Article

Sexual Paradox in the Conscious Brain

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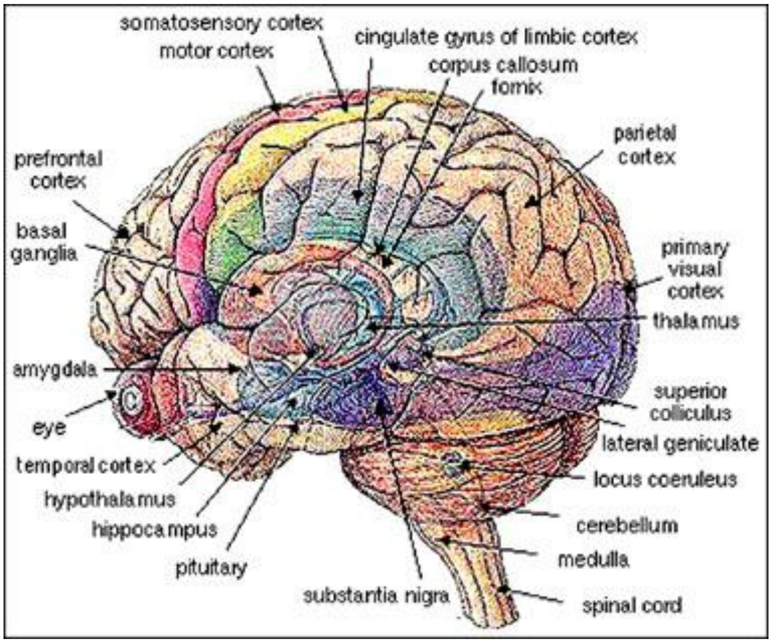
ABSTRACT

Despite its seemingly ephemeral basis in a sappy organismic brain at the 'apex' of evolution, subjective consciousness may be too fundamental a property to be explained, except in terms of fundamental physical principles, as a complementary manifestation to quantum non-locality, which directly manifests the principle of choice in free-will in generating history. This cosmology is intrinsically sexual. Subject-object complementarity is different from either panpsychism or Cartesian duality. The subjective aspect is described as complimentary to the physical loophole of quantum uncertainty and entanglement, just as the wave and particle aspects of the quantum universe are complementary. Subjective and objective are interdependent upon one another with neither fully described in terms of the other. Furthermore, the transactional interpretation is intrinsically sexual in the sense that all exchanges are mediated through entangled relationship between an emitter and an absorber in which reduction of the wave function is a match-making sequence of marriages. This sexual paradigm is not simply an analogy, but is a deep expression of the mutual complementarity and intrinsic relationship manifest in the existential realm, physically and subjectively.

Key Words: subjective, objective, complementary, quantum uncertainty, non-locality, quantum entanglement, sexual paradox, consciousness, brain.



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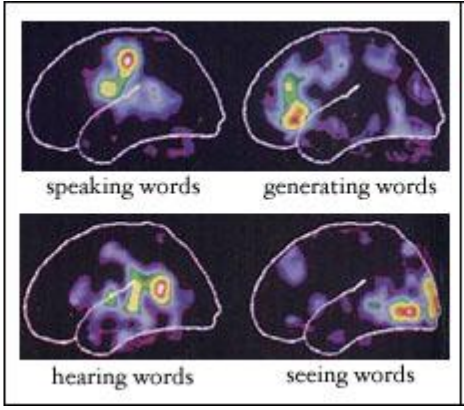
The Enigmatic Three Pound Universe

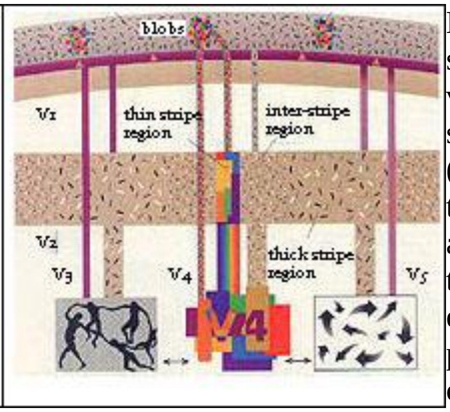
The brain is the gateway to the deepest enigma of modern science - subjective consciousness and the paradox of free will in a physical universe. It thus holds all the trump cards in the final frontier of scientific discovery, whose surface has only so far barely been scratched. Although researchers in the reductionist paradigm of artificial intelligence and related areas have sought to see the brain as simply a glorified computer, there is little about the brain which in any way resembles the digital device we have invented to carry out our computational tasks. For a start, the brain is a very bad computer. We have a memorizable digit span of only about seven figures and find even simple arithmetic calculations difficult without the aid of a pencil and paper. By contrast, we are able to remember whether or not almost a million different scenes are familiar or have been seen before, hinting at an almost unlimited 'environmental' memory capacity.

This kind of contrast is reflected in everything we know about the anatomy and physiology of the brain. Although the first nervous system to be studied, the giant axon potential of the squid, does have an apparently discrete response, it is in fact a pulse coded analogue signal which is being transferred, whose rate of discharge is proportional to the continuous depolarization at the cell body. When we come to examine even the simplest nervous systems such as the ganglia of the sea slug aplysia we find that it is the 'silent' analogue cells with continuous potential changes which act as the organizing centres for behavior, with the pulse coded cells merely acting as long distance relays.

Similarly when we look at brain waves in the cortical electroencephalogram or EEG, we find so-called 'brain waves' such as the a, b, and g rhythms, which are not only continuous changes but broad spectrum vibrations more characteristic of chaos or edge of chaos dynamics, than the exact resonances of an ordered dynamical system. In complete contrast to the essentially serial nature of the digital computer despite attempts to introduce some relatively trivial parallel architecture, the overweening paradigm for the central nervous system is 'parallel distributed processing'. Generally there are as little as 10 synapses between input and output despite there being between 10^{10} and 10^{11} neurons and around 10^{15} synapses in the cerebral cortex. Central nervous networks are also intrinsically fractal in architecture because of the many-to-many nature of connections arising from the tree structure of a neuron's dendrites and axons. The combination of this many-to-many fractal architecture and the wavelike nature of neuronal transmissions is a key concept in Karl Pribram's description of the 'holographic brain' (Pribram R553). Phase-locking can mark out populations of cells sharing a common 'experience' or process from other randomly related stimuli. This 'holographic' view is supported by much physiological evidence. EEGs, particularly in the gamma band 40-60 Hz (cycles/sec), and their averaged event-related potentials, display phase coherence in a situation when a given perception is recognized, and out-of-phase chaotic 'hunting', when we are trying to orient to an unfamiliar experience. Phase beats are the basis of the quantum uncertainty relationship (p 299) implying a potential connection. The complementarity between continuous wave coherence and the discrete local information carried to a given neuron or synapse is deeply similar to wave-particle complementarity.

Another important complementarity is provided by the reliance many neuronal connections make on non-linear processes and diverse chemical neurotransmitters to transduce information across the synaptic junction. Neurotransmitters come in a variety of types both excitatory and inhibitory of both temporary short-term effect and of potentially permanent effect in the long-term potentiation or LTP involved in memorization.





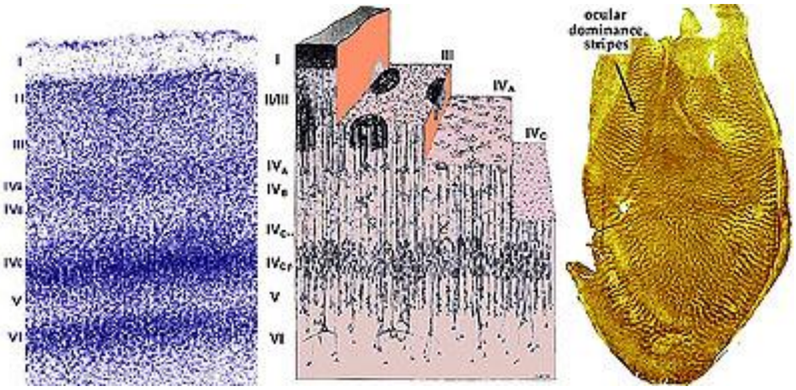
Despite the development of sophisticated techniques for visualizing brain activity such as those for speech (left), and ingenious work tracing connectivity of activity between neurons in the cortex such as that establishing distinct parallel processing regions for colour and movement in vision (right, Zeki R777), no objective brain state is equivalent to a subjective conscious experience. The difficulty of bridging this abyss is called the hard problem in consciousness research (Chalmers R112)

If we consider what brains actually have to do to ensure our survival we can see at once why this might be the case. Many problems which simulate environmental decision-making are computationally intractable. A good example is the traveling salesman problem - finding the shortest distance around n cities, which to be computed classically requires tracing every possible route which grows super-exponentially as (n-1)!/2 To calculate a route around some 30 cities would take a modern serial computer the entire history of the universe to complete.

A gazelle standing at a forking in the paths to a water hole would become stranded and eaten by the tiger if it had to resort to classical computation. Moreover many of these problems are prisoners' dilemma problems in which the 'opponent' is forever changing their strategy, making computation historically out-of-date. The tiger may for example choose the safest looking path, or switch unpredictably. Finally there is no single answer to many of these decisions, most of which have many possible outcomes rather than one computational solution, which is why we have evolved to have free choice in the first place.

The way the brain appears to have evolved to solve this problem is to engage a kind of Darwinistic internal ecosystem of resonating excitations, which are chaotic in time and enable holographic wave processing in 'space' across the cortex. In a dynamic brain, phases of chaos are essential, both to provide the sensitivity on initial conditions of chaos which is essential to respond acutely sensitively to the outside world, and to provide the unpredictable, seemingly random, variation required to prevent the system getting caught in the rut of one overwhelming 'attractor' - the nemesis of all ordered systems.

The overall architecture of the mammalian brain consists of an overarching cortex acting as a modifier of resonant excitations ascending from mid-brain centres in the thalamus and deeper basal brain centres driving phases of alertness, sleep and dreaming. The cortex has a modular parallel architecture with sensory and cognitive processing for different modes occurring in parallel in distinct centres. For example upward of 24 centres have been identified for vision, handling colour and motion in separate parallel processing units. These parallel differentiations extend to specific types of feature such as separate regions for recognition of different human faces and of human facial emotional expressions. Each of these modular regions is in turn organized into a series of columns on a scale of about 1mm which act as feature detectors for example of lines with a specific orientation. Processing occurs in three to five distinct cellular layers comprising a mix of excitatory and inhibitory cells forming feedback loops enabling processing such as contrast enhancement.



Typical cortical structures (centre) are a combination of five-layers of neurons (left), each composed into columnar modules about 1mm on the cortical surface. Such modules are sensitive to stimuli such as a line of a given orientation. Blob centres in layer II are also shown (p 365). Although specific sensory area have functional and anatomical specializations neural plasticity can enable changes of functional assignment indicating common principles throughout the cortex. Ocular dominance columns (right) for left or right eye illustrate functional columnar architecture.

Given only some 30,000 protein-producing structural genes in the human genome, there are far too few to genetically determine exact details of brain structure on a cell-to-cell basis in a hard-wired manner. The best specificity that can be managed consists of general rules of synaptic growth between specific cell types in different areas, which is what we see in cell migration and synaptic contact during development. In the visual system, the developing retina first begins to manifest chaotic excitation. Only then does differentiation in the lateral geniculate become evident and in turn from its dynamical excitation the visual cortex becomes differentiated for pattern recognition. Thus while genes may be able to encode interconnections between specific excitatory and inhibitory cell types and to promote growth of axons between cell types in different regions, the central nervous system depends on dynamical excitation to establish the developed architecture of its connections. Genetic determinism is thus a myth. Genes create developmental potentialities, which are shaped by excitation in both development and the environment. Nature thus utilizes nurture.

This dynamical basis for development is reflected in cortical plasticity, where emerging changes in function can result in regions previously assigned to one function taking over another. Examples are changes in binocular optical dominance when one or other eye is covered, through to the phenomenon of the phantom limb, where regions assigned to a removed limb become invaded by other functional areas, resulting in sensory confusion, and the illusion that the limb is still present, perhaps even painful. Changes also take place during higher learning such as becoming fluent in a new language. These kinds of specialization and development are reflected in the modular organization of the cortex we see in positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) studies of the language and perceptual areas of the cortex.

The cerebral cortex is divided between front and rear broadly into motor and perception areas by the Sylvian fissure, which divides frontal regions and the motor cortex from the somatosensory (touch) and other sensory areas, including vision and hearing. The broadly sensory 'input' and associated areas of the parietal and temporal cortices are complemented by frontal and pre-frontal areas which deal with 'output' in the form of action rather than perception and with forming anticipatory models of our strategic and living futures. These active roles of decision-making and 'working memory', which interact from pre-frontal cortical areas complement the largely sensory-processing of the temporal, parietal and occipital lobes with a space-time representation of our 'sense of future' and of our will or intent.

Another motif with undertones of sexual complementarity (p 388) is the fact that we possess two left and right hemispheres which are to all purposes separate cortices linked only by massive underlying parallel circuitry in the corpus callosum. Although much has been romanticized about our left and right brains in terms of the contrast between intuition and structured reasoning, and some people almost banish the sub-dominant hemisphere to inarticulate zombie-like status, there is abundant evidence for a degree of complementarity between foci in the two hemispheres, for example analytic language versus creative expression, linguistic versus musical perception, and holistic versus mechanical modes of thought.

Such lateralization has also been associated with the complementarity between different types of mathematical reasoning, the continuous ideas of topology (p 492) and calculus being associated with the right hemisphere, by contrast with the discrete operations of algebra (p 493) hypothetically assigned, like language to the left. The two key language areas, Broca's frontal area for verbal speech fluency and Wernicke's temporal area for semantic resolution are traditionally on the left. However one should note that lateralization is more prominent in males and that females have generally greater facility with language, despite their language processing being less lateralized (p 389).

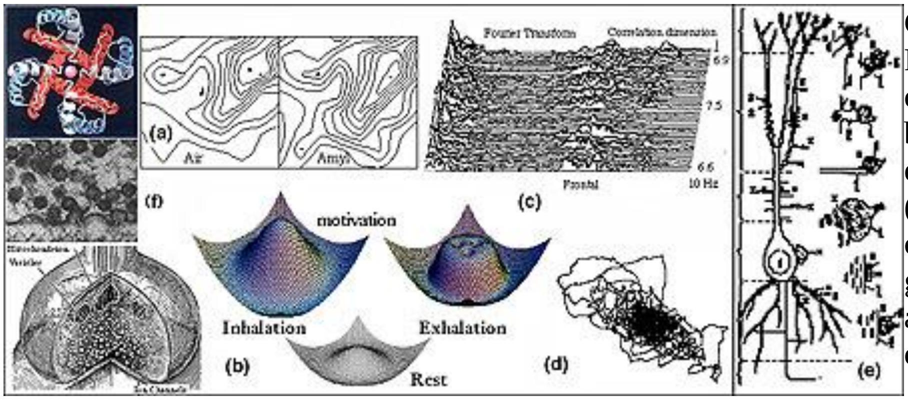
As of 2010 a slew of research has emerged, which shows that handedness is not just confined to humans, but extends widely throughout the 'bilaterally-symmetric' animal kingdom spanning arthropods and vertebrates. Vetrebrates from fish through birds to mammals are liable to hunt or forage with their right eyes and look for predators with their left, which allows brain areas in each cortex to become better adapted at serving each of these challenges. Prisoner's dilemma game theory simulations show that the safety in numbers when many members of a species adopt the same asymmetric strategy is offset to the best advantage of all players when there is a smaller subpopulation adopting the contralateral strategy thus confusing th epredator without becoming a primary target (Southpaws: The evolution of Handedness 2010 Nora Schultz New Scientist).

