is almost always caused by mutations in the *MECP2* gene[7]. Mice that have mutations in this gene show intellectual disability and mimic other key features of Rett syndrome, including impairment of motor skills and breathing control, and other neurological effects.

Hao *et al.* targeted DBS to the fimbria–fornix (Fig. 1), an intersection of nerve fibres that connects the hippocampus regions in each brain hemisphere (which are involved in certain forms of memory), both with each other and with other brain structures. The authors stimulated the fimbria–fornix of mice for two weeks and performed sensitive behavioural tests three weeks later. In normal mice that received DBS, there was a modest improvement compared with unstimulated mice in forms of learning and memory that are dependent on hippocampal function. Crucially, however, Rett-syndrome mice showed a dramatic improvement in hippocampus-dependent spatial learning and contextual fear memory. For both of these cognitive functions, behavioural performance in Rett-syndrome mice was restored to levels indistinguishable from those seen in normal, unstimulated animals.

These exciting findings could have major implications, but caution is required when extrapolating from cognitive tests in mice to the treatment of humans with intellectual disability. The tests used in animal models tend to be very specific, and it is unclear to what extent cognitive functions measured in rodents, such as ability to perform in a maze test, correspond to the cognitive domains that need treating in people. Moreover, behavioural tests in rodents can be poor predictors of human responses. This is particularly true for tests of drugs that enhance cognition — there is a high attrition rate for these drugs, because many that have shown promise in cognitive tests in animals lacked efficacy in human clinical trials.

The authors' results indicate that the effects of fimbria–fornix DBS are restricted to specific cognitive domains, with no improvement in other Rett-syndrome-like symptoms, such as altered anxiety, pain sensitivity or motor control. This is perhaps not surprising, given the brain region targeted by Hao and colleagues. However, DBS has been effective in lessening these other defects, especially in motor disorders. So it is possible that altering the position of electrodes may ameliorate other symptoms of Rett syndrome.

The next steps are to analyse the mechanism by which DBS improves learning in Rett-syndrome mice, and to determine whether similar effects can be expected in people with Rett syndrome or other forms of intellectual disability. The main way in which memory traces are thought to be encoded and stored is through changes in the strength of the synaptic connections between neurons, and disruption of this synaptic plasticity is a hallmark of many neurodevelopmental disorders. Hao *et al.* show that long-term potentiation — a particular type of synaptic plasticity that is required for certain forms of learning — is impaired in the hippocampus of Rett-syndrome mice but is boosted by DBS. Furthermore, DBS also enhanced the generation of neurons from stem cells that are resident in the hippocampus. Whether these effects are simply biomarkers of stimulation in hippocampal neural circuits, or whether they truly contribute to the procognitive action of DBS, awaits further experimentation.

Hao and colleagues' study is meaningful because finding effective treatments for the core symptoms of childhood intellectual-disability disorders is one of the great unmet medical challenges in contemporary neuroscience. Genetic studies indicate that a multitude of molecular abnormalities can cause intellectual disability[1,8], which probably explains the prevalence of these disorders and makes finding treatments so difficult — it is hard to envisage a drug therapy that would be effective for many forms of intellectual disability.

Although DBS is invasive, it is considered to be safe and controllable[4]. Whether or not DBS can be widely applied to intellectual-disability disorders, and whether it may one day constitute a common treatment option, remains to be seen. Nonetheless, the current study will doubtless provide impetus for future studies in this direction. ■

Stuart R. Cobb *is at the Institute of Neuroscience and Psychology, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow G12 8QQ, UK.*
e-mail: stuart.cobb@glasgow.ac.uk

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NANOPHYSICS

Microscopic friction emulators

Cold ions sliding across periodic energy-potential patterns formed by lasers have been used to elucidate the physics of dry friction between crystals. Experiments with no more than six ions suffice to explore a vast domain of frictional forces.

DAVIDE MANDELLI & ERIO TOSATTI

The study of friction is a centuries-old, but still vibrant, subject. The archetypal friction problem of dry sliding between solids concerns the force that resist the relative lateral motion of crystal surfaces in contact. In this case, the periodic spacing of the atoms in the crystals eliminates the complexity introduced by the ill-defined nature of ordinary, non-crystalline surfaces. Studies of nanometre-scale systems through tip-based instruments, non-equilibrium theory, computer simulations and, most recently, the use of artificial friction emulators have revived this topic[1]. Writing in *Science* and in *Nature Physics*, respectively, Bylinskii *et al.*[2] and Gangloff *et al.*[3] follow up earlier theoretical suggestions[4–6], and present friction emulators formed from trapped ions that slide over optical lattices — periodic energy potentials created by the interference of laser beams.

Although dry sliding is a well-defined problem, sufficient inroads have not been made into it. This is because suitable experimental systems are scarce, but also because the theory of frictional dynamics is mostly restricted to computer simulations, which are vivid, but incomplete, representations of the complex phenomenon of friction between real solid interfaces. Much of scientists' understanding of friction relies on apparently trivial, one-dimensional periodic potential models, such as the Prandt–Tomlinson (PT) single-slider[7] and the Frenkel–Kontorova (FK) sliding-chain descriptions[8].

The PT model illustrates the switch from stick–slip friction — for example, that arising from the intermittent motion of chalk on a blackboard — to smooth sliding as surface corrugation decreases. The same model also describes the passage from large friction at high sliding speeds to vanishingly small friction (thermolubricity) at very low speeds[7,9]. In the special case of mismatched lattices, the FK model describes the transition between frictionless (superlubric) motion and pinned frictional sliding (a regime in which it takes a large force to dislodge the lattice and nudge it forward).

