

Blindsight: Notes and References

(Longwinded Version)

Peter Watts

References and remarks, to try and convince you all I'm not crazy (or, failing that, to simply intimidate you into shutting up about it). Read for extra credit.

A Brief Primer on Vampire Biology

I'm hardly the first author to take a stab at rationalising vampirism in purely biological terms. Richard Matheson did it before I was born, and if the grapevine's right that damn Butler woman's latest novel will be all over the same territory before you even read this. I bet I'm the first to come up with the Crucifix Glitch to explain the aversion to crosses, though— and once struck by that bit of inspiration, everything else followed.

Vampires were accidentally rediscovered when a form of experimental gene therapy went curiously awry, kick-starting long-dormant genes in an autistic child and provoking a series of (ultimately fatal) physical and neurological changes. The company responsible for this discovery presented its findings after extensive follow-up studies on inmates of the Texas penal system; a recording of that talk, complete with visual aids, is available online¹; curious readers with half an hour to kill are referred there for details not only on vampire biology, but on the research, funding, and "ethical and political concerns" regarding vampire

¹ <http://www.rifters.com/blindsight/vampires.htm>

domestication (not to mention the ill-fated "Taming Yesterday's Nightmares For A Brighter Tomorrow" campaign). The following (much briefer) synopsis restricts itself to a few biological characteristics of the ancestral organism:

Homo sapiens vampiris was a short-lived Human subspecies which diverged from the ancestral line between 800,000 and 500,000 year BP. More gracile than either *neandertal* or *sapiens*, gross physical divergence from *sapiens* included slight elongation of canines, mandibles, and long bones in service of an increasingly predatory lifestyle. Due to the relatively brief lifespan of this lineage, these changes were not extensive and overlapped considerably with conspecific allometries; differences become diagnostically significant only at large sample sizes ($N > 130$).

However, while virtually identical to modern humans in terms of gross physical morphology, *vampiris* was radically divergent from *sapiens* on the biochemical, neurological, and soft-tissue levels. The GI tract was foreshortened and secreted a distinct range of enzymes more suited to a carnivorous diet. Since cannibalism carries with it a high risk of prionic infection², the vampire immune system displayed great resistance to prion diseases³, as well as to a variety of helminth and anasakid parasites. *Vampiris* hearing and vision were superior to that of *sapiens*; vampire retinas were quadrochromatic (containing four types of cones, compared to only three among baseline humans); the fourth cone type, common to nocturnal predators ranging from cats to snakes, was tuned to near-infrared. Vampire grey matter was "underconnected" compared to Human norms due to a relative lack of interstitial white matter; this forced isolated cortical modules to become self-contained and hypereffective, leading to omnisavant pattern-matching and analytical skills⁴.

Virtually all of these adaptations are cascade effects that— while resulting from a variety of proximate causes— can ultimately be

² Pennish, E. 2003. Cannibalism and prion disease may have been rampant in ancient humans. *Science* 300: 227-228.

³ Mead, S. *et al.* 2003. Balancing Selection at the Prion Protein Gene Consistent with Prehistoric Kurulike Epidemics. *Science* 300: 640-643.

⁴ Anonymous., 2004. Autism: making the connection. *The Economist*, 372(8387): 66.

traced back to a paracentric inversion mutation on the Xq21.3 block of the X-chromosome⁵. This resulted in functional changes to genes coding for protocadherins (proteins that play a critical role in brain and central nervous system development). While this provoked radical neurological and behavioral changes, significant *physical* changes were limited to soft tissue and microstructures that do not fossilise. This, coupled with extremely low numbers of vampire even at peak population levels (existing as they did at the tip of the trophic pyramid) explains their virtual absence from the fossil record.

Significant deleterious effects also resulted from this cascade. For example, vampires lost the ability to code for ϵ -Protocadherin Y, whose genes are found exclusively on the hominid Y chromosome⁶. Unable to synthesise this vital protein themselves, vampires had to obtain it from their food. Human prey thus comprised an essential component of their diet, but a relatively slow-breeding one (a unique situation, since prey usually outproduce their predators by at least an order of magnitude). Normally this dynamic would be utterly unsustainable: vampires would predate humans to extinction, and then die off themselves for lack of essential nutrients.

Extended periods of lungfish-like dormancy⁷ (the so-called "undead" state)—and the consequent drastic reduction in vampire energetic needs—developed as a means of redressing this imbalance. To this end vampires produced elevated levels of endogenous Ala-(D) Leu-enkephalin (a mammalian hibernation-inducing peptide⁸) and dobutamine, which strengthens the heart muscle during periods on inactivity⁹.

⁵ Balter, M. 2002. Ehat made Humans modern? *Science* 295: 1219-1225.

⁶ Blanco-Arias, P., C.A. Sargent, and N.A. Affara. 2004. A comparative analysis of the pig, mouse, and human PCDHX genes. *Mammalian Genome*, 15(4): 296-306.

⁷ Kreider MS, *et al.* 1990. Reduction of thyrotropin-releasing hormone concentrations in central nervous system of African lungfish during estivation. *Gen Comp Endocrinol.* 77(3):435-41.

⁸ Cui, Y. *et al.* 1996. State-dependent changes of brain endogenous opioids in mammalian hibernation. *Brain Research Bulletin* 40(2):129-33.

Another deleterious cascade effect was the so-called "Crucifix Glitch"—a cross-wiring of normally-distinct receptor arrays in the visual cortex¹⁰, resulting in *grand mal*-like feedback seizures whenever the arrays processing vertical and horizontal stimuli fired simultaneously across a sufficiently large arc of the visual field. Since intersecting right angles are virtually nonexistent in nature, natural selection did not weed out the Glitch until *H. sapiens sapiens* developed Euclidean architecture; by then, the trait had become fixed across *H. sapiens vampiris* via genetic drift, and—suddenly denied access to its prey—the entire subspecies went extinct shortly after the dawn of recorded history.