The cortex itself is relatively inert in electrodynamical terms and may actually form a complex boundary constraint on the activity of more active underlying areas such as the thalamus, which contains a number of centers with ordered projections to and from corresponding areas of the cortex.

Characteristic of the mammalian brain is also the peripheral 'limbic' system forming a loop around the periphery of the cortex, connecting primary frontal regions mediating integrated decision-making in action and the emotional centres of the cingulate cortex with the flight and fight centre of the amygdala, the long-term sequential memory of the hippocampus and basic bodily and sexual functions of the hypothalamus in great feedback loops whose dynamics are characteristic of changes in emotional mood and its influence on our outlook and strategic direction. The limbic system lies at the core of mammalian emotionality from fear and anger to love and our capacity to transcend immediate genetic determinacies.

The overall dynamical organization of the mammalian brain is also evident in the major ascending distributed pathways from the basal brain using specific neurotransmitters such as dopamine, noradrenaline and serotonin, which modify alertness and light and dreaming sleep (see New Scientist 28 Jun 2003 29) and are also modulated by psychedelics such as psilocin and mescaline. These fan out from basal brain centres into wide areas of the cortex connecting into specific cortical layers where processing is taking place. The large pyramidal cells which coordinate output thus have several different types of neurotransmitter modulating their excitation, both in an excitatory and an inhibitory manner.

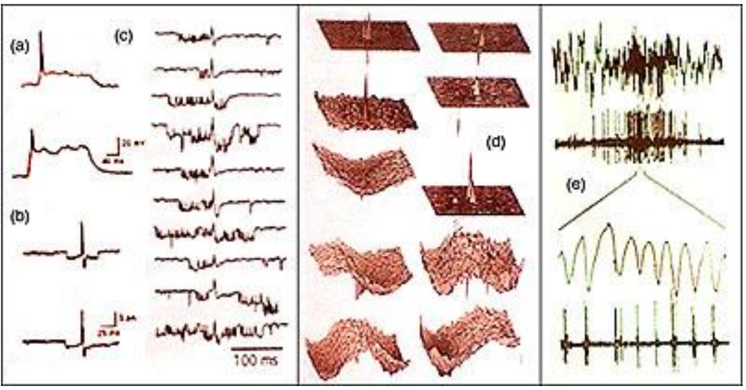
Walter Freeman's model of chaos in sensory perception (Skarda and Freeman R646, Freeman R226) gives a good feeling for how dynamical chaos (p 498) could play a key role in sensory recognition, for example, when a rabbit sniffs the air for a strange smell. The olfactory cortex enters high energy chaotic excitation forming a spatially correlated wave across the cortex, causing the cortex to travel through its space of possibilities without becoming stuck in any mode. As the sniff ends, the energy parameter reduces, carrying the dynamic down towards basins in the potential energy landscape. If the smell is recognized the dynamic ends in an existing basin, a recognized smell, but if it is a new smell, a bifurcation eventually occurs to form a new basin (a new symbol is created) constituting the learning process. The same logic can be applied to cognition and problem solving in which the unresolved aspects of a problem undergo chaotic evolution until a bifurcation from chaos to order arrives at the solution in the form of a flash of insight - "eureka!".



Chaos in perception: Freeman's model of olfaction is represented (a) by differing distributed excitations on the cortex. (b) A state of high energy chaos during inhalation gives rise to a lower energy attractor under recognition or learning. (c) Electroencephalogram shows broad spectrum waves with a finite correlation dimension, consistent with chaotic excitation. (d) A chaotic orbit generated by an EEG. (e) Neurons are fractal trees, potentially enabling inter-relationship between global instability and molecular or quantum uncertainty if the system is critically poised. (f) Top to bottom, ion channel is a single molecule which may display non-linear (quadratic dynamics) being turned on by two neurotransmitter molecules; synaptic vesicles budding at the membrane; a synaptic bulb containing vesicles and their recipient ion channels across the cleft. Eddington pointed out that the uncertainty of position of a vesicle is approximately the width of the membrane. Ion channels display stochastic activation (Liljenström R417) and have been modeled using fractal kinetics (Liebovitch R414).

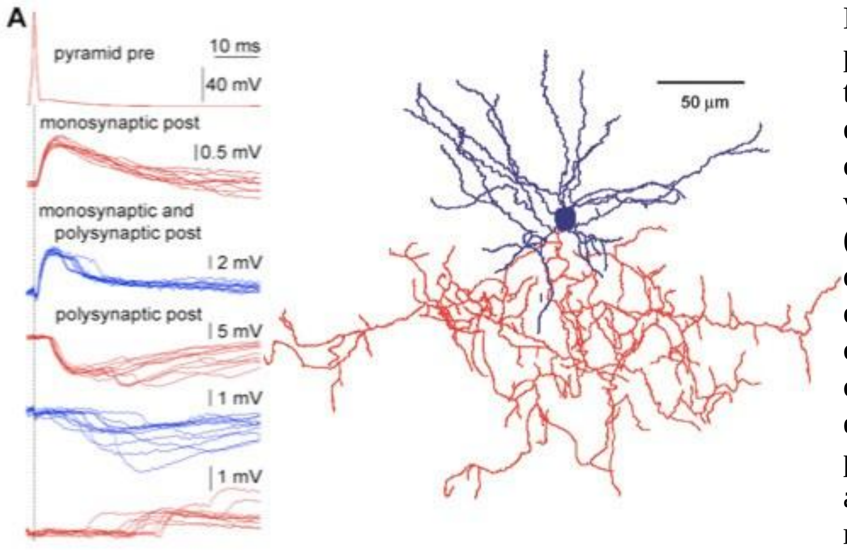
Indicators of the use of chaos in neurodynamics come also from measurements of the fractal dimension (p 499) of a variety of brain states, from pathology through sleep to restful wakefulness. Recordings from single neurons, and from other cells such as the insulin-releasing cells of the pancreas confirm their capacity for chaotic excitation. The organizers of neural systems are also frequently non-pulse coded 'silent' cells capable of continuous non-linear dynamics. Despite the approximate linearity of the axonal discharge rate with depolarization, virtually all aspects of synaptic transmission and excitation have non-linear characteristics capable of chaos and bifurcation. For example the acetyl-choline ion channel has quadratic concentration dynamics, requiring two molecules to activate. Many cells have sigmoidal responses providing non-linear hyper-sensitivity and are tuned to this threshold. The electroencephalogram itself although nominally described as having brain rhythms such as alpha, beta, gamma and theta actually consists of broad band frequencies, rather than harmonic resonances, consistent with a ground-swell of chaotic excitation (King R367, R369, R370, R373). Broadly speaking neurodynamics is "edge of chaos" (p 506) in the time domain and parallel distributed in a coherent 'holographic' manner (Pribram) spatially. Phase coherence (e.g. in the 40 Hz band) has been associated with binding between related parts of the brain supporting an integrated perceptual experience, providing a mathematical parallel with quantum wave coherence. While artificial neural nets invoke thermodynamic 'randomness' in annealing to ensure the system doesn't get caught in a sub-optimal local minimum, biological systems appear to exploit chaos to free up their dynamics to explore the 'phase space' of possibilities available, without becoming locked in a local energy valley which keeps it far from a global optimum.

Into this picture of global and cellular chaos comes another scale-linking property, the fractal (p 499) nature of neuronal architecture and brain processes and their capacity for self-organized criticality at a microscopic level. The many-to-many connectivity of synaptic connection, the tuning of responsiveness to an arbitrarily sensitive 'sigmoidal' threshold, and the fractal architecture of individual neurons combine with the sensitive dependence of chaotic dynamics (p 500) and self-organized criticality (p 501) of global dynamics to provide a rich conduit for instabilities at the level of the synaptic vesicle or ion channel to become amplified into a global change. The above description of chaotic transitions in perception and cognition leads naturally to critical states in a situation of choice between conflicting outcomes and this is exactly where the global dynamic would become critically poised and thus sensitive to microscopic or even quantum instabilities.



Evidence for complex system coupling between the molecular and global levels. Stochastic activation of single ion channels in hippocampal cells (a) leads to activation of the cells (c). Activation of such individual cells can in turn lead to formation of global excitations as a result of stochastic resonance (d). Individual cells are capable of issuing action potentials in synchronization with EEG peaks (e) (Liljenström R417).

From the synaptic vesicle, we converge to the ion channel, which in the case of the K+ voltage-mediated ion channel with its fractal kinetics (Liebovitch R414), and further to the structure and conformational dynamics of proteins, both of which operate on non-linear fractal protocols. The brain is thus capable of supersenstivity to the instabilities of the quantum milieu (Eccles R181).
Chaotic excitability may be one of the founding features of eucaryote cells (King R363, R366). The Piezo-electric nature and high voltage gradient of the excitable membrane provides an excitable single cell with a generalized quantum sense organ. Sensitive dependence would enable such a cell to gain feedback about its external environment, rather than becoming locked in a particular oscillatory mode. Excitation could be perturbed mechanically and chemically through acoustic or molecular interaction, and electromagnetically through photon absorption and the perturbations of the fluctuating fields generated by the excitations themselves. Such excitability in the single cell would predate the computational function of neural nets, making chaos fundamental to the evolution of neuronal computing rather than vice versa. The chemical modifiers may have been precursors of the amine-based neurotransmitters which span acetyl-choline, serotonin, catecholamines and the amino acids such as glutamate and GABA, several of which have a potentially primal status chemically. Positively charged amines may have complemented the negatively charged phosphate-based lipids in modulating membrane excitability in primitive cells without requiring complex proteins. It is possible that chaotic excitation dates from as early a period as the genetic code itself and that the first eucaryote cells may have been excitable via direct electrochemical transfer from light energy, before enzyme-based metabolic pathways developed.

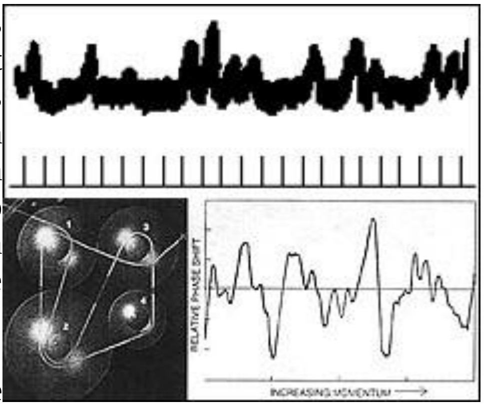


Left: Single pre-synaptic pyramidal action potential leads to multiple post-synaptic excitations. Right: Structure of chandelier or axon-axonal cells with dendrites (blue) and axons (red). Recently it has been discovered that a specific class of cortical neuron, the chandelier cell is capable of changing the patterns of excitation between the pyramidal neurons that drive active output to other cortical regions and to the peripheral nervous system, in such a way that single action potentials of human neurons are sufficient to recruit Hebbian-like neuronal assemblies that are proposed to participate in cognitive processes. Chandelier cells, which were only discovered in the 1970s, and are more common in humans than other mammals such as the mouse, and were originally thought to be purely inhibitory, are axon-axonal cells, which can result in specific poly-synaptic activation of pyramidal cells. (Molnar, G et. al. 2008 Complex Events Initiated by Individual Spikes in the Human Cerebral Cortex PLOS

Biology 6/9 222, Woodruff, A and Yuste R 2008 Of Mice and Men, and Chandeliers PLOS Biology 6/9 243)

It is thus natural to postulate that, far from being an epiphenomenon, consciousness is a feature which has been elaborated and conserved by nervous systems because it has had unique survival value for the organism. We are thus led to an examination of how chaotic excitation may have evolved from single-celled animals through the early stages represented by Hydra, which, despite having an unstructured neural net, has no less than 12 modes of locomotion, to the complex nervous systems of metazoa. We have seen how chaotic excitation provides for exploration of phase space and sensitivity to internal and external fluctuations. However the conservation of consciousness may also involve features expressed only by chaotic systems which are fractal to the quantum level.

It is a logical conclusion that the conscious brain has been selected by evolution because its biophysical properties provide access to an additional principle of predictivity not possessed by formal computational systems. One of the key strategies of survival is anticipation and prediction of events (King R365, Llinás R420). Computational systems achieve this by a combination of deductive logic and heuristic calculation of contingent probabilities. However quantum non-locality may also provide another avenue for anticipation which might be effective even across the membrane of a single cell, if wave reductions are correlated in a non-local manner in space-time.



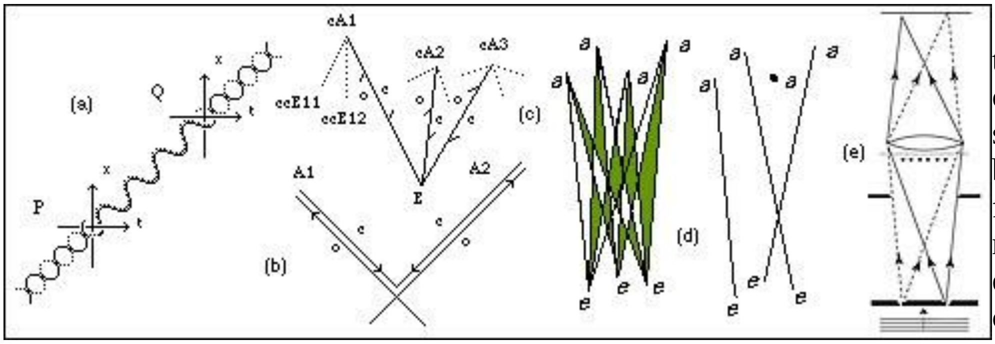
Above: Output from a frog retinal rod cell displays sensitivity to single quanta (Blakemore). Below: Phase shift in an electron traversing an open molecular medium shows chaotic phase shift (Gutzwiller R274) supporting a quantum chaotic model at the molecular level despite quantum suppresion of chaos in closed systems (p 501). Enzymes also depend on quantum tunneling to lower their transition energies, supporting a variety of quantum effects at the molecular level in brain function.

The limits to the sensitivity of nervous systems are constrained only by the physics of quanta (p 298) rather than biological limits. This is exemplified by the capacity of retinal cells to record single quanta, and by the fact that membranes of cochlear cells oscillate by only about one H atom radius at the threshold of hearing, well below the scale of thermodynamic fluctuations. Moth pheromones are similarly effective at concentrations consistent with one molecule being active, as are the sensitivities of some olfactory mammals. The sense modes we experience are not merely biological. They encompass the basic qualitative modes of quantum interaction with the physical universe - giving sensory consciousness plausible cosmological status. Vision deals with interaction between orbitals and photons, hearing with the harmonic excitations of molecules and potentially with membrane solitons as well. Smell is the avenue of orbital-orbital interaction, as is taste. Touch is a hybrid sense involving a mixture of these.

The very distinct qualitative differences between vision, hearing, touch and smell do not appear to be paralleled in the very similar patterns of electrical excitation evoked in their cortical areas. If all these excitations can occur simultaneously in the excitable cell, its quantum-chaotic excitation could represent a form of cellular synaesthesia, which is specialized in representing each individual sense mode. Thus in the evolution of the cortical senses from the most diffuse, olfaction, the mammalian brain may be using an ultimate universality, returning to the original quantum modes of physics in a way which can readily be expressed in differential organization of the visual, auditory, and somatosensory cortices according to a single common theme of quantum excitability. This is consistent with cortical plasticity which enables a blind person to use their visual areas for other sensory modes. Chaotic excitation thus leads naturally to a cellular multi-quantum-mode sense organ responding to external perturbations of the environment by sensitive dependence.

Can Transactions explain Conscious Intentional Will?

