abstract：

Here we report the discovery of the deepest and the most extensive chemosynthesis-based communities known to exist on Earth during an expedition to the Kuril – Kamchatka Trench and the western Aleutian Trench using the manned submersible Fendouzhe. The communities dominated by siboglinid Polychaeta and Bivalvia span a distance of 2,500 km at depths from 5,800 m to 9,533 m. These communities are sustained by hydrogen sulfide-rich and methane-rich fluids that are transported along faults traversing deep sediment layers in trenches, where methane is produced microbially from deposited organic matter, as indicated by isotopic analysis. Given geological similarities with other hadal trenches, such chemosynthesis-based communities might be more widespread than previously anticipated. These findings challenge current models of life at extreme limits and carbon cycling in the deep ocean.

信息技术Information Technology

DeepSeek-R1 incentivizes reasoning in LLMs through reinforcement learning

DeepSeek-R1通过强化学习激励大语言模型推理能力提升

▲ 作者：Daya Guo, Dejian Yang et al.

▲ 链接：

<https://www.nature.com/articles/s41586-025-09422-z>

▲ 摘要：

在此，我们展示了通过纯强化学习（RL）可有效激发大语言模型（LLMs）的推理能力，无需依赖人类标注的推理轨迹。所提出的强化学习框架促进了高级推理模式的自然涌现，包括自我反思、结果验证与动态策略调整等能力。

经此训练的模型在数学计算、编程竞赛和STEM领域等可验证任务中表现出卓越性能，显著超越基于人类示范的传统监督学习方法。更重要的是，这些大规模模型展现的涌现式推理模式，可系统性地用于指导并增强小型模型的推理能力。

▲ Abstract：

Here we show that the reasoning abilities of LLMs can be incentivized through pure reinforcement learning (RL), obviating the need for human-labelled reasoning trajectories. The proposed RL framework facilitates the emergent development of advanced reasoning patterns, such as self-reflection, verification and dynamic strategy adaptation. Consequently, the trained model achieves superior performance on verifiable tasks such as mathematics, coding competitions and STEM fields, surpassing its counterparts trained through conventional supervised learning on human demonstrations. Moreover, the emergent reasoning patterns exhibited by these large-scale models can be systematically used to guide and enhance the reasoning capabilities of smaller models.

A generic non-invasive neuromotor interface for human-computer interaction

通用型非侵入式神经运动人机交互接口

▲ 作者：Patrick Kaifosh, Thomas R. Reardon CTRL-labs at Reality Labs

▲ 链接：

<https://www.nature.com/articles/s41586-025-09255-w>

▲ 摘要：

在此，我们开发了一种通用型非侵入式神经运动接口，可通过表面肌电图（sEMG）解码实现计算机输入。我们研制了一种高灵敏度、易穿戴的sEMG腕带设备，并建立了从数千名受试者收集训练数据的可扩展基础设施。这些数据支持我们开发出具有跨个体泛化能力的通用sEMG解码模

型。

测试用户展示了在连续导航任务中达到每秒0.66次目标选择的闭环手势解码中位性能，在离散手势任务中实现每秒0.88次手势识别，并以每分钟20.9个单词的速度完成手写输入。我们表明，通过个性化定制sEMG解码模型，手写识别性能可进一步提升16%。据我们所知，这是首款具备开箱即用跨个体泛化能力的高带宽神经运动接口。

▲ Abstract :

Here, we describe the development of a generic non-invasive neuromotor interface that enables computer input decoded from surface electromyography (sEMG). We developed a highly sensitive, easily donned sEMG wristband and a scalable infrastructure for collecting training data from thousands of consenting participants. Together, these data enabled us to develop generic sEMG decoding models that generalize across people. Test users demonstrate a closed-loop median performance of gesture decoding of 0.66 target acquisitions per second in a continuous navigation task, 0.88 gesture detections per second in a discrete-gesture task and handwriting at 20.9 words per minute. We demonstrate that the decoding performance of handwriting models can be further improved by 16% by personalizing sEMG decoding models. To our knowledge, this is the first high-bandwidth neuromotor interface with performant out-of-the-box generalization across people.

作者：李言 来源：科学网微信公众号

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