You'll have noticed that Jukka Sarasti, like all reconstructed vampires, sometimes *clicked* to himself when thinking. This is thought to hail from an ancestral language, which was hardwired into a click-speech mode more than 50,000 years BP. Click-based speech is especially suited to predators stalking prey on savannah grasslands (the clicks mimic the rustling of grasses, allowing communication without spooking quarry)¹¹. The Human language most closely akin to Old Vampire is Hadzane¹².

Sleight of Mind

The Human sensorium is remarkably easy to hack; our visual system has been described as an improvised "bag of tricks"¹³ at best. Our sense organs acquire such fragmentary, imperfect input that the brain has to interpret their data using rules of probability

⁹ Miller, K. 2004. Mars astronauts 'will hibernate for 50 million-mile journey in space'. News.telegraph.co.uk, 11/8/04.

¹⁰ Calvin, W.H. 1990. *The Cerebral Symphony: Seashore Reflections on the Structure of Consciousness*. 401pp. Bantam Books, NY.

¹¹ Pennisi, E. 2004. The first language? *Science* 303: 1319-1320.

¹² Recordings of Hadzane click-based phonemes can be heard at <http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants/index.html>

¹³ Ramachandran, V.S. 1990. pp346-360 in *The Utilitarian Theory of Perception*, C. Blakemore (Ed.), Cambridge University Press, Cambridge.

rather than direct perception¹⁴. It doesn't so much *see* the world as make an educated guess about it. As a result, "improbable" stimuli tends to go unprocessed at the conscious level, no matter how strong the input. We tend to simply *ignore* sights and sound that don't fit with our worldview.

Sarasti was right: *Rorschach* wouldn't do anything to you that you don't already do to yourself.

For example, the invisibility trick of that young, dumb scrambler — the one who restricted its movement to the gaps in Human vision— occurred to me while reading about something called *inattentional blindness*. A Russian guy called Yarbus was the first to figure out the whole saccadal glitch in Human vision, back in the nineteen sixties¹⁵. Since then, a variety of researchers have made objects pop in and out of the visual field unnoticed, conducted conversations with hapless subjects who never realised that their conversational partner had changed halfway through the interview, and generally proven that the Human brain just *fails to notice* an awful lot of what's going on around it^{16, 17, 18}. Check out the demos at the website of the Visual Cognition Lab at the University of Illinois¹⁹ and you'll see what I mean. This really is rather mind-blowing, people. There could be Scientologists walking among us right now and if they moved just right, we'd *never even see them*.

¹⁴ Purves, D. and R.B. Lotto. 2003. *Why We See What We Do An Empirical Theory of Vision*. Sinauer Associates, Sunderland, MA. 272 pp.

¹⁵ Yarbus, A.L. 1967. Eye movements during perception of complex objects. In L. A. Riggs, Ed., *Eye Movements and Vision*, Plenum Press, New York, Chapter VII, 171-196.

¹⁶ Pringle, H.L., *et al.* 2001. The role of attentional breadth in perceptual change detection. *Psychonomic Bulletin & Review* 8: 89-95(7)

¹⁷ Simons, D.J., and Chabris, C.F. 1999. Gorillas in our midst: sustained inattentional blindness for dynamic events. *Perception* 28: 1059-1074

¹⁸ Simons, D.J., and Rensink, R.A. 2003. Induced Failures of Visual Awareness. *Journal of Vision* 3(1).

¹⁹ http://viscog.beckman.uiuc.edu/djs_lab/demos.html

Most of the psychoses, syndromes, and hallucinations described herein are real, and are described in detail by Metzinger²⁰, Wegner²¹, and/or Saks²² (see also *Sentience/Intelligence*, below). Others (e.g. Grey Syndrome) have not yet made their way into the DSM²³—truth be told, I invented a couple— but are nonetheless based on actual experimental evidence. Depending upon whom you believe, the judicious application of magnetic fields to the brain can provoke everything from religious rapture²⁴ to a sense of being abducted by aliens²⁵. Transcranial magnetic stimulation can change mood, induce blindness²⁶, or target the speech centers (making one unable to pronounce verbs, for example, while leaving the nouns unimpaired)²⁷. Memory and learning can be enhanced (or impaired), and the US Government is presently funding research into wearable TMS gear for—you guessed it—military purposes²⁸.

Sometimes electrical stimulation of the brain induces "alien hand syndrome"— the involuntary movement of the body against the will of the "person" allegedly in control²⁹. Other times it provokes equally involuntary movements, which subjects nonetheless insist

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- ²⁰ Metzinger, T. 2003. *Being No One: The Self-Model Theory of Subjectivity*. MIT Press, Cambridge, MA. 713pp.
- ²¹ Wegner, D.M. 2002. *The Illusion of Conscious Will*. MIT Press, Cambridge. 405pp.
- ²² Saks, O. 1970. *The Man who mistook his wife for a hat and other clinical tales*. Simon & Shuster, NY.
- ²³ American Psychiatric Association. 2000. *Diagnostic and Statistical Manual of Mental Disorders*. (4th Ed., Text Revision). Brandon/Hill.
- ²⁴ Ramachandran, V.S., and Blakeslee, S. 1998. *Phantoms in the Brain: Probing the Mysteries of the Human Mind*. William Morrow, New York.
- ²⁵ Persinger, M.A. 2001 *The Neuropsychiatry of Paranormal Experiences*. *J Neuropsychiatry & Clinical Neuroscience* 13: 515-524.
- ²⁶ Kamitani, Y. and Shimojo, S. 1999. Manifestation of scotomas created by transcranial magnetic stimulation of human visual cortex. *Nature Neuroscience* 2: 767-771.
- ²⁷ Hallett, M. 2000. Transcranial magnetic stimulation and the human brain. *Nature* 406: 147-150.
- ²⁸ Goldberg, C. 2003. Zap! Scientist bombards brains with super-magnets to edifying effect. *Boston Globe* 14/1/2003, pE1.
- ²⁹ Porter, R., and Lemon, R. 1993. *Corticospinal function and voluntary movement*. Oxford University Press, NY.

they "chose" to perform despite overwhelming empirical evidence to the contrary³⁰. Put all this together with the fact that the body begins to act before the brain even "decides" to move³¹ (but see^{32, 33}), and the whole concept of *free will*—despite the undeniable subjective *feeling* that it's real—begins to look a teeny bit silly, even outside the influence of alien artefacts.

