Consciousness Studies

Part II: Historical Review and Neuroscience

From Wikibooks, the open-content textbooks collection

Edition 1.0 14th February 2006

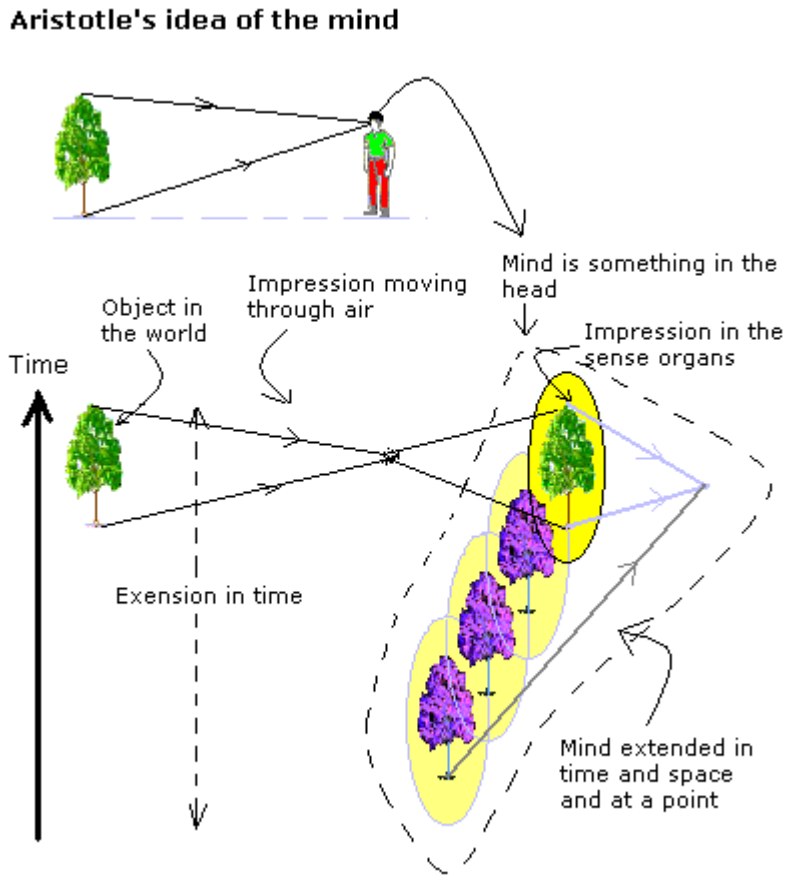
Note: current version of this book can be found at
http://en.wikibooks.org/wiki/Consciousness_studies

Historical Ideas

Aristotle. (c.350 BC). On the Soul.

(De Anima) http://psychclassics.yorku.ca/Aristotle/De-anima/

Aristotle, more than any other ancient philosopher, set the terms of reference for the future discussion of the problem of consciousness. His idea of the mind is summarised in the illustration below.



Aristotle was a physicalist, believing that things are embodied in the material universe:

"... That is precisely why the study of the soul must fall within the science of Nature, at least so far as in its affections it manifests this double character. Hence a physicist would define an affection of soul differently from a dialectician; the latter would define e.g. anger as the appetite for returning pain for pain, or something like that, while the former would define it as a boiling of the blood or warm substance surround the heart. The latter assigns the material conditions, the former the form or formulable essence; for what he states is the formulable essence of the fact, though for its actual existence there must be embodiment of it in a

material such as is described by the other."(Book I)

The works of Aristotle provide our first clear account of the concept of signals and information. He was aware that an event can change the state of matter and this change of state can be transmitted to other locations where it can further change a state of matter:

"If what has colour is placed in immediate contact with the eye, it cannot be seen. Colour sets in movement not the sense organ but what is transparent, e.g. the air, and that, extending continuously from the object to the organ, sets the latter in movement. Democritus misrepresents the facts when he expresses the opinion that if the interspace were empty one could distinctly see an ant on the vault of the sky; that is an impossibility. Seeing is due to an affection or change of what has the perceptive faculty, and it cannot be affected by the seen colour itself; it remains that it must be affected by what comes between. Hence it is indispensable that there be something in between-if there were nothing, so far from seeing with greater distinctness, we should see nothing at all." (Book II)