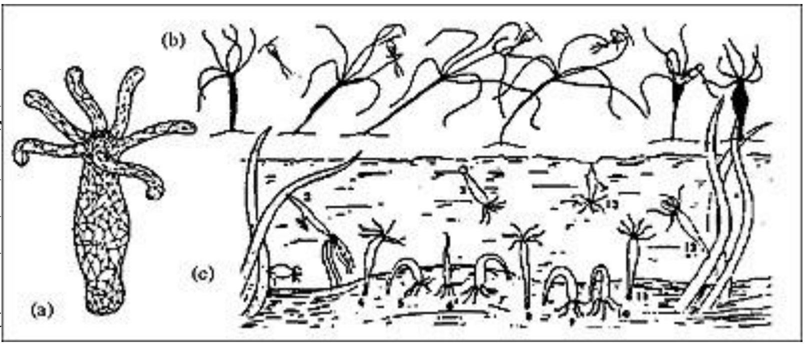
Supposing this chaotic sense organ found that these quantum properties also aided not just the perception of the world around it, but the anticipation of situations in the world critical to survival, through a novel form of physics which forms the basis of subjective consciousness. This is the critical function of any nervous system. A form of quantum anticipation of its own immediate future may be possible using the inner relationships of quantum entanglement - transactional handshaking with future states (p 308). This anticipation would have critical selective advantage for the organism and thus became fixed in evolution. This may explain directly why the brain is sentiently conscious rather than just being a computer. Computational capacity could be complemented with transactional anticipation through the chaotically fractal central nervous system. The work of Libet (R412) suggests the brain engages such time referrals. The transactional process is also compatible with quantum computation (Brown R86) using a superposition of states. The use by the brain of complex excitons may make it sensitive to an envelope of states spanning immediate past, present and future - the anticipatory 'quantum of the conscious present'. Such excitons might have restricted interactions which would isolate them from quantum decoherence effects (Zurek R784) as illustrated by quantum coherence imaging (Samuel R608, Warren R728). Hameroff and Penrose (R284) suggest that the brain may be able to function as a quantum computer and have speculated that neuronal microtubular protein units may function as quantum cellular automata in such computations, however their OOR model lacks the anticipatory properties and thus the raison d'etre for subjective consciousness described here (p 310).



Quantum transactions (p 308) offer a time-symmetric coupling between past and future states and may help explain the existence of consciousness as a way of anticipating future situations and 'free-will' as a physical manifestation of conscious anticipation.

What is interesting here is that the 'binding problem' - how sensory experiences being processed in parallel in different parts of the cortex are bound together to give the conscious expression we associate with our integrated perception of the world - has no direct solution in terms of being hard-wired to some collection point - the ultimate seat of consciousness. Every indication is that consciousness is distributed and bound together by non-linear resonances in the brain, such as gamma band phase coherence. This is very similar to the problem of quantum measurement (p 300) and exactly what we would expect if self-resonances were being used as part of a quantum transactional (p 308) solution to the perception-cognition dilemma. Just as with phase coherence, transactional interactions involve wave components interfering - the usual retarded ones and advanced ones travelling backwards in time, superimposing to form the real waves occurring in phase coherence. In the transactional model of conscious intention, subjective consciousness enters into the picture as the inner complement of the quantum space-time hand-shaking process. This violates the classical causality of initial states determining future states, which we associate with the Newtonian universe and temporal determinism. This is a consequence of special relativity and the fact that the boundary conditions of collapse include future contingent absorbing states (p 308). Since quantum transactions are general to all quantum interaction, their manifestation in resolving the fundamental questions of intentional action in the physical world gains a cosmological dimension. The conscious brain may thus be a key avenue for the expression of quantum non-locality in space time - a consummation of cosmology, not in the alpha of the big-bang, nor in the omega of finality but in the sigma of interactive complexity (p 298).

The brain has at the same time been evolving towards a type of universality (p 325) expressed in flexible processes for multi-sense processing and modeling. The qualitative differences between the sense modes are not matched by qualitative differences of cortical structure and electrochemical activity. Experiencers of synaesthesia witness multi-sense perception, suggesting conscious neural activity is potentially multisensory. A cosmological question is now raised. Is evolution simply accident, or is it part of the way the quantum universe explores its own space of possibilities, in reaching towards a universal expression of the entangled physical universe? If so what is the status of sensory consciousness?



Hydra poses a dilemma for theories of cognitive development based on neural net organization rather than the complex adaptability of individual neurons. Hydra can reassemble ectoderm and endoderm if turned inside out and has a disseminated neural net (a) with no global structure, except for a slight focus around the mouth. Nevertheless it can coordinate eating in a similar manner to an octopus (b) and possesses more diverse types of locomotion than animals such as molluscs and arthropods which have structured ganglia. These include snail-like sliding, tumbling, inch-worm motion and use of bubbles and surface films.

In a quantum universe we have the many-universes dilemma, inspiring the Schrödinger cat paradox (p 302). In the real world, if we wire a cat to a Geiger counter with possibly lethal consequence, when we open the box, the cat is either alive or dead, not in a superposition of both. Transactional supercausality (p 308) explains this paradox as follows - the many probability multiverses solve a problem of super-abundance by hand-shaking across space-time to reduce the packet of all possible emitter-absorber connections to one 'happy marriage' . The universe, thus becomes experientially historical. Napoleon meets his Waterloo, but Britain wins Trafalgar, despite the feigned uncertainty of Nelson's blind eye. The same goes for all the hopeful monsters of evolution when mutations become successful. Quantum non-locality appears to have a method, through space-time hand-shaking, to determine which of the multi-verses hovering in the virtual continuum will actually become manifest. The role of consciousness as a cosmological process appears to mediate effectively between the world of the cosmic subjective, represented in physics as quantum non-locality, with the uniqueness of historicity, which never fully converges to the statistical interpretation of the cosmic wave function, because each change leads to another, throughout cosmic epochs.

This leads to a deep question, shared by all human cultural traditions, from the dawning of shamanism, through Vedanta to the Tao and even in the Judeo-Christian prophetic tradition, that mental states of awareness and subsequent happenings are interrelated. If historicity is interactive with both the quantum realm and the existential condition, what are the consequences for science, society and cosmology itself? Our description of reality here suggests that the physical universe has a complement - the subjectively conscious existential condition. Such a view both of the cosmological role of evolution to sentience and the brain as an interface between the cosmic subjective and the physical universe puts us right back into the centre of the cosmic cyclone in a way which Copernicus, Galileo, Descartes, Leonardo and Albert Einstein would have all appreciated. Consciousness may then not just be a globally-modulated functional monitor of attention, subject helplessly to the physical states of the brain, but a complementary aspect to physical reality, interacting with space-time through uncertainty and quantum entanglement in a manner anticipated by Jungian synchronicity.

Although subjective consciousness, by necessity, reflects the constructive model of reality the brain adopts in its sensory processing and associative areas, this does not fully explain the subjective aspect of conscious experience. Conscious experience is our only direct avenue to existence. It underlies and is a necessary foundation for all our access to the physical world. Without the consensuality of our collective subjective conscious experiences as observers, it remains uncertain that the physical world would have an actual existence. It is only through stabilities of subjective conscious experience that we come to infer the objective physical world model of science as an indirect consequence. For this reason, despite its seemingly ephemeral basis in a sappy organismic brain at the 'apex' of evolution, subjective consciousness may be too fundamental a property to be explained, except in terms of fundamental physical principles, as a complementary manifestation to quantum non-locality, which directly manifests the principle of choice in free-will in generating history.

This cosmology is intrinsically sexual. Subject-object complementarity is different from either panpsychism or Cartesian duality. The subjective aspect is described as complimentary to the physical loophole of quantum uncertainty and entanglement, just as the wave and particle aspects of the quantum universe are complementary. Subjective and objective are interdependent upon one another with neither fully described in terms of the other. Furthermore, the transactional interpretation is intrinsically sexual in the sense that all exchanges are mediated through entangled relationship between an emitter and an absorber in which reduction of the wave function is a match-making sequence of marriages. This sexual paradigm is not simply an analogy, but is a deep expression of the mutual complementarity and intrinsic relationship manifest in the existential realm, physically and subjectively.

Furthermore, the theory suggests the evolution of sexuality, as it is found in metaphyta, is not simply an analogy with quantum complementarity, but is an emergent expression of the same complementarity principle. The single ovum, by necessity, is driven to seek fertilization through a solotonic wave of excitation which extends across the membrane. The multiple sperm, by contrast, are particulate packets of molecular DNA, without a cellular cytoplasmic contribution. Thus biological sexuality is utilizing quantum complementarity in the symmetry-breaking of gender.

The pivotal role of complementarity is reflected in both the Tantric (p 459) and Taoist (p 452) cosmologies. In Tantra, the subject-object relation is an intimate sexual union, which, in its retreat from complete intimacy, spawns all the complexity of the existential realm. In the Taoist view the same two dyadic principles are the creative and receptive forces which in their sequential transformation in the I Ching (p 457) give rise to all the dynamic states of existence. In Taoist thought, the cosmological principle is manifest in three phenomena, chance, life and consciousness, the very same phenomena appearing here in quantum physics, evolution and brain dynamics. The transactional principle clearly establishes the marital dance of emitter and absorber as the foundation of historicity - the collapse of the infinite shadow worlds of multiverses into the one line of history we experience in life, evolution, consciousness and social and natural history.
Randomness remains a scientific mystery, explained ultimately by quantum entanglement. The source of the scientific concept of randomness lies in theories, such as probability theory, statistical mechanics, and the Copenhagen interpretation of quantum mechanics which draw generalities from an incomplete knowledge of the system. However the source of supposedly random events in the real world lies either in highly unstable systems, which themselves may draw their uncertainty from the quantum level, or directly from the phenomena of reduction of the wave function under the probability interpretation. The transactional approach seeks to explain the sub-stratum of entanglement in a deeper interaction. This could provide an ultimate explanation for the origin of randomness in the underlying sexual weave of transactions.

The diversity of wave-particles resulting from cosmic symmetry-breaking (p 310) finds its final interactional complexity, in which all forces have a common asymmetric mode of expression, in complex molecular systems. It is thus natural that fundamental principles of their quantum interaction may be ultimately realized in the most delicate, complex and globally interconnected molecular systems known - those involved in brain dynamics. In this sense the brain is the culmination of a fractal interaction induced by' alpha limit' of cosmic symmetry-breaking - the cosmic sigma limit just as the heat death is an omega limit (p 298).

What is the relationship between the existential observer and the universe at large? What is the relation between conscious subjectivity and the objective physical world? This is a question which has plagued philosophers and scientists from the early Greeks through Bishop Berkeley and Descartes to modern researchers, from Francis Crick (Crick and Koch R137), who believes consciousness to be a product specific brain oscillations and their neural mechanisms, to David Chalmers (R112), who sees the 'hard problem in consciousness research' as a fundamental philosophical chasm, which can only be crossed through a greater description of reality.

Despite the advances of modern scanning techniques, a chasm still remains between the brain states under a researcher's probe and the subjective experiences of reality we depend on for our awareness of the physical world. This comes on top of a fundamental complementarity upon which we depend for our existence. Although we live as biological organisms, raise families, navigate our lives and perform our science on the assumption of the existence of the physical world, we access physical reality only through our subjective sensory experiences. Without the direct veridical access we have to subjective experience, there would be no conscious 'observers'. It remains unclear under these circumstances that one could establish that the physical universe would exist in any objective 'sense'. Ironically, a purely objective physical world description considers only brain states, leaving subjective consciousness to the perilously ephemeral status of an epiphenomenon, or not existent at all. However the physical world is really a consensual stability property of our conscious experiences, despite the fact that we are physical organisms whose consciousness appears to depend on our remaining alive. We can both consciously agree that the table is a table or that we will bleed if cut, so the subjective aspect is capable of representing the objective. The objective is capable in turn of 'incorporating' the subjective in terms of uncertainty in the physical. A fully cosmological theory would have to encompass both.
This access to the subjective is profoundly augmented by a variety of subjective states, some of which have no direct correlate in the physical world, yet can be commandingly real to the observer. Firstly consciousness is constructive, and fills in details to generate a subjective description of reality which can often lead to peculiar results as illustrated by visual illusions). More significantly we have a spectrum of subjective states, from meditative trance, through psychedelic hallucination, the intense phases of dreaming, to near death experience. Although various tests can be made by the astute subject to distinguish dreaming from waking reality, the very fact of dreaming as an alternative veridical reality raises a deep question about the nature of the everyday world we perceive. Is it nothing but an internal dream state anchored by additional stability constraints provided by sensory input? If we are actually witnessing exclusively and only our internal model of reality, what then, if at all, is the manifest nature of the physical world? And what IS the existential status of this 'internal model' we ALL appear to share subjectively even if in somewhat differing ways? If this is the only reality we actually do experience, isn't subjective reality in some sense a universal?

The brain may be one of the few places where the supercausal aspect of wave-packet reduction can be fully manifest, as a result of its unique capacity to utilize entanglement in its dynamic resonances. It is difficult to conceive of a physical system which could in any way match the brain as a potential detector of correlations and interrelationships within the domain of quantum mechanics. Cosmology is not simply a matter of vast energies, but also quantum rules. In these rules of engagement more fundamental even than symmetry-breaking, the stage appears to be set for the emergence of sentient organism as the culminating manifestation in complexity of quantum interaction. In this sense the conscious brain may be the ultimate inheritor and interactive culmination of the quantum process at the foundation of the universe itself.

Understanding the Sexual Brain

The human brain, by comparison with that of any other species shows extreme adaptable generality - the hallmark of humanity as a metaspecies, defining its own ecosystemic niches in an environment now determined in significant measure by the interactions between humans and the varied social strategies they adopt to ensure survival in a human society.

This picture extends well back into our gatherer-hunter emergence where, despite the occasional ravages of large carnivores, humanity has been a resourceful long-lived species with a life expectancy not dissimilar to our current span amid long periods of leisure and socio-sexual activity. By comparison with other species, which are often primed by chemical or other overt cues of estrus of a specific programmed nature which drives reproductive opportunity, humans have a subtle and complex set of cues for sexual attraction. Women remain sexually attractive throughout most of the ovarian cycle (all if you count Tantric practices) and pheromonal influences are so subtle, given concealed ovulation, that neither sex is fully aware of these cues, even when they are conscious of their existence.

Nevertheless love and sex are both highly addictive, central drives whose energy and vitality are absolutely essential for our survival so we would hardly expect them to have evolved to be a matter of whim. As we shall find, they are woven into the deepest and most ancient parts of our brains as well as being expressed in an elegant and complex way in the cortex.

If the development of the visual system is any clue to sexual differentiation, we would expect to see differentiation emerging dynamically in the same way vision does. On the other hand, the effects of hormonal modifiers such as steroids are pervasive. Given that development occurs under markedly different hormonal regimes in male and female embryos, this provides a rich opportunity for evolution over time to adapt to specific enhancements of the nervous system in each sex that prove favourable to survival. We would thus expect sexual differences to be pervasive and subtle at all levels, from neurosystems down to cellular and synaptic, and for these to vary in a variety of ways which reflect the ongoing dynamic process of adaption in individual species.

Consistent with this picture, the mid-brain centers, which researchers seek to identify with specific sexual behaviors, such as sexual orientation, are less clearly defined in humans than in rats and other mammals with clearly defined mating patterns. Moreover the most interesting sexual differences so far discovered revolve around major differences in emphasis of skills relevant to the gatherer-hunter way of life in a variety of ways which extend far beyond issues of simple sexual orientation. It is these differences and their consequences that are of profound interest to human society in reaching for a fertile social paradigm which takes best advantage of our complementary faculties. Again, consistent with maximum adaptability of the human CNS, individual differences in many of these skills are greater than the overall differences between the genders.