While electromagnetic stimulation is currently the most trendy approach to hacking the brain, it's hardly the only one. Gross physical disturbances ranging from tumors³⁴ to tamping irons³⁵ can turn normal people into psychopaths and pedophiles (hence that new persona sprouting in Susan James's head). Spirit possession and rapture can be induced through the sheer emotional bump-and-grind of religious rituals, using no invasive neurological tools at all (and not even necessarily any pharmacological ones)²¹. People can even develop a sense of ownership of body parts that aren't theirs, can be convinced that a rubber hand is their real one³⁶. Vision trumps proprioception: a prop limb, subtly manipulated, is enough to convince us that we're doing one thing while in fact we're doing something else entirely^{37, 38}.

³⁰ Delgado, J.M.R. 1969. Physical control of the mind: toward a psychocivilised society. Harper & Row, NY.

³¹ Libet, B. 1993. The neural time factor in conscious and unconscious events. *Experimental and Theoretical Studies of Consciousness* 174: 123-146.

³² P. Haggard, P., and Eimer, M. 1999. On the relation between brain potentials and the awareness of voluntary movements. *Experimental Brain Research* 126: 128-133.

³³ Velmans, M. 2003. Preconscious free will. *Journal of Consciousness Studies* 10: 42-61.

³⁴ Pinto, C. 2003. Putting the brain on trial. May 5, 2003, Media General News Service.

³⁵ Macmillan, M. 2000. An Odd Kind of Fame Stories: of Phineas Gage. MIT Press, Cambridge, MA.

³⁶ Ehrsson, H.H., C. Spence, and R.E. Passingham 2004. That's My Hand! Activity in Premotor Cortex Reflects Feeling of Ownership of a Limb. *Science* 305: 875-877.

³⁷ Gottlieb, J., and P. Mazzone. 2004. Action, illusion, and perception. *Science* 303: 317-318.

³⁸ Schwartz, A.B., D.W. Moran, and G.A. Reina. 2004. Differential representation of perception and action in the frontal cortex. *Science* 303: 380-383.

The latest tool in this arsenal is ultrasound: less invasive than electromagnetics, more precise than charismatic revival, it can be used to boot up brain activity³⁹ without any of those pesky electrodes or magnetic hairnets. In *Blindsight* it serves as a convenient back door to explain why *Rorschach's* hallucinations persist even in the presence of Faraday shielding— but in the here and now, Sony has been renewing an annual patent for a machine which uses ultrasonics to implant "sensory experiences" directly into the brain⁴⁰. They're calling it an entertainment device with massive applications for online gaming. Uh huh. And if you can implant sights and sounds into someone's head from a distance, why not implant political beliefs and the irresistible desire for a certain brand of beer while you're at it?

Are We There Yet?

The "telematter" drive that gets our characters to the story is based on teleportation studies reported in *Nature*⁴¹, *Science*,^{42,43} *Physical Review Letters*⁴⁴, and (more recently) everyone and their dog^{e.g., 45}. The idea of transmitting antimatter specs as a fuel template is, so far as I know, all mine. To derive plausible guesses for *Theseus's* fuel mass, acceleration, and travel time I resorted to The Relativistic Rocket⁴⁶, maintained by the mathematical

³⁹ Norton, S.J., 2003. Can ultrasound be used to stimulate nerve tissue? *BioMedical Engineering OnLine* 2:6, available at <http://www.biomedical-engineering-online.com/content/2/1/6>.

⁴⁰ Hogan, J., and Fox, B. 2005. Sony patent takes first step towards real-life Matrix. Excerpted from *New Scientist* 2494:10, available at <http://www.newscientist.com/article.ns?id=mg18624944.600>.

⁴¹ Riebe, M. *et al.* 2004. Deterministic quantum teleportation with atoms. *Nature* 429: 734 - 737.

⁴² Furusawa, A. *et al.* 1998. Unconditional Quantum Teleportation. *Science*, 282(5389): 706-709

⁴³ Carlton M. Caves, C.M. 1998. A Tale of Two Cities. *Science*, 282: 637-638

⁴⁴ Braunstein, S.L., and Kimble, H.J. 1998. Teleportation of continuous quantum variables. *Physical Review Letters* 80: 869-872.

⁴⁵ <http://www.research.ibm.com/quantuminfo/teleportation/>

⁴⁶ <http://math.ucr.edu/home/baez/physics/Relativity/SR/rocket.html>

physicist John Baez at UC Riverside. *Theseus'* use of magnetic fields as radiation shielding is based on research out of MIT⁴⁷. I parked the (solar powered) Icarus Array right next to the sun because the production of antimatter is likely to remain an extremely energy-expensive process for the near future^{48, 49}.

The undead state in which *Theseus* carries her crew is, of course, another iteration of the venerable suspended animation riff (although I'd like to think I've broken new ground by invoking vampire physiology as the mechanism). Two recent studies have put the prospect of induced hibernation closer to realization. Blackstone *et al.* have induced hibernation in mice by the astonishingly-simple expedient of exposing them to hydrogen sulfide⁵⁰; this gums up their cellular machinery enough to reduce metabolism by 90%. More dramatically (and invasively), researchers at Safar Center for Resuscitation Research in Pittsburgh claim⁵¹ to have resurrected a dog three hours after clinical death, via a technique in which the animal's blood supply was replaced by an ice-cold saline solution⁵². Of these techniques, the first is probably closer to what I envisioned, although I'd finished the first draft before either headline broke. I considered rejigging my crypt scenes to include mention of hydrogen sulfide, but ultimately decided that fart jokes would have ruined the mood.

