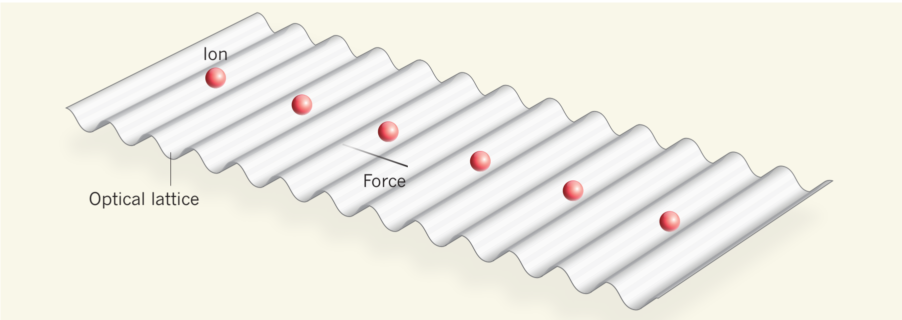

Figure 1 | Ion chain trapped in a lattice. Bylinskii *et al.*[2] and Gangloff *et al.*[3] investigate the friction that arises when one or a few ions are forced to slide across optical lattices in which a corrugated energy potential is created by counter-propagating lasers. These simple experiments have 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. ■

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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 function of people's behaviour alone[5,6].

Nishi and colleagues' experimental model used an assessment of people's willingness to contribute to public goods to test how initial wealth inequality and the structure of the social network influence the evolution of inequality. The researchers were particularly interested in the role of visibility of wealth — can mere observation of your neighbour's wealth lead to more inequality over time, even if such information does not change economic incentives? Visible wealth might have a psychological effect by triggering social comparisons and thereby influencing economic choices that have repercussions for inequality[3].

In their online laboratory, the researchers endowed all participants with tokens, worth real money. The endowment differed across individuals and treatments: in a treatment without inequality, all participants initially received the same number of tokens; in a low-inequality treatment, participants had similar but different initial endowments; and in the high-inequality treatment there was a substantial starting difference between participants.

The groups typically comprised 17 people arranged at random in a social network in which, on average, about 5 people were linked ('neighbours'). In each of the 10 rounds of the following game, participants had to decide whether to behave pro-socially ('cooperate') by reducing their own wealth by 50 tokens per connected neighbour to benefit each of them by 100 tokens, or to behave pro-selfishly ('defect') by keeping their tokens for themselves. These decisions had consequences for accumulated wealth levels and inequality. At the end of each round, the subjects learnt whether their neighbours had cooperated or defected and 30% of participants were given the opportunity to change their neighbour, that is, to either sever an existing link or to create a new one.

A crucial manipulation in this experiment was wealth visibility. Under invisible conditions, the participants could observe only their own accumulated wealth. Under visibility, they could see the accumulated wealth of their connected neighbours but not the whole network. Thus, there were six conditions in total: three levels of initial wealth inequality in each of the two visibility conditions.

The results are complex but illuminating. The authors find that, under high initial wealth inequality, visibility of neighbours' accumulated wealth increases inequality over time relative to the invisibility condition, although absolute inequality decreases over time under both visibility conditions. The reason for the relative increase under visibility is that inequality drops only moderately, whereas under invisibility the reduction in inequality is substantial. By contrast, in the case of initial wealth equality, inequality increases — similarly in both visibility conditions. Under moderate initial

Figure 1 | Wealth on display. Nishi *et al.*[4] use an experimental game to show that, when people can see the wealth of others whom they are linked with in a social network, inequality increases and the number of social connections decreases.

inequality, visibility leads to a small increase in inequality relative to invisibility.

Visibility of wealth also leads to lower social welfare, as measured by overall wealth (Fig. 1). By the end of the experiment, total accumulated wealth was substantially larger in the three conditions with invisible wealth than in the three conditions with visible wealth. The reason for this is that cooperativeness was lower under the condition of visible wealth compared to invisible wealth, and there were fewer links in the social network.

The most striking insight from these findings is the effect of wealth visibility on the dynamics of inequality: conspicuous inequality breeds more inequality. Although visibility of wealth does not change economic incentives in this experimental scenario, it invites social comparisons that, for various reasons[3,7] worth exploring further, undermine cooperation and diminish social ties. This observation adds to existing[8,9], but sparse, evidence that public information about individual pay-offs leads to more competition, which in a public-goods setting triggers more 'free-riding' by individuals (defecting when others cooperate), to improve their own pay-offs.

Nishi and colleagues' findings raise several intriguing methodological questions for future studies. For example, how much influence does the social network and its rewiring have on the main results of this experiment? Modelling interactions using a social network is certainly realistic, but is it crucial for the emergence of visibility effects in inequality? Another question concerns the result that visibility of wealth matters much less under initial equality of wealth. This is surprising, given that inequality of wealth increases over time and visibility effects should kick in, according to the results from the treatments with initial inequality. It is possible that these experiments, which used only ten iterations, might have been too short to allow for visibility effects arising as inequality grows.

The results also suggest substantive questions worthy of further research. As well as understanding the role of visibility of wealth (or pay-offs more generally) for cooperation, it would be interesting to gather evidence about how people's pro-social attitudes are affected by the ever-increasing amount of information about other people's consumption (as a signal of their wealth)[10], which nowadays is spread on an almost global scale by social media. And how do visibility and social comparisons affect the dynamics of inequality when the relevant game is not one of cooperation but of competition? This is interesting because, in many interactions in our modern societies, not only initial endowments (wealth) matter but also resources that are allocated as people compete for scarce rewards — good jobs, for instance[11].

These are just some questions that can be investigated with the experimental model put forward by Nishi and colleagues. Their most general contribution is to showcase the power of experiments to contribute to our understanding of the behavioural dynamics of inequality. ■

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