This all occurs in a context that paternal imprinting in mammals (p 346) appears to specifically favour development of mid-brain emotional systems while the maternally imprinted genes favour the development of cortical structures. The entire development of the cortex and its relationship to the emotional centres may thus be a product of a genetic arms race between the male and the female.

Some trends which have been regarded as a hallmark of human 'superiority' such as lateralization and cerebral lobe dominance turn out to be more a characteristic of male mammals generally, extending to testosterone-promoted cortical asymmetry in rats, shared by men in language and other development in a way which makes for intriguing contrast with women. However even some of these features, such as the differences in size and shape of the corpus callosum connecting the two cerebral hemispheres remain ambiguous to varying degrees in humans. One should note that handedness appears to operate with a distinct, although related basis, to cerebral lobe dominance. Most left-handed people, have the same cerebral lateralization as right-handed people.

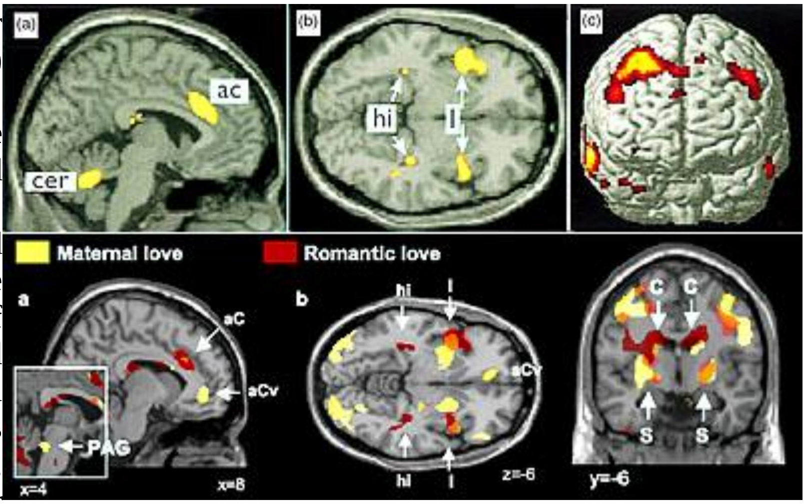
Love's Addictive Hunger, Empathy, Cooperation and Revenge

Nisa's penetrating comment (p 102), "Sex is food: ...hunger for sex can cause people to die" shows that the idea of sex and sexual lust as 'gratification' and a hunger and thirst abound. Falling in love is particularly 'driven' by sentiments like "I can't get enough of you".

Love, sex and addiction are associated in the popular mind, by addicts and lovers alike, and also now, by scientists. Stimulants like cocaine act on the brain's dopamine system, and so mimic the thrill of desire and anticipation. Depressant drugs like heroin, on the other hand, produce the opposite kind of pleasure - a dreamy satiation and freedom from pain, caused by their action .on the brain's opioid system. A speedball, a cocktail of cocaine and heroin, can be likened to a rapid, hyped-up sex simulation, moving rapidly from desire to climax. According to neuro-scientist Annarose Childress, what those systems usually do is control our sexual behaviour: "This circuitry has been well preserved throughout evolution to enable animals to eat and reproduce. Those functions have been around long before cocaine and opiates" (Szalavitz R680).

Whether nicotine, cocaine, heroin or alcohol, the more directly or profoundly a drug affects the dopamine system, the more craving and pleasure it produces. Dopamine responses to sex are known to vary between male and female rats. In male rats, she says, dopamine levels go up when they smell a female, see her or have sex. Anything to do with being introduced to a female, dopamine goes up, but female rats only get a 'hit' of dopamine when they can control sex". In the wild, females normally allow the male near, then flee, returning a few times, before they will eventually accept his advances. This 'pacing' ensures the rat is optimally primed for pregnancy. A release of estrogen sensitizes the dopamine system, so it will give her a 'kick', and simultaneously maximizes the odds of successful conception.

High levels of the receptor VlaR in the ventral pallidum are associated with monogamous behaviour in the prairie vole, a species specifically associated with oxytocin and vasopressin bonding (p 353). Other voles with fewer of these receptors seek multiple partners. It seems as though the monogamous voles get more pleasure from their partners, or become more addicted to them, while the promiscuous voles get more joy from novelty. Intriguingly oxytocin seems to reduce both the extreme effects of cocaine and opiates and their withdrawal symptoms, indicating that bonding may also heal the cravings of love.



Top: (a,b) regions with higher activity in romantic love (c) lateralized lower activity. Bottom: Romantic and Maternal love compared. (Bartels and Zeki R46, R47)

Bartels and Zeki (R46) used functional magnetic resonance imaging fMRI to scan the brains of 17 volunteers who described themselves as 'truly and madly' in love. During the scans, each was shown pictures of their loved one, or a friend of the same sex as their partner. Seeing a lover prompted activity in four brain regions that were not active when looking at pictures of a friend, and caused a significant reduction in the activity of another area. Two active areas lay deep in the cortex, the medial insula which may be responsible for 'gut' feelings, and a part of the anterior cingulate, which is known to respond to euphoria-inducing drugs and believed to be involved in emotional experience. Two lie in a deeper region known as the striatum, which is active when we find experiences rewarding. Deactivations were observed in the posterior cingulate gyrus and in the amygdala (regulating flight and fight) and were right-lateralized in the prefrontal, (a region that is overactive in depressed patients), the parietal and middle temporal cortices. This suggests that the cortex is functionally specialized for 'love'. The combination of these sites differs from those in previous studies of emotion, suggesting that a unique network of areas is responsible for evoking the most overwhelming of all affective states, that of romantic love. The authors note that "given the complexity of the sentiment of romantic love, it was not surprising to find that the activity was within regions of the brain found to be active in other emotional states, even if the pattern of activity evoked here is unique".

Bartels and Zeki (R47) have extended this work to compare romantic and maternal love and find some interesting parallels and differences. In particular, aspects of female romantic love fall closer to the patterns seen with maternal love than those in men. Romantic and maternal love are highly rewarding experiences, both linked to the perpetuation of the species and therefore have a closely linked biological function of crucial evolutionary importance. The authors used fMRI to measure brain activity in mothers while they viewed pictures of their own and of acquainted children, and of their best friend and of acquainted adults as additional controls. The activity specific to maternal attachment was compared to that associated to romantic love. The authors conclude that: "Both types of attachment activated regions specific to each, as well as overlapping regions in the brain's reward system that coincide with areas rich in oxytocin and vasopressin receptors. Both deactivated a common set of regions associated with negative emotions, social judgment and 'mentalizing', that is, the assessment of other people's intentions and emotions. We conclude that human attachment employs a push â€“ pull mechanism that overcomes social distance by deactivating networks used for critical social assessment and negative emotions, while it bonds individuals through the involvement of the reward circuitry, explaining the power of love to motivate and exhilarate". Those madly in love also have converging levels of testosterone (p 349).

In a study of the process of falling in love, Helen Fisher, Arthur Aron and Lucy Brown (Fisher R211) asked 7 male and l0 female volunteers who claimed to be 'madly in love' to look at pictures of either their loved one or another familiar person. Their fMRI scans show that, early on in a romantic relationship, dopamine-rich brain regions associated with motivation and reward become overactive when people see pictures of their sweetheart. The more intense the relationship, the greater the activity. Yet although love feels like an intense emotion, the researchers were surprised to see no extra activity in the emotional parts of the brain, such as the insula and parts of the anterior cingulate cortex. These regions are not activated until the later, more mature phases of a relationship. The findings suggest that romantic love is merely a motivation or drive, like hunger or thirst. Fisher explains: "Early on in a relationship, the brain seems to be very focused on planning and pursuit of pleasurable reward. This drive is mediated by the right caudate nucleus and right ventral tegmentum - the same brain regions that become active when you eat chocolate" (Szalavitz R679).

The team saw patterns of brain activity in the anterior cingulate cortex that resembles those in obsessive-compulsive disorder. The activity is correlated with the length of a relationship, lasting just into the emotional stage, by which time we overcome our obsession and form a more lasting bond, or not as the case maybe. An Italian team has reported that serotonin levels in the blood plummet in people who fall in love (New Scientist, 31 July 1999 42). People who suffer from OCD as well as those with depression, also have low levels of serotonin, however the cingulate area is very sensitive to serotonin levels, so taking antidepressants could wreck a person's chances of falling in love.

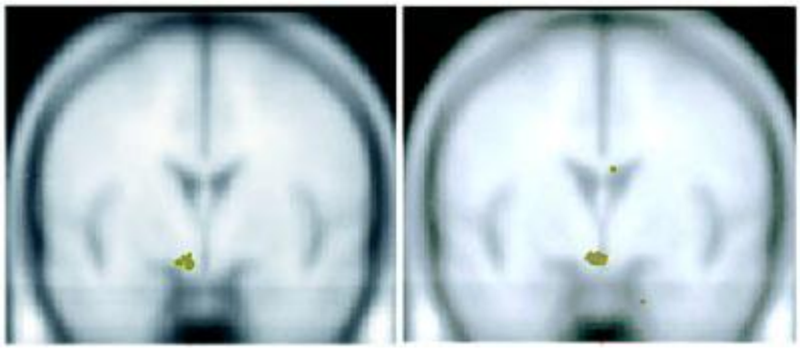
There are also noticeable sexual differences. Women in love show more emotional activity earlier on in a relationship. Their memory regions are more active as they look at pictures of their partner, perhaps paying more attention to past experience. In men ,love looks more like lust, with extra activity in visual areas that mediate sexual arousal and the regions associated with penile erection. Despite all this, the region responsible for making aesthetic judgements rates attractiveness in a very honest way, agreeing well with the ratings of independent observers. Fisher comments: "We say beauty is in the eye of the beholder, but part of the brain keeps track of the objective view" (ibid).

SOURCE: JOURNAL OF SEXUAL MEDICINE

Brain regions lit up by se-stimulation in three areas: (Linda Geddes *Sex on the brain: What turns* *women on, mapped out* New Scientist 6 Aug 2011, Journal of Sexual Medicine, DOI: 10.1111/j.1743-6109.2011.02388.x)

A 2011 study has finally shown the areas that light up under fMRI when women self stimulate either their inner vagina, the clitoris or the nipples, supporting the case that each of these areas in females have their own erogenous capacity and that vaginal orgasm is not simply clitoral orgasm. Furthermore nipple stimulation lit up genital areas supporting the erotic sensitivity of the nipples in females.

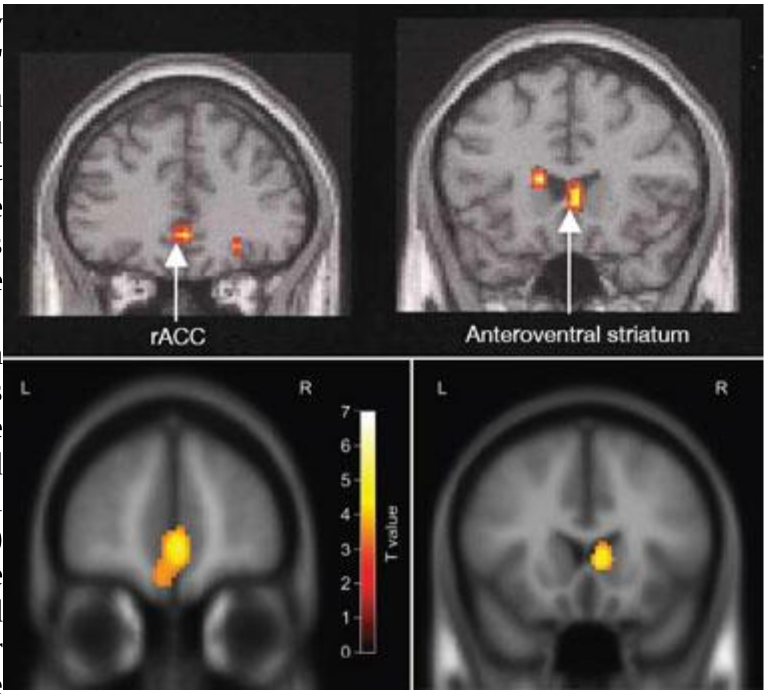
A PET study shows that many areas of the brain switch off during female orgasm. "At the moment of orgasm, women do not have any emotional feelings," says Gert Holstege of the University of Groningen in the Netherlands. His team compared the brain activity of 13 heterosexual women in four states: simply resting, faking an orgasm, having their clitoris stimulated by their partner's fingers, and clitoral stimulation to the point of orgasm. As the women were stimulated, activity rose in the primary somatosensory cortex, but fell in the amygdala and hippocampus, involved in alertness and anxiety, confirming that women cannot enjoy sex unless they are relaxed and free from worries and distractions. However, during orgasm, activity fell in many more areas of the brain, including the prefrontal cortex, compared with the resting state. From an evolutionary point of view, the brain may switch off emotions during sex because the chance to produce offspring becomes more important than the survival risk to the individual. Only one small part of the brain, in the cerebellum, was more active during female orgasm. The cerebellum is normally associated with coordinating movement, though there is also some evidence that it helps regulate emotions. When women were faking an orgasm areas of the brain involved in controlling conscious movement lit up, and there was none of the extreme deactivation (Le Page R792).



Hypothalamic differences in activity when men and women watch erotic images consistent with the activity of dimorphic centres in the hypothalamus. Left: male and female responses subtracted show a unique male activation centre. This has a close relationship to a region (right) differentially illuminated when males find erotic scenes particularly exciting (Karama et. al. R354).

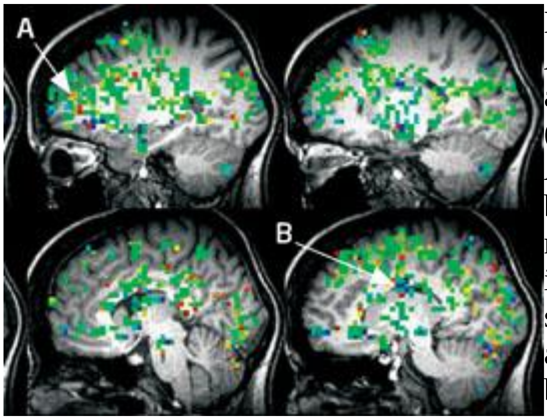
Mario Beauregard (Karama et. al. R354) uses fMRI to explore which brain areas become activated when men and women view erotic films. Not surprisingly, the visual areas are busy; but so too are many evolutionarily ancient circuits associated with emotion - the limbic system, anterior temporal pole and amygdala, and a region of the orbito-frontal cortex (OFC). Previous research found that these areas are important in prioritizing, decision making and giving emotional colour to an experience, and may subconsciously trigger physiological responses and desire. Pornographic images have been found to make men briefly blind to the orientation of immediately following neutral images (Sexy images cause temporary blindness New Scientist 20 August 2005).

Such response mechanisms extend further than sexual love into cooperation, defection and all the dimensions of the prisoners dilemma. De Quervain et. al. (R158) asked whether choosing to punish a defector would recruit brain circuits implicated in reward processing. They found that when subjects administered a monetary punishment to defectors, a the striatum was activated, indicating that punishing a defector activates brain regions related to feeling good about revenge rather than feeling bad about having been violated (Knutson R384). Indeed, these striatal foci lie near brain areas that rats will work furiously to stimulate electrically. They then asked whether the striatum would be activated even when administering the punishment carried a personal cost. They found that the striatum was still activated, as was a region in the medial prefrontal cortex, implicated in balancing costs and benefits. Effective punishment, as compared with symbolic punishment, activated the dorsal striatum, which has been implicated in the processing of rewards that accrue as a result of goal-directed actions. Subjects with stronger activations in the dorsal striatum were willing to incur greater costs in order to punish. The degree of striatal activation during no-cost punishment predicted the extent to which subjects chose to punish at a personal cost (that is, under less satisfying conditions). This finding suggested to the investigators that striatal activation indexed subjects' anticipation of satisfaction, rather than satisfaction per se.