⁴⁷ Atkinson, N. 2004. Magnetic Bubble Could Protect Astronauts on Long Trips . *Universe Today*,

http://www.universetoday.com/am/publish/magnetic_bubble_protect.html

⁴⁸ Holzscheiter, M.H., *et al.* 1996. Production and trapping of antimatter for space propulsion applications. American Institute of Aeronautics and Astronautics-1996-2786 ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 32nd, Lake Buena Vista, FL, July 1-3.

⁴⁹ www.engr.psu.edu/antimatter/Papers/NASA_anti.pdf

⁵⁰ Blacstone, E., *et al.* 2005. H 2 S Induces a Suspended Animation-Like State in Mice. *Science* 308: 518.

⁵¹ The data have not been published as of this writing.

⁵² Bails, J. 2005. Pitt scientists resurrect hope of cheating death. Pittsburgh Tribune-Review, June 29. Available online at

http://www.pittsburghlive.com/x/tribune-review/trib/regional/s_348517.html

The Game Board

Blindsight describes Big Ben as an "Oasa Emitter". Officially there's no such label, but Yumiko Oasa has reported finding hitherto-undocumented infrared emitters^{53, 54} — dimmer than brown dwarves, but possibly more common^{55,56} — ranging in mass from three to thirteen Jovian masses. My story needed something relatively local, large enough to sustain a superJovian magnetic field, but small and dim enough to plausibly avoid discovery for the next seventy or eighty years. Oasa's emitters suit my needs reasonably well (notwithstanding some evident skepticism over whether they actually exist⁵⁷).

Of course I had to extrapolate on the details, given how little is actually known about these beasts. To this end I pilfered data from a variety of sources on gas giants^{58, 59, 60, 61, 62, 63, 64} and/or brown

⁵³ Oasa, Y. *et al.* 1999. A deep near-infrared survey of the chameleon i dark cloud core. *Astrophysical Journal* 526: 336-343.

⁵⁴ Normile, D. 2001. Cosmic misfits elude star-formation theories. *Science* 291: 1680.

⁵⁵ Lucas, P.W., and P.F. Roche. 2000. A population of very young brown dwarfs and free-floating planets in Orion. *Monthly Notices of the Royal Astronomical Society* 314: 858-864.

⁵⁶ Najita, J.R., G.P. Tiede, and J.S. Carr. 2000. From stars to superplanets: The low-mass initial mass function in the young cluster IC 348. *Astrophysical Journal* 541(Oct. 1):977-1003.

⁵⁷ Matthews, Jaymie. 2005. Personal communication.

⁵⁸ Liu, W., and Schultz, D.R. 1999. Jovian x-ray aurora and energetic oxygen ion precipitation. *Astrophysical Journal* 526:538-543.

⁵⁹ Chen, P.V. 2001. Magnetic field on Jupiter. *The Physics Factbook*, <http://hypertextbook.com/facts/>

⁶⁰ Osorio, M.R.Z. *et al.* 2000. Discovery of Young, Isolated Planetary Mass Objects in the σ Orionis Star Cluster. *Science* 290: 103-106.

⁶¹ Lemley, B. 2002. Nuclear Planet. *Discover*23(8).

⁶² <http://www.nuclearplanet.com/>

⁶³ Dulk, G.A., *et al.* 1997. Search for Cyclotron-maser Radio Emission from Extrasolar Planets. Abstracts of the 29th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society, July 28–August 1, 1997, Cambridge, Massachusetts.

⁶⁴ Marley, M. *et al.* 1997. Model Visible and Near-infrared Spectra of Extrasolar Giant Planets. Abstracts of the 29th Annual Meeting of the Division for

dwarves^{65, 66, 67, 68, 69, 70, 71, 72, , 73, 74, 75}, scaling up or down as appropriate. From a distance, the firing of *Rorschach's* ultimate weapon looks an awful lot like the supermassive x-ray and radio flare recently seen erupting from a brown dwarf that should have been way too small to pull off such a trick⁷⁶. That flare lasted twelve hours, was a good billions times as strong as anything Jupiter ever put out, and is thought to have resulted from a twisted magnetic field⁷⁷.

Burns-Caulfield is based loosely on 2000 Cr₁₀₅, a trans-Newtonian comet whose present orbit cannot be completely explained by the gravitational forces of presently-known objects in the solar system⁷⁸.

Planetary Sciences of the American Astronomical Society, July 28–August 1, 1997, Cambridge, Massachusetts.

⁶⁵ Boss, A. 2001. Formation of Planetary-Mass Objects by Protostellar Collapse and Fragmentation. *Astrophys. J.* 551: L167.

⁶⁶ Low, C., and D. Lynden-Bell. 1976. The minimum Jeans mass or when fragmentation must stop. *Mon. Not. R. Astron. Soc.* 176: 367.

⁶⁷ Jayawardhana, R. 2004. Unraveling Brown Dwarf Origins. *Science* 303: 322-323

⁶⁸ Fegley, B., and K. Lodders. 1996. Atmospheric Chemistry of the Brown Dwarf Gliese 229B: Thermochemical Equilibrium Predictions. *Astrophys. J.* 472: L37.

⁶⁹ Lodders, K. 2004. Brown Dwarfs--Faint at Heart, Rich in Chemistry. *Science* 303: 323-324

⁷⁰ Adam Burgasser. 2002. June 1 edition of the Astrophysics Journal Letters

⁷¹ Reid, I.N. 2002 Failed stars or overachieving planets? *Science* 296: 2154-2155.

⁷² Gizis, J.E. 2001. Brown dwarfs (enhanced review) Online article supplementing *Science* 294: 801.

⁷³ Clarke, S. 2003. Milky Way's nearest neighbour revealed. *NewScientist.com* News Service, 04/11/03.

⁷⁴ Basri, G. 2000. Observations of brown dwarfs. *Annu. Rev. Astron. Astrophys* 38:485–519.

⁷⁵ Tamura, M. *et al.* 1998. Isolated and Companion Young Brown Dwarfs in the Taurus and Chamaeleon Molecular Clouds. *Science* 282: 1095-1097.

⁷⁶ Berger, E. 2001. Discovery of radio emission from the brown dwarf LP944-20. *Nature* 410: 338-340.

