termed conditional preparation, has been extensively used, especially in quantum optics⁷. The fast measurements demonstrated by Robledo *et al.*¹ and Togan *et al.*² allowed them to conditionally prepare the state of the nuclear spins in the vicinity of the NV centre. There are limitations associated with scaling up such preparation to multiple systems, as the more unlikely the desired input state is, the more experimental runs one has to discard before performing a successful experiment. However, introducing the act of conditional manipulation into a measurement cycle should be feasible for NV spins in future experiments, providing a route to deterministic preparation of spin states.

With the achievement of fast measurement, platforms based on NV centres further establish themselves as a promising building block for quantum technologies. A single NV centre has only a limited capacity for storing and processing information (in the work of Robledo *et al.*¹, there are four quantum bits). This is already sufficient for applications such as sensing magnetic fields. But the

more ambitious tasks of simulation, and ultimately general computation, will require far greater capacity. Fortunately, there are emerging ideas for connecting multiple NV centres together within a single crystal^{8,9}, or resorting once again to the power of quantum measurement to project two distant devices into a mutually entangled state¹⁰. This profound effect has already been demonstrated for atomic systems¹¹ and the great progress being made using NV centres¹² indicates that entangling remote centres — perhaps the last key ingredient to enable quantum technologies — now lies within grasp. □

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MUSICAL RHYTHMS

Perfecting imperfection

When György Ligeti composed *Continuum* for harpsichord in 1968, he played masterly with the limitations of human sound perception. Humans can only separate 18 or so individual sounds per second; when notes arrive in quicker succession, we perceive them as one continuous sound. The harpsichord can be played at a pace very close to — although not quite at — that limit, but the instrument's mechanics produce additional sounds that tip the sequence over the threshold. The result then is a truly overwhelming listening experience.

Ligeti's creation of 'musical continua' highlights one aspect of human music perception. Holger Hennig and colleagues have explored another, and demonstrate how rhythmic imperfections influence our listening experience (*PLoS ONE* **6**, e26457; 2011).

Hennig *et al.* asked volunteers, both musicians and non-musicians, to produce rhythmic patterns ranging in complexity, guided by a metronome. They were given various means of sound generation — drumming, singing and tapping with a hand on a drumhead. Those performers who were able to follow the metronome for an extended period of time tended to produce comparable patterns of temporal deviations from the perfect interbeat intervals. Most interestingly, these deviations — typically of the order of ten milliseconds — displayed long-range correlations. Fluctuations at one point of the rhythmic sequence could influence the behaviour several tens of seconds later. (Such long-range correlations were, however, absent when volunteers were not able to stay in time with the metronome.)

Does this tendency to introduce imperfections with long-range

correlations also have a bearing on how we perceive music? It's a question that's particularly relevant for computer-generated music. Perfectly timed beats output by a computer do sound artificial, and professional software often sports 'humanizing' features. According to Hennig *et al.*, these tools are based on the addition of white-noise fluctuations — that is, the extent of temporal deviation from the ideal is uncorrelated between successive tones. As an alternative approach, the authors instead introduced correlated $1/f$ noise. When they played the two versions of humanized electronic music to members of local choirs, on average listeners preferred, to a statistically significant degree, the new $1/f$ -noise version to its white-noise counterpart.

But listen for yourself: audio samples are available on the authors' website (http://www.nld.ds.mpg.de/humanized_audio), as well as a link to a survey, through which the researchers hope to gather further data on just what musical imperfection should sound like.

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