What these models have achieved is a description of how properties such as corrugation, temperature, velocity and lattice-matching

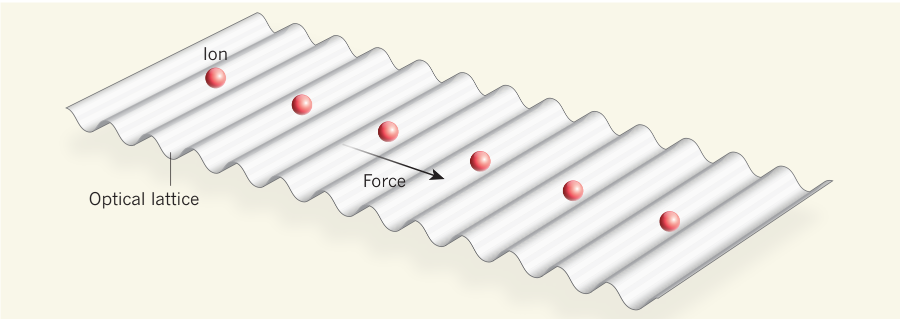

Figure 1 | Ion chain trapped in a lattice. Bylinskii *et al.*[2] and Gangloff *et al.*[3] investigate the friction that arises when one or a few ions are forced to slide across optical lattices in which a corrugated energy potential is created by counter-propagating lasers. These simple experiments have provided benchmark tests of long-standing frictional models for sliding crystal surfaces. (Adapted from ref. 2.)

of materials in contact might influence and determine friction. In principle, the understanding gained from the models could allow researchers to control frictional forces, something desirable in many practical settings. However, despite the firm theoretical background[7–9], neither of these models has been tested experimentally. That is what emulators are meant to do.

The emulators of Bylinskii *et al.* and Gangloff *et al.* are based on short chains of trapped ionized atoms that, under the influence of an electric field, are forced to slide across a laser-generated optical lattice (Fig. 1). These techniques may seem arcane, yet they are accurate and powerful, because parameters such as the temperature, atom velocity and spacing, chain length and the amplitude of the lattice's potential can be flexibly adjusted across a vast range of values.

In this vein, Gangloff and colleagues present experiments involving one or two ions that slide across an optical lattice, a set-up that emulates the PT model to near perfection. In their single-ion set-up, the authors demonstrate that, even at microkelvin temperatures, there is a speed below which the friction between the sliding ion and the lattice vanishes — in agreement with thermodynamics. For higher speeds, stick–slip friction ensues and rises by more than a factor of 100 with increasing speed. No experiment involving real crystals can span this range of friction and speed. Although many of the authors' findings had been known from numerical simulations[7], their emulator is superior to those — for example, it reproduces the theoretically expected dependence of friction on velocity[10] much more accurately.

To adequately emulate the FK model, one would need an infinitely long ion chain instead of a single ion. All that Bylinskii *et al.* use are short chains of two to six ions sliding across an optical lattice — so is this just a baby step towards that goal? Not quite. By adjusting the distances between the ions, the authors tune the amount of mismatch between the chain and the corrugation of the lattice's periodic potential, and produce a dramatic effect on the friction that they measure.

Starting from large friction for perfect chain–lattice matching, Bylinskii and colleagues observe a rapid decrease in friction as they increase a parameter that controls the amount of chain–lattice mismatch. This trend reflects the evolution from strong pinning friction towards lubricity or even superlubricity. Superlubricity, however, is reached only when the intensity of the lattice's potential falls below the value that demarcates the transition (known as the Aubry transition) between frictionless and pinned frictional sliding[11].

Studies of the Aubry transition are of interest, as has been suggested by theoretical studies of systems with long ion chains[4,12]. It will be even more interesting to study this transition in short-chain systems such as those that Bylinskii *et al.* and Gangloff *et al.* use. Overall, it is surprising how much can be learnt about the physics of infinitely long systems from studies that involve just a few ions.

As always, experiments teach us more than we anticipate. Clear-cut techniques, such as the cold-ion emulators reported in these two papers, provide insights into the complexity that underlies even the simplest act of friction involving a handful of ions. The physicist Philip Warren Anderson once said[13], "more is different". But in the case of the current papers, one could counter that dictum by saying that, sometimes, less can be different after all. ■

Davide Mandelli *and* **Erio Tosatti** *are at the International School for Advanced Studies (SISSA), 34136 Trieste, Italy.* **E.T.** *is also at the Abdus Salam International Centre for Theoretical Physics, Trieste, and the Democritos National Laboratory, Istituto Officina dei Materiali, Consiglio Nazionale delle Ricerche, Trieste.*
e-mails: davide.mandelli@sissa.it; tosatti@sissa.it

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BEHAVIOURAL ECONOMICS

Visible inequality breeds more inequality

Experiments suggest that when people can see wealth inequality in their social network, this propels further inequality through reduced cooperation and reduced social connectivity. **SEE LETTER P.426**

SIMON GÄCHTER

Inequality is a growing concern in many societies[1]. Like most important social phenomena, it is a complex issue that has many interacting sources and consequences[1–3]. To understand inequality and its dynamics over time, multiple theoretical and empirical approaches are necessary. In this issue, Nishi *et al.*[4] (page 426) use laboratory-style experiments (conducted online) to study how the visibility of wealth inequality in people's social environment shapes the behavioural dynamics of inequality. The attraction of an experimental approach is that it allows the control of factors that are inherently uncontrollable in naturally occurring data. Crucially, for example, the experimenter can control the initial level of inequality and see how inequality evolves as a