⁷⁷ Anonymous, 2000. A brown dwarf solar flare. *Science@Nasa*, http://science.nasa.gov/headlines/y2000/ast12jul_1m.htm

⁷⁸ Schilling, G. 2001. Comet's course hints at mystery planet. *Science* 292: 33.

Scrambler Anatomy and Physiology

Like many others, I am weary of humanoid aliens with bumpy foreheads, and of giant CGI insectoids that may *look* alien but who act like rabid dogs in chitin suits. Of course, difference for its own arbitrary sake is scarcely better than your average saggital-crested Roddenoid; natural selection is as ubiquitous as life itself, and the same basic processes will end up shaping life wherever it evolves. The challenge is thus to create an "alien" that truly lives up to the word, while remaining biologically plausible.

Scramblers are my first shot at meeting that challenge— and given how much they resemble the brittle stars found in earthly seas, I may have crapped out on the whole unlike-anything-you've-ever-seen front, at least in terms of gross morphology. It turns out that brittle stars even have something akin to the scrambler's distributed eyespot array. Similarly, scrambler reproduction— the budding of stacked newborns off a common stalk— takes its lead from jellyfish. You can take the marine biologist out of the ocean, but...

Fortunately, scramblers become more alien the closer you look at them. Cunningham remarks that nothing like their time-sharing motor/sensory pathways exists on Earth. He's right as far as he goes, but I can cite a precursor that might conceivably evolve into such an arrangement. Our own "mirror neurons" fire not only when we perform an action, but when we observe someone else performing the same action⁷⁹; this characteristic has been cited in the evolution of both language and of consciousness^{80, 81, 82}.

Things look even more alien on the metabolic level. Here on Earth anything that relied solely on anaerobic ATP production never got past the single-cell stage. Even though it's more efficient

⁷⁹ Evelyne Kohler, E. *et al.* 2002. Hearing Sounds, Understanding Actions: Action Representation in Mirror Neurons. *Science* 297: 846-848

⁸⁰ Rizzolatti, G, and Arbib, M.A. 1998. Language Within Our Grasp. *Trends in Neuroscience* 21(5):188-194.

⁸¹ Hauser, M.D., N. Chomsky, and W.T. Fitch. 2002. The faculty of language: what is it, who has it, and how did it evolve? *Science* 298: 1569-1579.

⁸² Miller, G. 2005. Reflecting on Another's Mind. *Science* 308: 945-947

than our own oxygen-burning pathways, anaerobic metabolism is just too damn *slow* for advanced multicellularity⁸³. Cunningham's proposed solution is simplicity itself. The catch is, you have to sleep for a few thousand years between shifts.

The idea of quantum-mechanical metabolic processes may sound even wonkier, but it's not. Wave-particle duality can exert significant impacts on biochemical reactions under physiological conditions at room temperature⁸⁴; heavy-atom carbon tunnelling has been reported to speed up the rate of such reactions by as much as 152 *orders of magnitude*⁸⁵.

And how's *this* for alien: *no genes*. The honeycomb example I used by way of analogy originally appeared in Darwin's little-known treatise⁸⁶ (*damn* but I've always wanted to cite that guy); more recently, a small but growing group of biologists have begun spreading the word that nucleic acids (in particular) and genes (in general) have been seriously overrated as prerequisites to life^{87, 88}. A great deal of biological complexity arises not because of genetic programming, but through the sheer physical and chemical interaction of its components^{89, 90, 91, 92}. Of course, you still need something to set up the initial conditions for those processes to

⁸³ Pfeiffer, T., S. Schuster, and S. Bonhoeffer. 2001. Cooperation and Competition in the Evolution of ATP-Producing Pathways *Science* 20 292: 504-507.

⁸⁴ McMahon, R.J. 2003. Chemical Reactions Involving Quantum Tunneling. *Science* 299: 833-834.

⁸⁵ Zuev, P.S. *et al.* 2003. Carbon Tunneling from a Single Quantum State. *Science* 299: 867-870

⁸⁶ Darwin, Charlie "Chuckles". 1859. The Origin of Species by Means of Natural Selection. Penguin Classics Edition, reprinted 1968. Originally published by John Murray, London.

⁸⁷ Cho, A. 2004. Life's Patterns: No Need to Spell It Out? *Science* 303: 782-783.

⁸⁸ Cohen, J., and Stewart, S. 2005. Where are the dolphins? *Nature* 409: 1119-1122.

⁸⁹ Reilly, J.J. 1995. After Darwin. *First Things*, June/July. Article also available online at <http://pages.prodigy.net/aesir/darwin.htm>.

⁹⁰ Devlin, K. 2004. Cracking the da Vinci Code. *Discover* 25(6): 64-69.

⁹¹ Snir, Y, and Kamien, R.D. 2005. Entropically Driven Helix Formation. *Science* 307: 1067.

⁹² Wolfram, S. 2002. A New Kind of Science. Wolfram Media. 1192pp.

emerge; that's where the magnetic fields come in. No candy-ass string of nucleotides would survive in *Rorschach's* environment anyway.

The curious nitpicker might be saying "Yeah, but without genes how do these guys *evolve*? How do they adapt to novel environments? How, as a species, do they cope with the *unexpected*?" And if Robert Cunningham were here today, he might say, "I'd swear half the immune system is actively targeting the other half. It's not just the immune system, either. Parts of the nervous system seem to be trying to, well, hack each other. I think they evolve *intraorganismally*, as insane as that sounds. The whole organism's at war with itself on the tissue level, it's got some kind of cellular Red Queen thing happening. Like setting up a colony of interacting tumors, and counting on fierce competition to keep any one of them from getting out of hand. Seems to serve the same role as sex and mutation does for us." And if you rolled your eyes at all that doubletalk, he might just blow smoke in your face and refer to one immunologist's interpretation of exactly those concepts, as exemplified in (of all things) *The Matrix Revolutions*⁹³. He might also point out that that the synaptic connections of your own brain are shaped by a similar kind of intraorganismal natural selection⁹⁴, one catalysed by bits of parasitic DNA call *retrotransposons*.