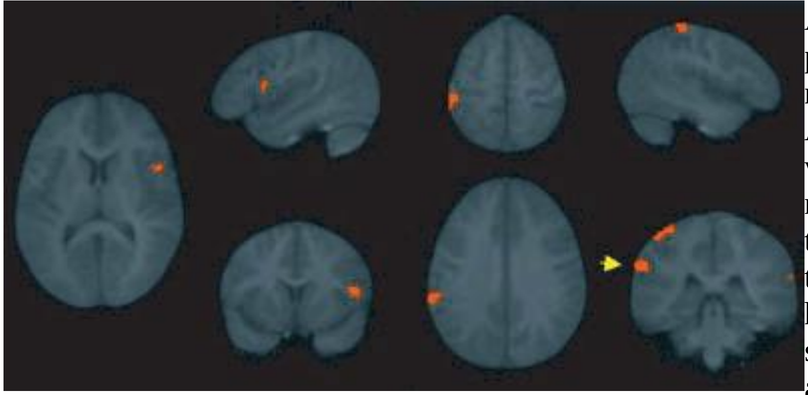
Above activation of areas by cooperative playing of the prisoners' dilemma game among women (Rilling R583). Below Left frontal and right striatal areas activated by 'sweet revenge' (de Quervain R158). The similarity of the areas suggests anticipated social rewards motivate both these contrasting behaviors.

Ironically, punishment of defectors in this study activated the same regions (that is, striatum and MPFC) that were activated when people rewarded cooperators in a recent functional magnetic resonance imaging (fMRI) study (Rilling et. al. R583). The monetary awards were apportioned after each round. If one player defected and the other cooperated, the defector earned $3 and the cooperator nothing. If both chose to cooperate, each earned $2. If both opted to defect, each earned $1. Mutually cooperative social interactions in the prisoner's dilemma game were associated with activations in anteroventral striatum, rostral ACC, and OFC that were not observed in response to monetary reinforcement in a nonsocial control condition. OFC activation but not the other areas was also observed for mutual cooperation with a computer partner, suggesting that the ACC and striatal activations may relate specifically to cooperative social interactions with human partners.



Moment of female orgasm recorded in fMRI. Activation in the prefrontal cortex (A) is clearly visible, as well as activity in the anterior cingulate cortex (B). New Scientist

A pattern of neural activation is thus identified that may be involved in sustaining cooperative social relationships, perhaps by labeling cooperative social interactions as rewarding, and/or by inhibiting the selfish impulse to accept but not reciprocate an act of altruism. These seemingly diametrically opposite social behaviors are united by a common psychological experience - both involve the anticipation of a satisfying social outcome. While the former study of defectors included male subjects, the f MRI study of cooperators included only females. Future research will undoubtedly need to explore which social interactions most powerfully motivate men compared with women (as well as members of different social groups).



Activation of left frontal and right parietal areas involving mirror neuron activity (Iacoboni R335).

Another set of brain areas to do with both empathy and one's reactions and behavior in relation to others associated with 'reading the minds' of others (MotlukR491) has been discovered in the form of so-called 'mirror neurons' which although they may be in areas we usually associate with motor function intentional action and even the expression of language, contain a population of neurons which react in the same way when the same action is being performed by another individual (or even another species). Monkeys were found to have neurons in a frontal area (Di Pellegrino R168, Rizzolatti and Craighero R586) that discharge both when the monkey does a particular action and when it observes another individual (monkey or human) doing a similar action. Imitation may be based on a mechanism directly matching the observed action onto an internal motor representation of that action.

To test this hypothesis (Iacoboni et. al. R335), normal human participants imitated a finger movement and to perform the same movement after spatial or symbolic cues. Brain activity was measured with functional magnetic resonance imaging. If the direct matching hypothesis is correct, there should be areas that become active during finger movement, regardless of how it is evoked, and their activation should increase when the same movement is elicited by the observation of an identical movement made by another individual. Two areas with these properties were found in the left inferior frontal cortex and right superior parietal. Rizzolatti and Arbib (R585) have commented that such mirroring, occurring in 'motor' areas such as Broca's area associated with language expression would give a basis for a transition to language, based on mirroring of actions gestures, cries and facial expressions. Such mirroring is also central to the empathy we associate with the way emotions transcend simple barriers of genetic determinism through imprinted instinct as well as the capacity to assess complex social situations of deceit and betrayal.

Sex, Brain and Steroids

One of the most outstanding examples of sexual dimorphism is in the brains of song birds where a whole sexually-typed brain region grows in the male only, waxing each spring and waning in the autumn. In mammals, timed bursts of hormones such as testosterone are believed to play critical roles in gender-typing certain key areas of the hypothalamus involved in female and male reproductive behavior around the time of birth, particularly in species such as rats and voles. Roger Gorski and his colleagues at the University of California at Los Angeles have shown that a region of the pre-optic area of the hypothalamus is visibly larger in male rats than in females. The size increment in males is promoted by the presence of androgens in the immediate postnatal, and to some extent prenatal, period. Laura Allen in Gorski's lab has found a similar sex difference in humans.

While rats have a very marked difference in their sexually dimorphic nuclei, humans vary only moderately between males and females, exemplified by the spinal bulbocavernosus centre which exists only in rat males, but is merely 28% different in human males and females because the muscles it controls work both in the base of the penis, promoting ejaculation and in the muscles constricting the vagina (Blum R66 30). To make matters worse, excision of such nuclei in rats causes only transient disturbance to sexual behavior and in monogamous prairie voles, the sexually dimorphic nuclei, whose differences between adolescent males and females are evident, become difficult to differentiate in parentally engaged bonded male and female pairs (Blum). This suggests that these centres may be dynamic consequences of activity rather than simply genetic differences determining sexual orientation. Each case of sexual dimorphism seems to be part of a distributed network of sexually dimorphic neuronal populations which normally interact with each other.

There are also marked differences in hormonal specificity in the development of brain and behaviour across mammalian species. Paradoxically in rats for example, testosterone aromatized to estradiol plays a major role in sexual determination in the male brain, preventing programmed apostosis (cell-death) the sexually dimorphic centres. This flood of estrogen is apparently quenched in females by binding to excess a-fetoprotein (Kandell et. al. R353). In prairie voles oxytocin in females and vasopressin in males are linked to parental care of the newborn (Angier, Blum) ((p 353), (p 33)). Neither of these clear-cut processes can be demonstrated to work in the same way in primates and in particular in humans. Even the role of testosterone in imprinting the human brain around the time of birth is debated. The review by Marc Breedlove's team (Cooke et. al. R131) notes "there is ample evidence of sexual dimorphism in the human brain, as sex differences in behavior would require, but there has not yet been any definitive proof that steroids acting early in development directly masculinize the human brain". Many studies link testosterone to dominance in men (Mazur and Booth R451) and women (Grant R254).

Because the nervous system is plastic, any sexual dimorphism seen in the adult brain could be the result of differences in experience, either during development or in adulthood, rather than as a direct result of fetal steroid action. Obviously a sexual dimorphism present at birth could not be due to sex differences in experience or social stimulation. One dimorphism present at birth is the sex difference of some 15% in the weight of the human brain, an issue trumpeted by some male scientists with political agendas. Deborah Blum (R66 38) notes: "More than any other gender comparison in biology, it's fair to say feminist scholars hate this one the most. Brown University geneticist Anne Fausto-Sterling argues this work is biased from the start. Male scientists consistently find male scientists have bigger brains. Since we tend to assume bigger is better the implications are obvious." Bente Pakkenberg claims there is a corresponding slightly higher number of brain cells in a man, 23 billion as against 19 billion. However Raquel and Reuben Gur have found that the male human brain loses neurons at almost three times the rate of women, probably due to the influence of androgens, so in mid life the male frontal lobe ends up the same size as in women (R66 52). Similar results apply to the hippocampus involved in sequential memory. Sandra Wittelson has also found that women have about 15% more neurons in layers four and five, packed more tightly than in men - 35,000 in women in each sample and 30,000 in men (Blum 60). Because it is mirrored by the sex difference in body weight, brain size may be an indirect result of steroid hormone action. Testicular androgens may masculinize the secretion of factors such as growth hormone or its companion factors to give males a larger body and brain. But the effect does not seem to be specific to the nervous system, so it is unlikely that it can account for sex differences in human behavior.

The brain structure that has been best studied in humans is the sexually dimorphic nucleus of the pre-optic area (POA) also called INAH-1. Swaab and Fliers (R675) found that males had a larger nucleus, with more neurons, than females, but this sex difference in neuronal number is not detectable in children younger than 6â€“10 years of age. Allen and Gorski (R9) and Le Vay (R409) could not replicate this sex difference but both did find dimorphism in INAH-3. However no one has examined its size in human development, so we do not know whether dimorphism is present at birth (and likely to be engendered by fetal steroids) or arises later in life (and could alternatively be due to social influences). The conflicting reports concerning sexual dimorphism in the human brain indicate sexual dimorphism is more subtle in the brains of humans than of other animals (Cooke et. al. R131). It may also be a consequence rather than a cause of sexual orientation.

Another strategy for asking whether fetal steroids affect the human brain is to find whether inadvertent exposure to fetal hormones alters sexually dimorphic behaviors. Unfortunately, the results of such studies are contradictory. Females with androgen overproduction from congenital adrenal hyperplasia (CAH) do behave more like boys, showing more rough and tumble play and tomboy behaviors than other girls. As women, CAH patients usually are sexually attracted to men, but are also more likely to be attracted to women than are other women (p 386). However it is hard to eliminate cultural factors here. CAH females have slightly masculinized genitalia and this effect could also be due to differences in their social experience, because of family or personal gender confusion.

Androgen insensitive XY individuals, who look like normal females externally, display feminine spatial learning behavior and verbal behavior, and are sexually attracted to men. But this might be due to their unambiguous upbringing as girls. If, as in rodents, the estrogens coming from aromatized testosterone masculinized the developing human brain, then we would expect these people to display masculine behaviors despite their feminine exterior. Androgen insensitive rats present feminine exterior, but a masculine SDN-POA, and a refusal to display feminine 'lordosis'. The feminine behavior of androgen insensitive humans indicates that aromatized metabolites of androgen cannot be playing a major role in masculinizing the human brain, either because steroids have no effect on the developing human brain, or because steroids act through androgen receptors themselves to exert such an effect. It is also possible that in humans, androgen receptors must be functional for estrogen receptor activation to be effective or to occur at all.

Contrasting this, Melissa Hines (R318) found that women who had been exposed to the estrogen diethylstilbestrol (DES) in utero showed greater evidence of cognitive lateralization (for a dichotic listening task and a visual search task) than their non-DES-treated 'sisters'. We shall see that this is a characteristic of males. However the effect is small and cannot be readily related to most human sex differences in behavior, so estrogen may be making only a small contribution to human neural sex differences. On the other hand a twin boy who had had a surgical mishap at 8 months and was given a sex change operation and reared as a girl decided at puberty to identify as a male and successfully became married with step children, suggesting masculinization had occurred (p 362).

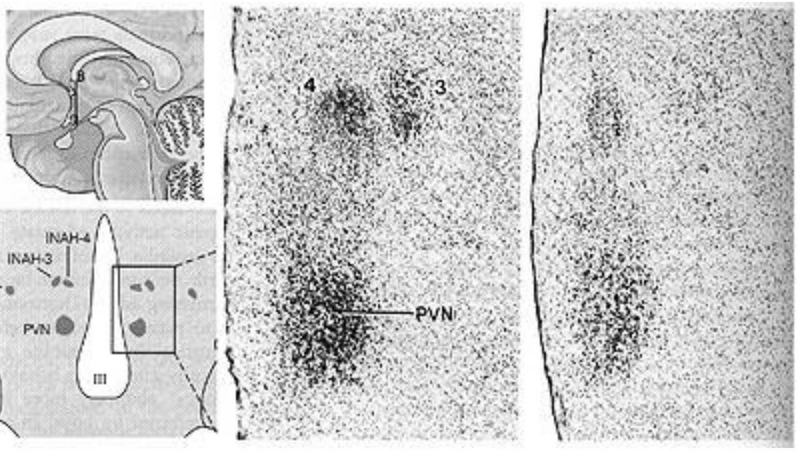
Sexual differences in specialized abilities also fluctuate with hormone levels in both women during the ovarian cycle and in men, suggesting hormones continue to have a dynamical influence on gender difference in brain function (p 348).

Despite the fact that there is not yet any conclusive proof that fetal steroids directly masculinize the human brain, the rampant masculinizing effect of androgen during early brain development of other vertebrates makes it seem likely that at least some such influences remain in our species. There is however no doubt that adult steroid manipulations do alter human behavior and both the behavior and the neural structure of other species.

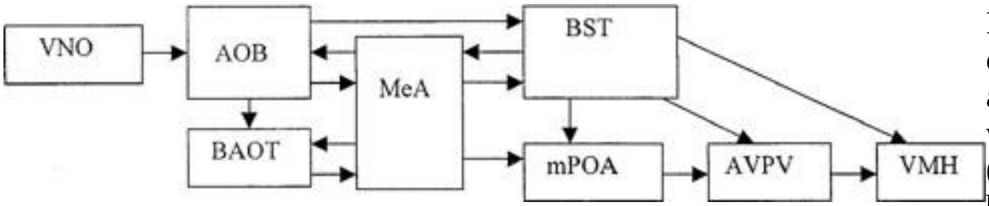
Gay Genes and Cultural Brains

The saga of the 'gay gene' is probably one of the most sensational and hotly disputed genetic discoveries. Bailey and Pillard (R35) made the first of two twin studies in which a genetic basis for sexual orientation was found in both human males and subsequently females. The same year Simon Le Vay (R409) found an area in the hypothalamus (INAH-3) which was larger in men than women but more intermediate in gay males. Homosexual men are also claimed to have a larger suprachiasmatic nucleus and a larger anterior commissure than heterosexual men. Moreover another dimorphic nucleus the so-called 'bed nucleus' of the stria terminalis BNST or BSTc, which is larger in human males than females is even larger in homosexual men (Zhou. et. al. R781) suggesting hyper-masculinization rather than 'feminization'. However these measures, made in adulthood, cannot tell us whether the brain caused, or are a result of the differences in sexual orientation. As few of these orientation dimorphisms have been replicated, their status remains uncertain.

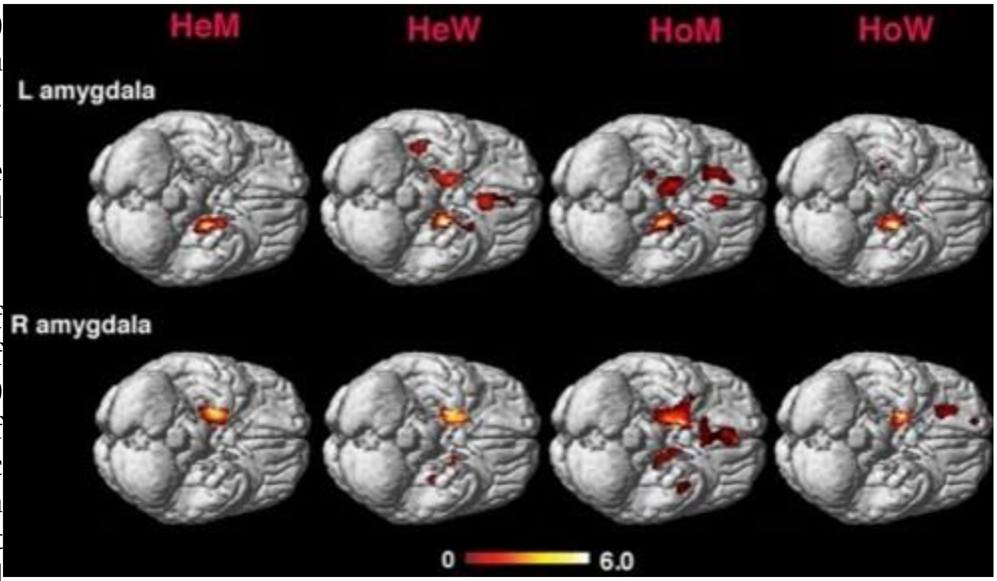
Interstitial nuclei of the anterior hypothalamus INAH-3,4 display sexual differences (Kandel et. al. R353). Section of the hypothalamus showing differences between male (left) and female (right). It is this centre that Le Vay claimed was closer to the female profile in homosexual men. Because these are adult structures and the brain adapts to behavior, it is difficult to distinguish fetal cause from cultural effect.



