Cerebral damage and functional localization

SIR—H. Stowell's[1] response to my *News and Views* comment[2] on the paper by Hart *et al.*[3] raises more problems than it solves. I, of course, agree that the brain damage sustained by Hart *et al.*'s patient was indeed global by the criteria of those who work with surgical ablations in animals (not to speak of single cell recordings). But by the standards of human neuropsychology, the infarct was relatively focal; we work with the lesions that nature, sadly, gives us.

Like Stowell, I too have my doubts about direct mappings between categories of cognitive impairment and lesion sites and find no difficulty in providing Stowell with further ammunition for his position. For example: in 1925, Vendryes[4] wrote that "it is wrong to think of the brain as if it were built on the plan of a grammar, cut into sections for the different parts of speech." Yet in 1985, McCarthy and Warrington[5] could report a case of severe agrammatism, consequent upon diffuse cortical atrophy, in which a specific disorder of verb use was the most outstanding symptom. If it is any consolation to Stowell, I lie awake at nights worrying about how such phenomena are possible.

Finally, I have the greatest respect for Maxwell, Einstein, Pellionisz, and Llinás, and would much appreciate hearing from Stowell about exactly how we could apply their insights to the interpretation of the highly constrained linguistic deficits seen after (not so focal) brain damage.

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1. Stowell, H. *Nature* **318**, 414 (1985).
2. Marshall, J.C. *Nature* **316**, 388 (1985).
3. Hart, J., Berndt, R.S. & Caramazza, A. *Nature* **316**, 439 (1985).
4. Vendryes, J. *Language: A Linguistic Introduction to History* (Routledge and Kegan Paul, London, 1925).
5. McCarthy, R. & Warrington, E.K. *Neuropsychologia* **23**, 709 (1985).

The magnetic field of Uranus

SIR—Reports that the Planetary Radio Astronomy experiment (PRA) on Voyager 2 has not so far detected radio emissions from Uranus, particularly in the previously reported 0.5 MHz region, do not necessarily imply that Uranus has no magnetic field. On the contrary, we think it likely that Uranus will be found to have a polar magnetic field strength of 0.01 to 0.1 gauss, which would imply a magnetosphere extending out to 8 to 16 planetary radii (R_U). But such field strengths would be unlikely to lead to radio emissions detectable by PRA and also imply that the observed[2,3] Lyman-α emission from Uranus may only in part be caused by the interaction of the solar wind with the magnetosphere.

The presence of a magnetic field, however small, is suggested by estimates of the internal composition of Uranus leading to the conclusion that the planet has a core constituted of refractory elements (Si, Mg, Fe, Ni,...) with a radius of 0.3 R_U and a mass four times that of the Earth[4–7]. Such a core would contain about 10% Fe and Ni oxides and, if some of the SiO_2 were in the liquid metal form, there would be a liquid core similar in size to that of the Earth. On this basis, one might assume a molten core with a magnetic moment not very different from that of the Earth, which would in turn imply a field strength at the surface equal to that of the Earth at a distance of R_U, whence the estimate of a polar field strength of 0.01 gauss.

The corresponding distance to the magnetopause on the upstream side, assuming a modified Chapman–Ferraro estimate of the maximum magnetic pressure, is in the range 8–16 R_U, in which case the magnetosphere may extend as far as the orbit of the satellite Umbriel or, at the strong-field end of the range, at least to that of Oberon. A complication, at the present heliocentric phase of Uranus, is that the magnetic axis should be approximately aligned with the solar wind; the funnel, however, should end about two-thirds of the distance to the magnetopause[8], while the penetration of the solar wind plasma will be determined primarily by the reconnection of the magnetic field lines. Accordingly, we expect that Voyager 2 will enter the magnetosphere at 8–16 R_u, some 2–3 hours before closest approach, that it will miss the dayside funnel or polar cusp and remain in the magnetotail for about 12–24 hours after closest approach.

Using these estimates and the calculations of Siscoe[9] (modified by a planetary rotation period of 16.3 hours), we conclude that the plasmasphere will extend essentially to the magnetopause with a convection timescale of 14 to 29 hours.

We estimate that the power supplied to the system by the magnetohydrodynamic dynamo driven by the solar wind will be in the range $2–9 \times 10^9$ W, greater than the power supplied by a disk-driven dynamo of the kind considered by Hill and Dessler[10], which, with our parameters, would lie between 1×10^8 and 2×10^9 W. The magnetic field-strength in the tail will range from 1.5 nanotesla near the planet to 0.5 nanotesla at greater distances.

It is also possible to predict the geometry of the auroral emissions on the planet's disk if the magnetosphere is taken to be Earth-like with due allowance for the pole-on orientation of Uranus. On the night side of the planet, hard plasma-sheet precipitation should produce a crescent-shaped auroral band on one side of the polar cap, while soft polar-cusp precipitation should produce another band on the other side. The same configuration is expected on the day-side on Uranus, but with the difference that the plasma-sheet aurora will be thin and that the polar-cusp aurora will fill a substantial part of the polar cap.

The failure of the Voyager PRA experiment to detect radio emission early in the approach to Uranus is explicable if the planet has a comparatively weak magnetic field. Radio emission will be confined[11] to those regions in which the ratio of the electron-plasma and gyro-frequencies is less than unity, which implies that for $B =$ 0.01 to 0.1 gauss, there will be no wave generation even at the ionospheric electron densities of about 10^4 cm^{-3} typical of those in the terrestrial ionosphere.

Two other arguments lead to the conclusion that radio emission from the magnetosphere of Uranus may have been too weak to be detected in the early stages of the approach of Voyager 2. The observed radio emissions from the Earth, Jupiter and Saturn, when scaled empirically, suggest that the total power radiated is approximately 5×10^{-6} of the energy flux of the incident solar wind, which implies that if there is any dayside emission from Uranus, the flux would be $1–5 \times 10^6$ W, corresponding to $4–20 \times 10^{-18}$ W m^{-2} at a distance of 1 astronomical unit, which is considerably less than the radio power from the three other sources. Further support for the view that the radio emission from Uranus would not have been detected early in the encounter comes from the assumption that it may be permissible to scale the frequency-peak of the emission from a planet with the strength of the magnetic field, in which case the frequency maximum at Uranus should appear at 0.3 to 3.0 kHz, 0.5–5.0 kHz and 5.0–50.0 kHz if scaled from Earth, Jupiter and Saturn, respectively[12]. But the lowest frequency channel of the PRA experiment at 0.7–1.7 kHz is below the plasma frequency of the solar wind plasma behind the bow shock, while the next channel (19.9–20.9 kHz) is well above the position of the peak unless the magnetic field at the surface of Uranus is greater than about 0.04 gauss.

For these reasons, we believe that the absence of radio emissions in the early records of the PRA experiment does not imply that Uranus does not have a significant magnetic dipole moment and a magnetosphere of considerable extent.

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