Cunningham actually did say something like that in an earlier draft of this book, but the damn thing was getting so weighed down with theorising that I just cut it. After all, *Rorschach* is the proximate architect of these things, so it could handle all that stuff even if individual scramblers couldn't. And one of *Blindsight's* take-home messages is that life is a matter of *degree*—the distinction between living and non-living systems has always been an iffy one^{95, 96, 97}, never more so than in the bowels of that pain-in-the-ass artefact out in the Oort.

⁹³ Albert, M.L. 2004. Danger in Wonderland. *Science* 303: 1141

⁹⁴ Muotri, A.R., *et al.* 2005. Somatic mosaicism in neuronal precursor cells mediated by L1 retrotransposition. *Nature* 435: 903-910.

⁹⁵ Nelson, D.L., and M.M Cox. 200. *Lehninger principles of biochemistry*. Worth, NY, NY.

⁹⁶ Prigogine, I., and G. Nicholis. 1989. *Exploring Complexity*. Freeman, NY.

Sentience/Intelligence

This is the heart of the whole damn exercise. Let's get the biggies out of the way first. Metzinger's *Being No One*²⁰ is the toughest book I've ever read (and there are still significant chunks of it I haven't), but it also contains some of the most mindblowing ideas I've encountered in fact or fiction. Most authors are shameless bait-and-switchers when it comes to the nature of consciousness. Pinker calls his book *How the Mind Works*⁹⁸, then admits on page one that "We don't understand how the mind works". Koch (the guy who coined the term "zombie agents") writes *The Quest for Consciousness: A Neurobiological Approach*⁹⁹, in which he sheepishly sidesteps the whole issue of why neural activity should result in any kind of subjective awareness whatsoever.

Towering above such pussies, Metzinger takes the bull by the balls. His "World-zero" hypothesis not only explains the subjective sense of self, but also why such an illusory first-person narrator would be an emergent property of certain cognitive systems in the first place. I have no idea whether he's right—the man's way beyond me—but at least he addressed the *real* question that keeps us staring at the ceiling at three a.m., long after the last roach is spent. Many of the syndromes and maladies dropped into *Blindsight* I first encountered in Metzinger's book. Any uncited claims or statements in this subsection probably hail from that source.

If they don't, then maybe they hail from Wegner's *The Illusion of Conscious Will*²¹ instead. Less ambitious, far more accessible, Wegner's book doesn't so much deal with the nature of *consciousness* as it does with the nature of *free will*, which Wegner thumbnails as "our mind's way of estimating what it thinks it did.". Wegner presents his own list of syndromes and maladies, all of

⁹⁷ Dawkins, R. 1988. *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design*. Norton.

⁹⁸ Pinker, S. 1997. *How the mind works*. WW Norton & Co., NY. 660pp.

⁹⁹ Koch, C. 2004. *The Quest for Consciousness: A Neurobiological Approach* Roberts, Englewood, CO. 447pp.

which reinforce the mind-boggling sense of what fragile and subvertible machines we are. And of course, Oliver Saks²² was sending us memos from the edge of consciousness long before consciousness even had a bandwagon to jump on.

It might be easier to list the people who *haven't* taken a stab at "explaining" consciousness. Theories run the gamut from diffuse electrical fields to quantum puppet-shows; consciousness has been "located" in the fronto-insular cortex and the hypothalamus and a hundred dynamic cores in between^{100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110}. (At least one theory¹¹¹ suggests that while great apes and adult Humans are sentient, young Human children are not. I admit to a certain fondness for this conclusion; if children *aren't* nonsentient, they're certainly psychopathic).

But beneath the unthreatening, superficial question of what consciousness *is* floats the more functional question of what it's good for. *Blindsight* plays with that issue at length, and I won't reiterate points already made. Suffice to say that, at least under routine conditions, consciousness does little beyond taking memos from the vastly richer subconscious environment, rubber-stamping them, and taking the credit for itself. In fact, the nonconscious

¹⁰⁰ McFadden, J. 2002. Synchronous firing and its influence on the brain's electromagnetic field: evidence for an electromagnetic field theory of consciousness. *J. Consciousness Studies*, 9, No. 4, 2002, pp. 23–50

¹⁰¹ Penrose, R. 1989. *The Emperor's New Mind*. Oxford University Press.

¹⁰² Tononi, G., and G.M. Edelman. 1998. Consciousness and Complexity. *Science* 282: 1846-1851.

¹⁰³ Baars, B.J. 1988. *A Cognitive Theory of Consciousness*. Cambridge Univ. Press, New York.

¹⁰⁴ Hilgetag, C.C. 2004. Learning from switched-off brains. *Sci. Amer.* 14: 8-9.

¹⁰⁵ Roth, G. 2004. The quest to find consciousness. *Sci. Amer.* 14: 32-39.

¹⁰⁶ Pauen, M. 2004. Does free will arise freely? *Sci. Amer.* 14: 41-47.

¹⁰⁷ Zimmer, C. 2003. How the mind reads other minds. *Science* 300:1079-1080.

¹⁰⁸ Crick, F.H.C., and C. Koch. 2000. The unconscious homunculus. *In Neural Correlates of Consciousness—Empirical and Conceptual Questions* (T. Metzinger, Ed.) MIT Press, Cambridge.

¹⁰⁹ Churchland, P.S. 2002. Self-Representation in Nervous Systems. *Science* 296: 308-310.

¹¹⁰ Miller, G. 2005. What is the biological basis of consciousness? *Science* 309: 79.

¹¹¹ Blakeslee, S. 2003. The christmas tree in your brain. *Toronto Star*, 21/12/03

mind usually works so well on its own that it actually employs a gatekeeper in the anterior cingulate cortex to do nothing but *prevent* the conscious self from interfering in daily operations^{112, 113, 114}. (If the rest of your brain *were* conscious, it would probably regard you as the pointy-haired boss from *Dilbert*.)