In adult rodents, the BNST, is 75% larger and contains many more cells in males and the anteroventral periventricular nucleus, or AVPV, is both larger and richer in cells in females. If a male rat is castrated shortly after birth, its BNST and AVPV will develop in the female pattern. Conversely, if a female rat pup is treated with testosterone its adult brain will be indistinguishable from a male's. A single gene Bax, from the Bcl2 family shaping neuron growth and death, has been found to govern the pruning of neurons. In the Bax-"knockout" mice used by Forger and her colleagues (R216), both the BNST and AVPV had many more cells than are seen in mice and the number of cells was equal in males and females.



Pathways linking odor to reproductive activity include the vomeral nasal organ (VMO) olfactory bulb (AOB) medial amygdala (MeA) bed nucleus (BST) and preoptic area (mPOA) (Cooke et. al. R131).



Asymmetries in the amygdala seed region.

In 2008 a study of 25 heterosexuals of each sex and 20 homosexyal also of each sex by Savic and Lindstrom (R793) found that cerebral and amygdala asymmetries of the homosexual group reflected those of the opposite sex in heterosexuals. This again suggests that gays may inherit brain structures that more closely resemble the oppostie sex, but how this might lead to attraction towards the same sex or whether it is inevitable 'from the womb' or still subject to social selection remains to be established. Despite the comments of some scientists such as the one below, it is premature to conclude we are born with a rigid sexual orientation, since identical twins which share the same genes display opposite sexual orientation around 50% of the time when one of the twins is gay.

"As far as I'm concerned there is no argument any more - if you are gay, you are born gay" Dr Qazi Rahman, Queen Mary, University of London

However this is far from the case. 'In a landmark study published in the Archives of Sexual Behavior in October 2003, Robert Spitzer interviewed 200 men and women who once considered themselves homosexuals but who had lived their lives as heterosexuals for at least five years. Most of the participants had undergone some form of reorientation therapy. In addition to determining whether such therapy actually worked, Spitzer wanted to know just how dramatically people could alter their orientation. To his surprise, most of his subjects not only reported living long-term (more than 10 years) as heterosexuals, they also declared they had experienced "changes in sexual attraction, fantasy and desire" consistent with heterosexuality' (Epstein, Robert 2009 *Do Gays Have a Choice?* Sci. Am. Mind, Jun 20/3).

In 1993 Dean Hamer announced (R283) that he had found a gene on the X-chromosome that had a powerful influence on sexual orientation. Homosexuality is highly heritable, as twin studies show. Among 54 gay men who were fraternal twins, there were 12 whose twin was also gay. Among 56 gay men who were identical twins, there were 29 whose twin was also gay. Since twins share the same environment, whether fraternal or identical, such a result implies that a gene or genes accounts for about half of the tendency for a man to be gay. A dozen other studies came to a similar conclusion. Hamer's team interviewed 110 families with gay male members and noticed that homosexuality seemed to run in the female line. If a man was gay, the most likely other member of the previous generation to be gay was not his father but his mother's brother. That suggested the gene might be on the X-chromosome, the only set of nuclear genes a man inherits exclusively from his mother. However his work has been scientifically disputed.

By comparing a set of genetic markers between gay men and straight men in the families in his sample, he found a candidate region in Xq28, the tip of the long arm of the chromosome. Gay men shared the same version of this marker seventy-five per cent of the time; straight men shared a different version of the marker seventy-five per cent of the time.

Consistent with this discovery, Trivers noted that, because an X-chromosome spends twice as much time in women as it does in men, a sexually antagonistic gene that benefited female fertility could survive even if it had twice as large a deleterious effect on male fertility. However Michael Bailey's research on homosexual pedigrees has failed to find a maternal bias to be a general feature. Other scientists, too, have failed to find Hamer's link with Xq28. However the discovery of the fertile mother effect in about 14% of gay men (p 384) may clarify these contradictions.

Homosexual orientation shows heritability in both sexes. By comparing identical and dizygotic twins we can estimate how much genes (~30%), family and siblings (~20) and environment and culture (~50%) affect sexual orientation. Even given the strong genetic influence, culture is still the major determining factor. Nature is more than complemented by 'nurture' here (Kandel et. al. R353).

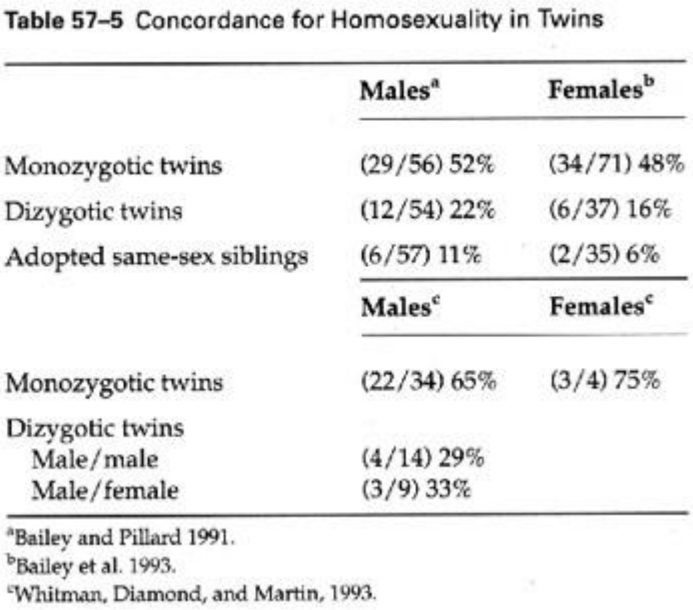


Table 57–5 Concordance for Homosexuality in Twins

	Males[a]	**Females**[b]
Monozygotic twins	(29/56) 52%	(34/71) 48%
Dizygotic twins	(12/54) 22%	(6/37) 16%
Adopted same-sex siblings	(6/57) 11%	(2/35) 6%
	Males[c]	**Females**[c]
Monozygotic twins	(22/34) 65%	(3/4) 75%
Dizygotic twins		
Male/male	(4/14) 29%	
Male/female	(3/9) 33%	

[a] Bailey and Pillard 1991.
[b] Bailey et al. 1993.
[c] Whitman, Diamond, and Martin, 1993.

There have been reports of several physiological differences between homosexual and heterosexual men that could reflect nervous system involvement. Homosexual men are, on average, shorter than heterosexual men, will have undergone puberty at an earlier age than heterosexual men and will have more symmetrical left-versus-right fingerprint patterns than heterosexual men.

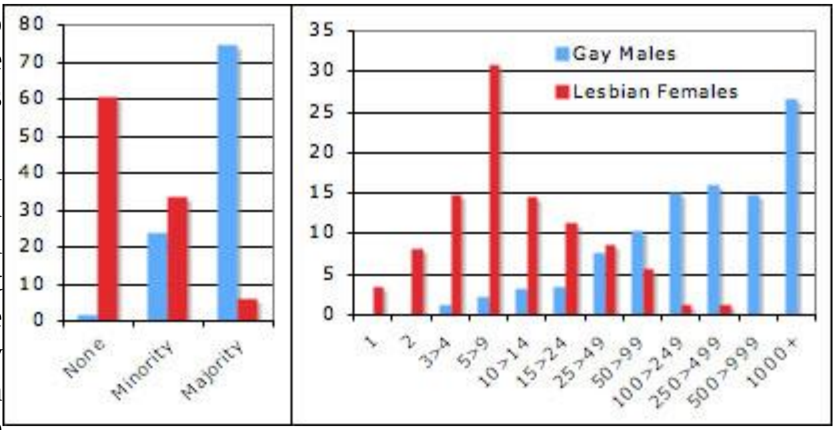
The proportion of gay people is also a matter of debate. Michael Bailey estimates that 2-3% of US men are exclusive homosexuals and 1.5% of women. Occasional bisexuals double the number and the idly curious swell it to perhaps 8.7% of men and 11.1% of women - considerably less than the 20% some political proponents would claim. Masters, Johnson and Kolodny (R449 373) report even lower figures from a spectrum of international studies, around 1.4% of men and 0.4% of women reporting same sex contact in the previous year in a typical French study, with similar figures from Britain, Japan, Philippines, Thailand, Denmark and Holland with no study reporting figures as high as 10% when bisexuality is included. Gwen Broude (R83) points out the higher incidence of male homosexuality is consistent with the shotgun male reproductive strategy of trying to have sex with everything in sight. There is little evidence for a biological pattern of exclusive homosexual orientation in ape societies (p 66) nor in world societies in which male homosexuality is part of the social norm, from Greece (p 203) through Amazonia (p 149) to New Guinea (p 171), where Sambia males go through a period of obligate homosexual activity before entering marriage.

Deborah Blum in 'Sex on the Brain' (R66) devotes a chapter to differences in sexual orientation, aptly entitled 'the second date' for its quotable quote, attributed to Daryl Bem:

"There's a joke in the gay community that goes like this -
'What does a lesbian bring on her second date?' - 'A U-Haul'.
'And what does a gay man bring on his second date?' - "What second date?'

Don Symons elaborated this into the theory that male gay behavior, rather than mimicking female behavior, is an extreme of where biology leads men without women - i.e. to sew male wild oats to oblivion. By contrast lesbian women display extreme nesting.

In studies, gay males and lesbian females do show diametrically opposite sexual behaviors, which conform strongly to the reproductive strategies of their own sex, rather than the implied gender reversal of their same-sex orientation. Gay men display a runawaymale pattern of sex with many strangers, while lesbians bond with established partners. This belies claims of gay men to be more 'feminine' sexually than heterosexual men. These sexual strategies of males and females are confirmed in heterosexual dating experiments, where women consistently refuse casual offers of sex from male strangers, conforming to the careful, choosy strategy, while almost all men offer to accept a sexual advance from a strange woman (R449 433). There is however a large difference between married heterosexual and homosexuals on whether love is central to a sexual relationship. 41% of married women and 27% of married men do not approve of sex without love, but only 19% of lesbians and 7% of gay men do so (R449320).



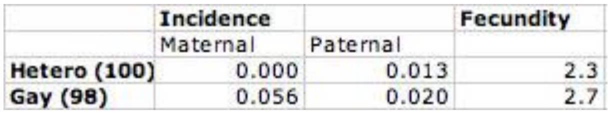
Left: Percentage of partners who were strangers. Right: Lifetime number of homosexual partners (R449).

Blum (R66) claims women seem to be more flexible sexually and more tolerant of sexual orientation. She reports that many lesbian women experience attraction to men but simply don't act on it. By contrast men tend to subdivide more into homophobic males and freely flaunting gays. Bem also considers the gay genetic influence may be about another personality trait than sexual orientation, which may cause social factors which predispose to sexual orientation, such as sex differences in play interest between classic childhood sex role play such as dolls and making house versus action games and sports, which themselves seem to be partially inherited. Edward O. Wilson also suggested gay men might favour survival of their relatives by helping with children and in cementing family ties. There is some evidence for this in ancient American Indian cultures and it might apply in matrilineal societies, where mother's brothers figure strongly in parenting without having to reproduce, but it is far from established generally.

The more flexible attitude of women towards sexual orientation is reflected in studies of the brains of heterosexual adn homosexual women and men watching erotic movies. "Heterosexual women's level of arousal increased along with the intensity of the sexual activity largely irrespective of who or what was engaged in it. In fact, these women were genitally excited by male and female actors equally and also responded physically to bonobo copulation. (Gay women, however, were more particular; they did not react sexually to men masturbating or exercising naked.) The men, by contrast, were physically titillated mainly by their preferred category of sexual partner - that is, females for straight men and males for gay men - and were not excited by bonobo copulation. The results, the researchers say, suggest that women are not only aroused by a variety of types of sexual imagery but are more flexible than men in their sexual interests and preferences."(Portner, Martin *The Orgasmic Mind*. Sci. Am. Mind, Jun 2009 20/3)

This is consistent with the much higher attribution of bisexual receptivity of women at around 25%.

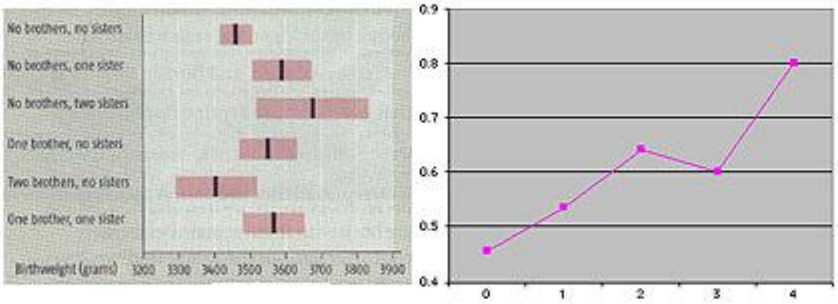
Roughgarden (R593) suggests same-sex orientation is too frequent to be a genetic 'error' and proposes that social selection in the form of both same-sex and heterosexual bonding acts as a major filter to reproductive opportunity (p 55). However, only a few species use social sex profligately and often have purely non-sexual forms of grooming and amatory behaviour, so it remains unclear that a 'rainbow' of sexual orientations plays a significant role in reproductive advantage. Even in bonobos where socio-sexual bonding is abundant (p 66), it is only female socio-sexuality which is a significant selector of reproductive fitness.



	Incidence		Fecundity
	Maternal	Paternal	
Hetero (100)	0.000	0.013	2.3
Gay (98)	0.056	0.020	2.7

In 2004 Camperio-Ciani and co-workers (R134) discovered the 'fertile mother effect' - that female relatives of gay men had more children on average than the female relatives of straight men. But the effect was only seen on their mother's side of the family. Mothers of gay men produced an average of 2.7 babies compared with 2.3 born to mothers of straight men. And maternal aunts of gay men had 2.0 babies compared with 1.5 born to the maternal aunts of straight men. The effect accounts for about 14% of the incidence of gay individuals. This provides a resolution of the sexual paradox implied by the reduced heterosexual fertility of gay men - in Camperio-Ciani's words: "The same factor that influences sexual orientation in males promotes higher fecundity in females." Simon LeVay puts a genetically determinist spin on the idea this is a gene for overweening attraction to males: "This is a novel finding. We think of it as genes for 'male homosexuality', but it might really be genes for sexual attraction to men. These could predispose men towards homosexuality and women towards 'hyper-heterosexuality', causing women to have more sex with men and thus have more offspring." However the evidence doesn't necessarily indicate that this is a gene causing genetically deterministic sexual orientation but merely female fecundity. "There is no single gene accounting for these observations. It's a combination of something on the X chromosome with other genetic factors on the non-sex chromosomes," Camperio-Ciani says. He estimates that about 20% of the predisposition to being gay is caused by genetic factors, including the following birth order effect, to which he attributes 7%.

