Disturbances of the autonomic nervous system are notoriously difficult to manage. In this issue, Japanese investigators\(^1\) show that heart rate variability, a measure of autonomic dysfunction\(^2\), can be restored in patients with multiple systems atrophy (MSA) to levels approaching those seen in healthy individuals. Surprisingly the therapeutic maneuver did not involve a new surgical procedure, implanted stem cells, or the use of pharmacological agents. The benefits were obtained by stimulating the vestibular nuclei with noise, i.e. electrical currents that fluctuate in a random and uncontrolled manner.

Vestibular afferents lie directly below the mastoid bone and can be stimulated transcutaneously using small amplitude galvanic currents. Although galvanic vestibular stimulation (GVS) has been extensively used to study the effects of the vestibular nuclei on stance, posture and ocular control\(^3\); these nuclei also have important effects on heart rate through their influence on neuronal circuits in medullary cardiovascular areas\(^4\). Up until now, the clinical use of GVS has been limited by side effects\(^3\), such as ocular torsion, postural compensations, and perceptions of body rotation. In contrast, GVS that utilizes noisy currents which have zero mean ("noisy GVS") do not produce these side effects. Yamamoto et al\(^1\) demonstrated that noisy GVS was most effective in restoring heart variability in patients with MSA when the stimulating currents were designed to have the 1/f-type power spectrum characteristic of noise measured in the nervous system\(^5\). The beneficial effects of noisy GVS were not limited to this neurodegenerative disease. Noisy GVS also benefited daytime trunk activity dynamics and improved cognitive performance in patients with levodopa responsive Parkinson’s disease and levodopa unresponsive Parkinsonism, presumably through connections of the vestibular nuclei to the basal ganglia and limbic system via the cerebellar vermis.

The possibility that noise could benefit neural function has only gradually been realized by neuroscientists. Just 55 years ago Fatt and Katz\(^6\) proclaimed that noise was detrimental to neural encoding. Today it is well established that noise plays important roles both in the encoding of sensory stimuli\(^7\) and in the planning\(^8\) and control\(^9\) of certain movements. This paradigm shift was initiated by physicists over the last 25 years who studied the effects of noise on threshold-type devices, including neurons, to subthreshold inputs. It was shown that information transfer improves because noise increases the threshold crossing rate through a mechanism known as stochastic resonance\(^7\) (SR). Subsequently several studies drew attention to the value of SR-based treatment strategies; noise improves the performance of cochlear implants\(^10\) and vibrating insoles improve balance control in the elderly\(^11\). It is possible that the effects of noisy GVS for patients with neurodegenerative diseases are also related to SR; however, the predicted optimal noise level for improvement has not yet been observed.

This study by Yamamoto et al\(^1\) is one example of many that illustrate the impact that the new field of computational neuroscience is coming to have on the treatment of patients with neurological disease. As the basic principles of information flow and processing within the nervous system are revealed using mathematical and computer models, new pathways leading to the development of strategies to replace or enhance neural functions diminished by disease are illuminated\(^12\). The exponential growth in the use of devices such as cochlear implants and deep brain stimulators underscores the willingness of neurologists to incorporate these devices into their therapeutic arsenals.

Admittedly the therapeutic successes that have been achieved are modest; however, the future looks bright. Here are three possibilities that suggest how the face of neurology is about to change.

1. The observation that brief electrical pulses can abort seizures lends hope to patients with medically intractable epilepsy that implantable brain defibrillators will soon be available\(^12\).
2. The development of devices that link brain activity directly with another electronic computational device, the digital computer\(^13\-14\), suggests that we may soon be able to restore mobility to those who have lost it, e.g. the BrainGate clinical trial.
3. The possibility that gene expression can be controlled using external noise and constructed molecular switches\(^15\) suggests that we may eventually have the capability to employ nanotechnologies to battle neurological disease at the level of single neurons.

The mere possibility that man-machine interfaces can be effective adjuncts for patient care points to se-
vere deficiencies in current educational programs for training physicians and neurologists. Quantitative skills of medical students are universally poor and curricula in medical schools do not typically include even the simplest concepts of control or facilitate the acquisition of computing skills. The language of computational neurology is not that of genes and gene products, but that of dynamical systems; its focus is not to identify abnormalities but to devise strategies to overcome them. As Plato observed, “The direction in which education starts a man, will determine his future life”. Thus it may already be too late for those students currently entering medical school. For the first time in history the field of neurology must become interested in how students are prepared even before they enter medical school. One possibility is for neurologists to give input into progressive educational initiatives at the undergraduate level, for example BIO 201016. The stakes are high: the good of the patients under our care.

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References