Sentience isn't even necessary to develop a "theory of mind". That might seem completely counterintuitive: how could you learn to recognise that other individuals are autonomous agents, with their own interests and agendas, if you weren't even aware of your own? But there's no contradiction, and no call for consciousness. It is entirely possible to track the intentions of others without being the slightest bit self-reflective¹⁰⁷. Norretranders declared outright that "Consciousness is a fraud"¹¹⁵.

Art might be a bit of an exception. Aesthetics seem to require some level of self-awareness—in fact, the evolution of aesthetics might even be what got the whole sentience ball rolling in the first place. When music is so beautiful it makes you shiver, that's the reward circuitry in your limbic system kicking in: the same circuitry that rewards you for fucking an attractive partner or gorging on sucrose¹¹⁶. It's a hack, in other words; your brain has learned how to get the reward without actually earning it through increased fitness⁹⁸. It feels good, and it fulfills us, and it makes life worth living. But it also turns us inward and distracts us. Those rats back in the sixties, the ones that learned to stimulate their own pleasure centers by pressing a lever: remember them? They pressed those levers with such addictive zeal that they forgot to eat. They starved to death. I've no doubt they died happy, but they *died*. Without issue. Their fitness went to Zero.

¹¹² Matsumoto, K., and K. Tanaka. 2004. Conflict and Cognitive Control. *Science* 303: 969-970.

¹¹³ Kerns, J.G., *et al.* 2004. Anterior Cingulate Conflict Monitoring and Adjustments in Control. *Science* 303: 1023-1026.

¹¹⁴ Petersen, S.E. *et al.* 1998. The effects of practice on the functional anatomy of task performance. *Proceedings of the National Academy of Sciences* 95: 853-860.

¹¹⁵ Norretranders, T. 1999. *The User Illusion: Cutting Consciousness Down to Size*. Penguin Press Science. 467pp.

¹¹⁶ Altenmüller, E.O. 2004. Music in your head. *Scientific American*. 14: 24-31.

Aesthetics. Sentience. Extinction.

And that brings us to the final question, lurking way down in the anoxic zone: the question of what consciousness *costs*. Compared to nonconscious processing, self-awareness is slow and expensive¹¹². (The premise of a separate, faster entity lurking at the base of our brains to take over in emergencies is based on studies by, among others, Joe LeDoux of New York University^{117, 118}). By way of comparison, consider the complex, lightning-fast calculations of savantes; those abilities are noncognitive¹¹⁹, and there is evidence that they owe their superfunctionality not to any overarching integration of mental processes but due to relative neurological *fragmentation*⁴. Even if sentient and nonsentient processes were equally efficient, the conscious awareness of visceral stimuli—by its very nature—distracts the individual from other threats and opportunities in its environment. (I was quite proud of myself for that insight. You'll understand how peeved I was to discover that Wegner had already made a similar point back in 1994¹²⁰.) The cost of high intelligence has even been demonstrated by experiments in which smart fruit flies lose out to dumb ones when competing for food¹²¹, possibly because the metabolic demands of learning and memory leave less energy for foraging. No, I haven't forgotten that I've just spent a whole book arguing that intelligence and sentience are different things. But this is still a relevant experiment, because one thing both attributes do have in common is that they are metabolically *expensive*. (The difference is, in at least some cases intelligence is worth the price. What's the survival value of obsessing on a sunset?)

While a number of people have pointed out the various costs and drawbacks of sentience, few if any have taken the next step and

¹¹⁷ Helmuth, L. 2003. Fear and Trembling in the Amygdala. *Science* 300: 568-569.

¹¹⁸ Dolan, R.J. 2002. Emotion, cognition, and behavior. *Science* 298: 1191-1194.

¹¹⁹ Treffert, D.A., and G.L. Wallace. 2004. Islands of genius. *Scientific American* 14: 14-23.

¹²⁰ Wegner, D.M. 1994. Ironic processes of mental control. *Psychol. Rev.* 101: 34-52.

¹²¹ *Proceedings of the Royal Society of London B* (DOI 10.1098/rspb.2003.2548)

wondered out loud if the whole damn thing isn't more trouble than it's worth. Of course it is, people assume; otherwise natural selection would have weeded it out long ago. And they're probably right. I hope they are. *Blindsight* is a thought experiment, a game of *Just suppose* and *What if*. Nothing more.

On the other hand, the dodos and the Steller sea cows could have used exactly the same argument to prove their own superiority, a thousand years ago: *if we're so unfit, why haven't we gone extinct?* Why? Because natural selection takes time, and luck plays a role. The biggest boys on the block at any given time aren't necessarily the fittest, or the most efficient, and the game isn't over. The game is *never* over; there's no finish line this side of heat death. And so, neither can there be any winners. There are only those who haven't yet lost.

Cunningham's stats about self-recognition in primates: those too are real. Chimpanzees have a higher brain-to-body ratio than orangutans¹²², yet orangs consistently recognise themselves in mirrors while chimps do so only half the time¹²³. Similarly, those nonhuman species with the most sophisticated language skills are a variety of birds and monkeys—not the presumably "more sentient" great apes who are our closest relatives^{81, 124}. If you squint, facts like these suggest that sentience might almost be a phase, something that orangutans haven't yet grown out of but which their more-advanced chimpanzee cousins are beginning to. (Gorillas don't self-recognise in mirrors. Perhaps they've already grown out of sentience, or perhaps they never grew into it.)

Of course, Humans don't fit this pattern. If it even is a pattern. We're outliers: that's one of the points I'm making.

I bet vampires would fit it, though. That's the other one.

¹²² Aiello, L., and C. Dean. 1990. An introduction to human evolutionary anatomy. Academic Press, London.

¹²³ Gallup, G.G. (Jr.). 1997. On the rise and fall of self-conception in primates. *In The Self Across Psychology-- self-recognition, self-awareness, and the Self Concept*. Annals of the NY Acad. Sci. 818:4-17

¹²⁴ Carstairs-McCarthy, A. 2004. Many perspectives, no consensus—a review of *Language Evolution*, by Christiansen & Kirby (Eds). *Science* 303:1299-1300.