A (right-handed) male with one or more elder brothers is also more likely to be gay than a man with no siblings, only younger siblings, or with one or more elder sisters. Each additional older brother increases the probability of homosexuality by roughly 1/3. Since the most important variable is how many sons their mother carried before them (rather than how many older brothers grew up in their household), these data suggest a maternal effect on the developing fetus. The effect has now been reported in Britain, the Netherlands, Canada and the United States, and in many different samples of people. Ray Blanchard (Blanchard and Cantor R64), who has pioneered studies on the 'fraternal birth order effect' estimates that 1 out of 7 gay men can attribute their sexual orientation to this cause (see "The big brother effect New Scientist 29 Mar 2003 44-8). The best explanation concerns a set of three active genes on the Y chromosome called the H-Y minor histocompatibility antigens. One of these genes encodes AMH. What the other two genes do is not certain. They are not essential for the masculinization of the genitals, which is achieved by testosterone and anti-Mullerian hormone alone.



Effects of successive older brothers on birth weight and the probability of being gay from an equal population of heterosexual and homosexual men (New Scientist 29 Mar 2003 44-8).

These gene products are called antigens because they provoke a reaction from the immune system of the mother. As a result, the immune reaction is likely to be stronger in successive male pregnancies. Ray Blanchard, one of those who studies the birth-order effect, argues that the H-Y antigens' job is to switch on other genes in certain tissues, in particular in the brain and indeed there is good evidence that this is true in mice. If so, the effect of a strong immune reaction against these proteins from the mother would be partly to prevent the masculinization of the brain, but not that of the genitals. That in turn might cause them to be attracted to other males, or at least not attracted to females. Baby mice immunized against H-Y antigens grow up to be largely incapable of successful mating, consistent with this idea. Paradoxically, data from John Manning and Marc Breedlove with both gay men and those with older brothers suggests there is an increase in testosterone consistent with the idea that later male offspring may be primed to be more competitively physical.

Researchers have also noticed skewing in the usually random X-chromosome inactivation (p 342) when investigating 97 mothers of gay men with 103 mothers of heterosexuals. They found this in 23% of mothers with two gays sons, 14% of mothers with one but only 4% of those with none, although there appears to be no skewing in their daughters (New Scientist 6 Nov 2004 14). The article notes that such skewing is usually associated with genetic disorder but the mothers all appear to be healthy.

Whether of biological or socio-dynamic, origin, gay men and straight women appear to share stimulation of sexual centres when sniffing a male pheromone AND, by contrast with estrogenic EST, lavender, cedar oil, eugenol or butanol. PET and MRI scans revealed that the ordinary odours activated parts of the brain associated with smelling in all test subjects. But AND also excited the anterior hypothalamus and medial preoptic area of gay men and straight women alike, brain areas associated with sexual behaviour, as did EST for straight men. However the brain scans revealed no anatomical differences between any of the participant's brains (Savic et. al. R614). In a second study by Dr. Charles Wysocki due to appear in Psychological Science, gay men preferred the odours of other gay men and heterosexual women, but the smell of gay men were least liked by heterosexual men and women and lesbians, suggesting sexual orientation affects both pheromone production and responses.

Highly sexed females are 27 times as likely as men to become attracted to their own sex. A survey of 3500 people showed that 0.3% of men and 8% of women were attracted to their own sex. For most women, a high sex drive increases sexual attraction to men and women. In men, a high sex drive simply exaggerates existing sexual orientation (Lipps R419).

In women, testosterone comes predominantly from the adrenals. Congenital adrenal hyperplasia, or CAH, and another associated condition, polycystic ovarian syndrome PCOS, in which ovulation fails to complete, result in increased testosterone levels in females. Mild 'symptomless' forms of the polycystic condition are 2-3 times as common in lesbian women, in whom a high proportion - up to 80% in one study (BBC) - display mild signs of the condition, suggesting a linkage between hormones and female sexual orientation. Otoacoustic emissions (faint clicks emitted from the tympanic membrane either spontaneously or in response to click presentation) are also more masculine (i.e., quieter) in lesbians compared to heterosexual women. A similar, effect is seen in the female twins of boys, a slight freemartin-like effect echoing the sterile androgenized twins of male calves which Frank Lillie correctly observed in a classic 1917 publication was due to male hormones altering a genetic female (Fausto-SterlingR202 163).

CAH is caused indirectly by a failure of 21-hydroxylase which the adrenal cortex uses to produce other steroids such as cortisol, causing an overflow of precursors to testosterone (p 351). With CAH as well, some researchers note changes of play in girls to more traditionally rough and tumble 'tomboyish' interests, forsaking "clothing, cosmetics, doll-play and infant care", even when the condition is hormonally corrected shortly after birth. These trends were found to continue in adolescence in "modeling, football, working with engines" as opposed to admittedly contrived 'feminine' traits such as "fashion magazines, cheer-leading or keeping a diary" (Campbell A R103 126). Those who are treated with hormones only later in childhood show male patterns of sexuality when they become young adults, including quick arousal by pornographic images, an autonomous sex drive centered on genital stimulation, and the equivalent of wet dreams.

Anne Fausto-Sterling (R202 75) critiques such studies as imposing expectations of gender biased behavior, questioning the lack of doll play because there was more interest in pets, stating that: "All in all, the results provide little support for a role for prenatal hormones in the production of gender differences". She extends this however to a professedly political position, working from an avowedly cultural constructionist feminist attitude toward sexual orientation, and lesbianism in particular, as if 'gender' itself is simply a social construct and there are as many 'genders' as human cultural 'morality' or transsexual and individual gender orientation will embrace. Simply equating the democracy of human equality with a genderless social construction fails to understand the critical issue about biological gender. Since we do have two sexes, evolution is likely to select for biological traits which, in their complementarity achieve a greater prospect of survival than any genderless social construction. Just as there is a danger in jumping overboard with political correctness in assuming male homosexuality is 'born in the genes', so assuming a political rejection of biology may commit cultural feminists to exactly the fate committed by patriarchs throughout history, who, in rejecting the completion of sexuality, while seeking paternity certainty, repressed woman and nature alike, by refusing to accept the healing power of natural sexuality on the human condition. Neither is it clear such 'political science' is good biological science.

Fausto-Sterling (R202 26) openly admits such a highly political position in regard to the gay gene research so avidly pursued by gay male scientists:

"A few years ago, when the neuroscientist Simon Le Vay reported that the brain structures of gay and heterosexual men differed (and that this mirrored a more general sex difference between straight men and women) he became the centre of a fire storm. Although an instant hero among many gay males, he was at odds with a rather mixed group. On the one hand, feminists such as myself disliked his unquestioning use of gender dichotomies, which have in the past never worked to further the equality of women. On the other, members of the Christian right hated his work because they believe that homosexuality is a sin that individuals can choose to reject."

Fausto-Sterling then pinpoints the issue central to her:

"politically the nature/nurture framework holds immense dangers ... In most public and scientific discussions, sex and nature are thought to be real, while gender and culture are seen as constructed. But these are false dichotomies".

She then cites trans-gender individuals, female genital mutilation, and sex-change operations, (while opposing some of these practices), as instances of the shaping of 'sex' by culture, as if this avowedly political position can be realized by 'affirmative' action.

Anne Campbell (R103 22) criticizes this political approach as deceptive:
"Many feminists have objected that the very questions posed by scientists are laden with tacit political agendas and that the scientific method can never be value-free. The solution they offer is for researchers to announce their politics at the same time as their results ... this has the side effect of allowing the reader to pick and choose in terms of the author's politics and to be prejudicially positive to articles that gel with their own agendas. Fausto-sterling for example writes of the difficulty she experiences in distinguishing between 'science that is well done and science that is feminine'. She is also surprisingly honest about the double standard that she employs in evaluating data which are not congenial to her ideological position: 'I impose the highest standards of proof for example on the claims about biological inequality, my high standards stemming directly from my philosophical and political beliefs in equality'. Theories that are not consistent with a feminist viewpoint usually fail to achieve this higher standard. Feminists are keen to promote high-quality research - but this claim is made difficult by their inability to distinguish between feminist science and good science. many feminist journals will refuse to publish data that are unacceptable to their ideological position. This state of affairs has already inhibited open debate among those who fear that they will incur feminist wrath, and if it continues, it will seriously jeopardize academic freedom."

Campbell cites a fundamental issue about the pursuit of knowledge. "The postmodern rejection of grand theory (feminist theory excepted) which emphasizes close qualitative description of experiences and discourse which are contextually and historically bound. This effectively replaces theory with subjectively interpreted description. Since there are multiple possible descriptions of any event and no objective criterion for deciding between them the best one is the one that resonates with the feminist readers own experience and intuition" - but this invalidates any notion of validity outside one's own personal perspective, hence also any historical truth of men's oppression of women as well.

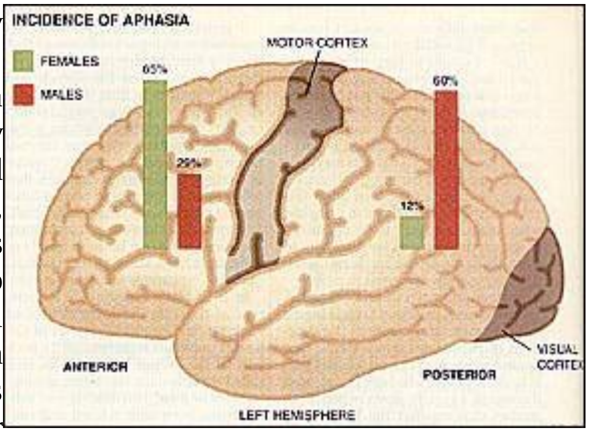
We have noted that biological gender may be a minimum energy solution which allows for natural slippage in transsexual and homosexual behavior. Orientation to the same sex is noted in many species besides humans. Certain male sheep seem to display a rigid orientation to other males, suggestive of a genetically imprinted effect. However one of our closest species, the bonobo uses frank homosexual engagement in sexual socialization. Females will engage sexual rubbing to orgasm and males sexually massage one another's genitals. The female clitoris has even evolved to facilitate mutual female-female 'coitus' called 'hoka-hoka' for its ecstatic cries. However here the context of sexual activity is manifestly psycho-social and not just reproductive. An entire troop may engage a sexual spree on sight of food and many of these homosexual encounters appear to be appeasement to reduce tension rather than driven by sexual appetite. Moreover this behavior fits naturally without conflict into the reproductive behavior of bonobo colonies. Although bonobos are genetically adapted to such behavior it is flexible bisexuality with a motive of reconciliating tensions rather than committed exclusive attachment to the same sex.

In studies of human sexual orientation, a gulf separates culturally constructionist ideas of sexual orientation advanced in particular by some schools of lesbian feminist thought which see sexual orientation as a social choice and the professed enthusiasm the male gay community has for each discovery that suggests a 'born to be gay' genetic basis for exclusive homosexuality either in genetic or neuroscience discoveries. There is some justification to both these points of view. Twin studies of Bailey and Pillard show that a genetic component may explain 30% of both male and female homosexual orientation, familial influences another 20%. Bailey himself worried that the statistics might have been inflated by the fact that the respondents had been found through gay activist newspapers (Blum R66 133). However the remaining cultural influence of some 50% is still the major factor and even though genetic influences may play an early formative role, we need to keep in mind the hallmark capacity of human adaptability is over and above all other species to retain a personal autonomy over our choices and fates. The evidence both from bonobos and our own physiology suggests this remains true for sexual orientation, despite genetic influences.

The Gatherer-hunter Cortex

Although women's brains are slightly smaller on average than men, Jill M. Goldstein and co-workers have found that certain areas in the frontal cortex and emotional limbic system, including the hippocampus, are relatively larger in women, while parietal regions dealing with spatial orientation and the amygdala dealing with emotional impulses are relatively larger in men. Moreover Sandra Witelson and colleagues have found that language areas in the temporal lobe and in the frontal lobes have a greater density of neurons in women (Cahill R99). Such variations are likely connected with steroids in development as they contain some of the highest levels of sex hormone receptors.

Doreen Kimura (R361), studying sex differences in the human brain notes broad differences in activities, contrasting spatial and linguistic ability, as well as mathematical reasoning.



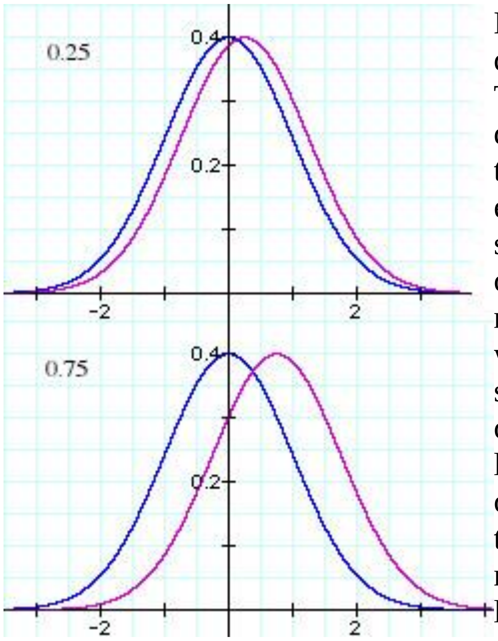
Incidence of aphasia after stroke are significantly different between men and women (Kimura R361). Women have on the mean, comparable (and often superior) intelligence to men. Females are generally more accomplished in language development and social maturity, particularly during adolescence, although men tend to have the edge in the mechanics of mathematical manipulation and spatial map reading (R361). In all of these, except mathematical manipulation individual differences are much greater than gender differences. These differences also reflect, to a degree, gatherer-hunter specializations of the two sexes.

Major sex differences in intellectual function seem to lie in differing patterns of ability rather than in overall level of intelligence. Men, on average, perform better than women on certain spatial tasks. Men have an advantage in certain spatial tasks, such as tests that require the subject to imagine rotating an object or manipulating it in some other way. They outperform women in navigating their way through a route. Map reading has become a clichÃ© of gender difference. Further, men are more accurate in tests of target-directed motor skills-that is, in guiding or intercepting projectiles. They do better on disembedding tests, in which they have to find a simple shape, once it is hidden within a more complex figure and men tend to do better than women on tests of mathematical reasoning (R361). Deborah Blum jokingly comments "my favorite part of this is that the wonders of human math/spatial skills are based on sexual promiscuity" noting that map reading is not just for hunting but for keeping track of one's sexual partners. See also Geary (R234).

These maths skills differences appear to be real. The most comprehensive study published in Science in 1995 found that in maths and science in the top ten percent, boys outnumbered girls three to one. In the top one percent there were seven boys to each girl. By contrast in language skills there were twice as many boys at the bottom and twice as many girls at the top. In writing skills girls were so much better, boys were considered 'at a rather profound disadvantage' (Blum R66 58). This tallies with the less lateralized distribution of language in females, as the creative use of language may occur in the subdominant right hemisphere.

Women tend to be better than men at rapidly identifying matching items, a skill called perceptual speed. They have greater verbal fluency, including the ability to find words that begin with a specific letter or fulfill some other constraint. Women also out perform men in arithmetic calculation and in recalling landmarks from a route. Moreover, women are faster at certain precision manual tasks, such as placing pegs in designated holes on a board. In addition, women remember whether an object, or a series of objects, has been displaced. On some tests of ideational fluency, those in which subjects must list objects that are the same color, and on tests of verbal fluency, in which participants must list words that begin with the same letter, women also outperform men. And women do better than men on mathematical calculation tests (Kimura R361).