Finally, some very timely experimental support for this unpleasant premise came out just as *Blindsight* was being copy edited: it turns out that the unconscious mind is better at making complex decisions than is the conscious mind¹²⁵. The conscious mind just can't handle as many variables, apparently. Quoth one of the researchers: "At some point in our evolution, we started to make decisions consciously, and we're not very good at it."¹²⁶

Miscellaneous Ambience (Background Details, Bad Wiring, and the Human Condition)

The child Siri Keeton was not unique: we've been treating certain severe epilepsies by radical hemispherectomy for over fifty years now¹²⁷. Surprisingly, the removal of half a brain doesn't seem to impact IQ or motor skills all that much (although most of hemispherectomy patients, unlike Keeton, have low IQs to begin with)¹²⁸. I'm still not entirely sure why they *remove* the hemisphere; why not just split the corpus callosum, if all you're trying to do is prevent a feedback loop between halves? Do they scoop out one half to prevent alien hand syndrome—and if so, doesn't that imply that they're knowingly destroying a sentient personality?

The maternal-response opioids that Helen Keeton used to kickstart mother-love in her damaged son was inspired by recent work on attachment-deficit disorders in mice¹²⁹. The iron-scavenging clouds that appear in the wake of the Firefall are based

¹²⁵Dijksterhuis, A., *et al.* 2006. *Science* 311:1005-1007.

¹²⁶Vince, G 2006. "Sleeping on it' best for complex decisions." Newscientist.com, <http://www.newscientist.com/channel/being-human/dn8732.html>.

¹²⁷Devlin, A.M., *et al.* 2003. Clinical outcomes of hemispherectomy for epilepsy in childhood and adolescence *Brain* 126: 556-566.

¹²⁸Pulsifer, M.B., *et al.* 2004. The cognitive outcome of hemispherectomy in 71 children. *Epilepsia*. 45: 243-54.

¹²⁹Moles, A., Keiffer, B.L., and F.R. D'Amato. 2004. Deficit in attachment behavior in mice lacking the μ -Opioid receptor gene. *Science* 304: 1983-1986.

on those reported by Plane *et al.*¹³⁰. I trawled The Gang of Four's linguistic jargon from a variety of sources^{81, 131, 132, 133}. The multilingual speech patterns of *Theseus'* crew (described but never quoted, thank God) were inspired by the musings of Graddol¹³⁴, who suggests that science must remain conversant in multiple grammars because language leads thought, and a single "universal" scientific language would constrain the ways in which we view the world.

The antecedent of Szpindel's and Cunningham's extended phenotypes exists today, in the form of one Matthew Nagel¹³⁵. The spliced prosthetics that allow them to synesthetically perceive output from their lab equipment hails from the remarkable plasticity of the brain's sensory cortices: you can turn an auditory cortex into a visual one by simply splicing the optic nerve into the auditory pathways (if you do it early enough)^{136, 137}. Bates' carboplatinum augments have their roots in the recent development of metal musculature^{138, 139}. Sascha's ironic denigration of TwenCen psychiatry hails not only from (limited) personal experience, but from a pair of papers^{140, 141} that strip away the mystique from cases of so-called *multiple personality disorder*.

¹³⁰ Plane, J.M.C., *et al.* 2004. Removal of meteoric iron on polar mesospheric clouds. *Science* 304: 426-428.

¹³¹ Fitch, W.T., and M.D. Hauser. 2004. Computational Constraints on Syntactic Processing in a Nonhuman Primate. *Science* 303:377-380.

¹³² Premack, D. 2004. Is Language the Key to Human Intelligence? *Science* 303: 318-320

¹³³ Holden, C. 2004. The origin of speech. *Science* 303: 1316-1319.

¹³⁴ Graddol, D. 2004. The future of language. *Science* 303: 1329-1331.

¹³⁵ BBC News. 2005. Brain chip reads man's thoughts. March 31. Story online at <http://news.bbc.co.uk/go/pr/fr/-/1/hi/health/4396387.stm>

¹³⁶ Weng, J. *et al.* 2001. Autonomous Mental Development by Robots and Animals. *Science* 291: 599-600.

¹³⁷ Von Melchner, L, *et al.* 2000. Visual behaviour mediated by retinal projections directed to the auditory pathway. *Nature* 404: 871-876.

¹³⁸ Baughman, R.H. 2003. Muscles made from metal. *Science* 300: 268-269.

¹³⁹ Weissmüller, J., *et al.* 2003. Change-induced reversible strain in a metal. *Science* 300: 312-315.

¹⁴⁰ Piper, A., and Merskey, H. 2004. The Persistence of Folly: A Critical Examination of Dissociative Identity Disorder. Part I. The Excesses of an Improbable Concept. *Can. J. Psychiatry* 49: 592-600.

(Not that there's anything wrong with the concept; merely with its diagnosis.) The fibrodysplasia variant that kills Chelsea was based on symptoms described by Kaplan *et al.*¹⁴².

And believe it or not, those screaming faces Sarasti used near the end of the book represent a very real form of statistical analysis: Chernoff Faces¹⁴³, which are more effective than the usual graphs and statistical tables at conveying the essential characteristics of a data set¹⁴⁴.

¹⁴¹ Piper, A., and Merskey, H. 2004. The Persistence of Folly: A Critical Examination of Dissociative Identity Disorder. Part II. The Defence and Decline of Multiple Personality or Dissociative Identity Disorder. *Can. J. Psychiatry* 49: 678–683.

¹⁴² Kaplan, F.S., *et al.* 1998. The Molecules of Immobility: Searching for the Skeleton Key. *Univ. Pennsylvania Orthopaedic J.* 11: 59-66. Available online at <http://www.uphs.upenn.edu/ortho/oj/1998/oj11sp98p59.html>

¹⁴³ Chernoff, H. 1973. Using faces to represent points in k-dimensional space graphically. *Journal of the Americal Statistical Association* 68:361-368.

¹⁴⁴ Wilkinson, L. 1982. An experimental evaluation of multivariate graphical point representations. *Human Factors in Computer Systems: Proceedings*. Gaithersberg, MD, 202-209.

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