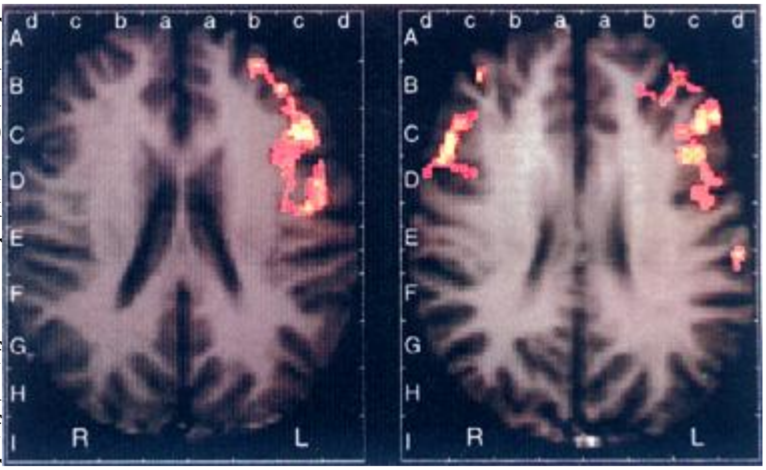
Deborah Blum (R66 56), following the research of Thomas Beaver, notes that there are two ways of following a route, using landmarks or calculating distances traveled and that women tend to navigate by landmarks 'the gas station past the furniture store' as opposed to 'turn left on 69 for 15 miles then right for a mile and left'. Beaver has found that, in both rats and humans, although males did better on featureless mazes; in tests where the distances were changed, but the landmarks were correct, females performed better than males. This difference in approach may be reflected in the larger hippocampus in women. There is some evidence gay men make more use of landmarks than heterosexual men (R563), although they also use male distance and direction strategies, but no evidence for a difference between lesbian and heterosexual women. The only measure on which they appear to shift is on language production or verbal fluency. Like straight men, lesbians tend to be more sparing with words than straight women. Gay men, however, are inclined to speak as much as straight women.



Effect sizes of 0.25 and 0.75 illustrated for a normal distribution

To compare the magnitude of a difference across several distinct tasks, the difference between groups is divided by the standard deviation. The resulting number is called the effect size. Effect sizes below 0.5 are generally considered small. There are typically no differences between the sexes on tests of vocabulary (effect size 0.02), nonverbal reasoning (0.03) and verbal reasoning (0.17). On tests in which subjects match pictures, find words that begin with similar letters or show ideational fluency such as naming objects that are white or red-the effect sizes are somewhat larger: 0.25, 0.22 and 0.38, respectively. Women tend to outperform men on these tasks. Researchers have reported the largest effect sizes for certain tests measuring spatial rotation (effect size 0.7) and targeting accuracy (0.75). The large effect size in these tests means there are many more men at the high end of the score distribution.

We have noted that women also have slightly smaller brains with slightly fewer cells on average, but all these features are in relation to the relative body size of women, and do not indicate any significant differences in mental capacity. There are also significantly different types of functional organization in the cerebral cortex between men and women. These are strongly illustrated in the differences in the aphasias which result from strokes in the frontal and parietal regions of the cortex (p 388).

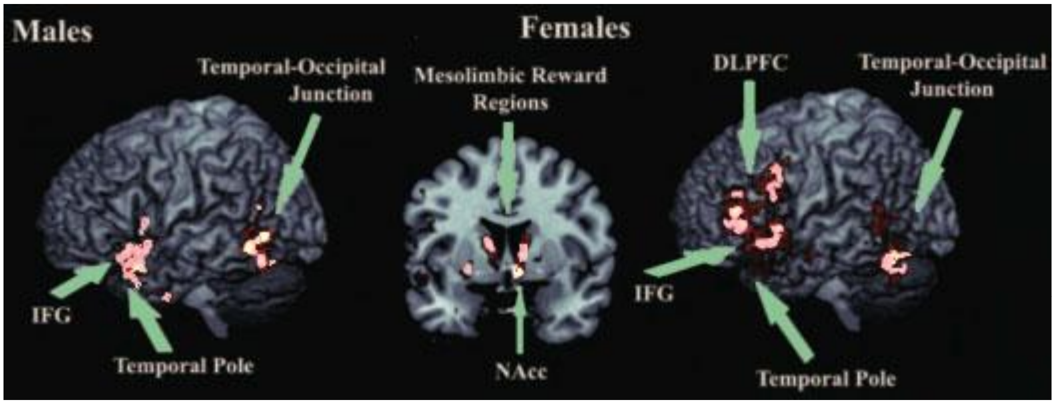


Sexual dimorphisms in language under letter recognition, rhyming and semantic category tasks, with a visual task as control, averaged over 19 males left and 19 females right, all right handed. By subtracting task fMRIs one can test for semantics or phonology alone (Shaywitz et. al. R636).

One of the most outstanding studies of language is that of the Sally and Bennett Shaywitz, in which a series of language tasks were examined under functional magnetic resonance imaging. The tasks were subtracted to highlight language activity over other functional activity. They show the less lateralized language function in women. The Gurs' studies on the resting brain (Blum R66 61) found male activity occurred more from the amygdala and women from the cingulate gyrus, two parts of the limbic emotional system, one ancient and reptilian and the other of more recent evolution, suggesting men are primed to react physically and women verbally. Contradicting these studies, Steven Petersen found little or no differences in region, although the male brains worked a little harder (R66 62). This increased activity may be correlated with the higher rate of cell death in males.

It is assumed by many researchers studying sex differences that the two hemispheres are more asymmetrically organized for speech and spatial functions in men than in women. Parts of the corpus callosum, a major set of axons connecting the two hemispheres, may be more extensive in women. Perceptual techniques that probe brain asymmetry in normal-functioning people sometimes show smaller asymmetries in women than in men, and damage to one brain hemisphere sometimes has a lesser effect in women than the comparable injury has in men. In 1982 it was reported that the back part of the corpus callosum, an area called the splenium, was larger in women than in men. This finding has subsequently been both refuted and confirmed. The view that a male brain is functionally more asymmetric than a female brain is long-standing. Androgens have been claimed to increase the functional potency of the right hemisphere.

In 1981 Marian Diamond found that the right cortex is thicker than the left in male rats but not in females. Jane Stewart, and Bryan E. Kolb (R99), pinpointed early hormonal influences on this asymmetry: androgens appear to suppress left cortex growth. In the 1990s Marie-Christine de Lacoste and her colleagues reported a similar pattern in human fetuses (Kimura R361). They found the right cortex was thicker than the left in males. Thus, there appear to be some anatomic reasons for believing that the two hemispheres might not be equally asymmetric in men and women. Despite this expectation, the evidence in favor of it is meager and conflicting, which suggests that the most striking sex differences in brain organization may not be related to asymmetry.

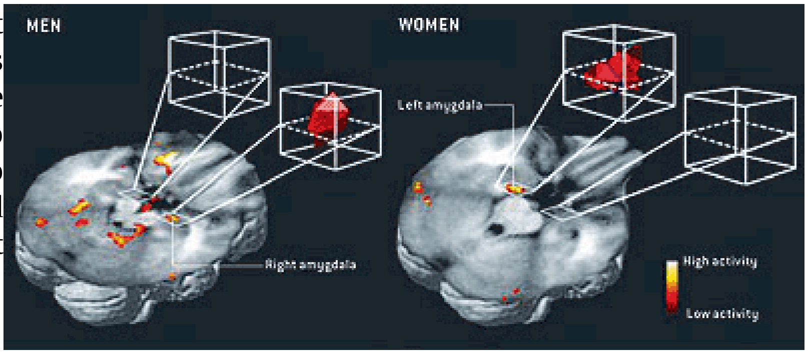


Responses to humourous cartoons (Azim et al. R29) show significant differences in frontal processing and a more decisive response in emotional centres when women appreciated the joke.

Significant differences exist in the way the two sexes respond to and process humour (Azim et al. R29) Males and females share an extensive humor-response strategy as indicated by recruitment of similar brain regions: both activate the temporalé occipital junction and temporal pole, structures implicated in semantic knowledge and juxtaposition, and the inferior frontal gyrus, likely to be involved in language processing. Females, however, activate the left prefrontal cortex more than males, suggesting a greater degree of executive processing and language-based decoding. Females also exhibit greater activation of mesolimbic regions, including the nucleus accumbens, implying greater reward network response and possibly less reward expectation. Women were more analytical in their response, and felt more pleasure when they decided something really was funny. "Women appeared to have less expectation of a reward, which in this case was the punch line of the cartoon, so when they got to the joke's punch line, they were more pleased about it." Women subject humor to more analysis with the aim of determining if it was indeed funny. Men were prepared to laugh along with slapstick.

There are significant limbic differences which reflect these trends. Males' hippocampi appear to thrive on short-term stress but to succumb to long-term stress while females have the reverse pattern (Cahill R99). Emotionally stressful experiences also fire up the right amygdala in men but the left in women. This tends to make men acutely aware of central aspects of the situation while women are made more aware of the surrounding details and ambience. Men also tend to have significantly higher serotonin levels making them less liable to depression

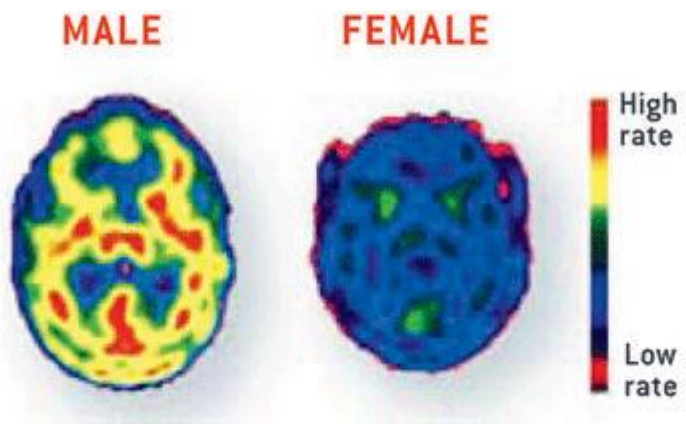
Response to an unpleasant experience, in the amygdala, differs between men, who respond in the right amygdala and are drawn to central features, and women who respond in the left amygdala and remember more of the context (R99).



Tania Singer et al. (R644) analyzed the brain activity of 32 volunteers after their participation in the Prisoners' Dilemma, which we know allows players to cooperate or double-cross one another,

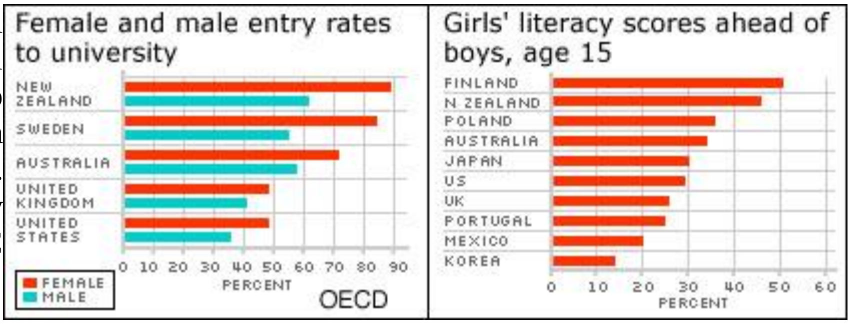
and so fosters camaraderie or enmity between them. Following the game, participants were placed inside an fMRI imager and saw their fellow players zapped with electricity. The scans revealed changes in activity as players who had cooperated got zapped, compared with those who had double-crossed them in the game. The results suggest that men get a much bigger kick than women from seeing revenge physically exacted on someone perceived to have wronged them.
In a study by Haier et. al. (R277) men used nearly 6.5 times the amount of gray matter related to general intelligence than women, whereas women used nearly 10 times the amount of white matter.

Baron-Cohen (R43, R44) suggests the female brain is adapted to 'empathy' while the male brain is adapted for understanding and building systems. These differences are at least partly innate. Even at 24 hours after birth sex differences emerge with girls looking longer at faces and boys longer at inanimate mobiles. This appears to relate to pre-natal testosterone with higher levels correlating with less eye contact and slower vocabulary development at 12 and 18 months respectively. Of course parents tend to reinforce such gender stereotypes in their boys and girls often claiming male maths skill is 'a whizz' while female achievement is 'hard work', but the innate differences still appear to exist. Similarly the preference of boys for action toys and girls for dolls is reflected in similar choices made by monkeys (R99).



Serotonin levels are often higher in men, consistent with women suffering more from depression (R99).
The empathic factor also appears to relate to networking. In "The First Sex", Helen Fisher (R210) contrasts step-by-step analytic thinking, which discounts extraneous data to get at the essential principles, with a web-based associative networking mentality that gathers together disparate facts and nuances and integrates them into a coherent social process. Although both sexes do both, she claims from a host of studies that across disparate cultures, men more naturally assume the former and women the latter.

Many sexual differences found between women and men may be adaptions to gatherer hunter life. Good map reading is important for hunting in the wild. By contrast women are better at classifying a large number of similar objects in a space consistent with recognizing plants and tubers. These factors also relate to differing styles of social grouping between the male hierarchies and coalitions of females we find in ape societies, although here again both sexes can and do use both strategies. For example, although male chimps form hierarchies, and female chimps and bonobos form coalitions, female competition can also give rise to hierarchies, and male coalitions play an important role in dominance and competition. Women also often show a much more developed sense of place, developing a sustaining 'home' environment, while single men tend towards a more shiftless existence.



(a) Changes of educational trends from male preferential patterns have seen girls leap ahead in university admission rates. Compare figure (p 49). (b) Female adolescent literacy surpasses that of males (BBC 16 Sep 2003).

It seems clear that the sex differences in cognitive patterns arose because they proved evolutionarily advantageous. And their adaptive significance probably rests in the entire period of say 100,000 years during which Homo sapiens has emerged, and not just the cultural phase of the last 10,000 years, although this too will be having a cumulative effect. The organization of the human brain was determined over many generations by natural selection. As studies of fossil skulls have shown, our brains are essentially like those of our ancestors of 50,000 or more years ago. For these longer epochs during which our brain characteristics evolved, humans lived in relatively small groups of gatherer-hunters (p 84). The division of labor between the sexes in such a society probably was quite marked, as it is in existing hunter-gatherer societies (p 106). Men were responsible for hunting large game, which often required long-distance travel. They were also responsible for defending the group against predators and enemies and for the shaping and use of weapons. Women most probably gathered food near the camp, tended the home, prepared food and clothing and cared for children. Such specializations would put different selection pressures on men and women. Men would require long-distance route-finding ability so they could recognize a geographic array from varying orientations. They would also need targeting skills. Women would require short-range navigation, perhaps using landmarks, fine-motor capabilities carried on within a circumscribed space, and perceptual discrimination sensitive to small changes in the environment or in children's appearance or behavior. Men's hunting is often silent vigil, while women's gathering is frequently talkative and full of gossip which could explain some of the linguistic differences. Nevertheless both sexes and particularly men who are uncertain of their offspring depended on the grapevine and their intuitive senses of fidelity and betrayal to ensure their genes were passed on into the selective process. Mellowing with age in which older people are better at perceiving happiness has been confirmed in neuroscience experiments and may have been a specific gatherer-hunter asset in elders facilitating conflict resolution (Journal of Neuroscience DOI: 10.1523/jneurosci.0022-06.2006).

In an ironic reflection of these differences, a study by the Pew Internet Project found that as of late 2005 roughly the same percentage of men and women in the US are serious internet users, but use it differently. Men value the net for the freedom it gives them to try new ways of doing things. By contrast women like the opportunities the net gives them to make and maintain human connections (Gender gap alive and well online BBC 29-12-05). "This moment in internet history will be gone in a blink," said Deborah Fallows, senior research fellow at Pew who wrote the report." We may soon look back on it as a charming, even quaint moment, when men reached for the farthest corners of the internet, trying and experimenting with whatever came along, and when women held the internet closer and tried to keep it a bit more under control." Yet these differences are older than culture itself.

References

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