He was also clear about the relationship of information to 'state':

"By a 'sense' is meant what has the power of receiving into itself the sensible forms of things without the matter. This must be conceived of as taking place in the way in which a piece of wax takes on the impress of a signet-ring without the iron or gold; we say that what produces the impression is a signet of bronze or gold, but its particular metallic constitution makes no difference: in a similar way the sense is affected by what is coloured or flavoured or sounding, but it is indifferent what in each case the substance is; what alone matters is what quality it has, i.e. in what ratio its constituents are combined"(Book II)

Aristotle also mentioned the problem of the simultaneity of experience. The explanation predates Galilean and modern physics so lacks our modern language to explain how many things could be at a point and an instant:

"... just as what is called a 'point' is, as being at once one and two, properly said to be divisible, so here, that which discriminates is qua undivided one, and active in a single moment of time, while so far forth as it is divisible it twice over uses the same dot at one and the same time. So far forth then as it takes the limit as two' it discriminates two separate objects with what in a sense is divided: while so far as it takes it as one, it does so with what is one and occupies in its activity a single moment of time. (Book III)

He described the problem of recursion that would occur if the mind were due to the flow of material things in space:

"...mind is either without parts or is continuous in some other way than that which characterizes a spatial magnitude. How, indeed, if it were a spatial magnitude, could mind possibly think? Will it think with any one indifferently of its parts? In this case, the 'part' must be understood either in the sense of a spatial magnitude or in the sense of a point (if a point can be called a part of a spatial magnitude). If we accept the latter alternative, the points being infinite in number, obviously the mind can never exhaustively traverse them; if the former, the mind must think the same thing over and over again, indeed an infinite number of times (whereas it is manifestly possible to think a thing once only)."(Book I)

Aristotle explicitly mentions the regress:

"..we must fall into an infinite regress or we must assume a sense which is aware of itself." (Book III,425b)

However, this regress was not as problematic for Aristotle as it is for philosophers who are steeped in nineteenth century ideas. Aristotle was a physicalist who was not burdened with materialism and so was able to escape from the idea that the only possibility for the mind is a flow of material from place to place over a succession of disconnected instants. He was able to propose that subjects and objects are part of the same thing, he notes that thought is both temporally and spatially extended:

"But that which mind thinks and the time in which it thinks are in this case divisible only incidentally and not as such. For in them too there is something indivisible (though, it may be, not isolable) which gives unity to the time and the whole of length; and this is found equally in every continuum whether temporal or spatial."

This idea of time allowed him to identify thinking with the object of thought, there being no need to cycle thoughts from instant to instant because mental time is extended:

"In every case the mind which is actively thinking is the objects which it thinks."

He considered imagination to be a disturbance of the sense organs:

"And because imaginations remain in the organs of sense and resemble sensations, animals in their actions are largely guided by them, some (i.e. the brutes) because of the non-existence in them of mind, others (i.e. men) because of the temporary eclipse in them of mind by feeling or disease or sleep.(Book III)"

And considered that all thought occurs as images:

"To the thinking soul images serve as if they were contents of perception (and when it asserts or denies them to be good or bad it avoids or pursues them). That is why the soul never thinks without an image."(Book III).

Aristotle also described the debate between the cognitive and behaviourist approaches with their overtones of the conflict between modern physicalism and pre twentieth century materialism:

"Some thinkers, accepting both premisses, viz. that the soul is both originative of movement and cognitive, have compounded it of both and declared the soul to be a self-moving number."(Book I)

The idea of a 'self-moving number' is not as absurd as it seems, like much of Ancient Greek philosophy.

Aristotle was also clear about there being two forms involved in perception. He proposed that the form and properties of the things that are directly in the mind are incontrovertible but that our inferences about the form and properties of the things in the world that give rise to the things in the mind can be false:

"Perception (1) of the special objects of sense is never in error or admits the least possible amount of falsehood. (2) That of the concomitance of the objects concomitant with the sensible qualities comes next: in this case certainly we may be deceived; for while the

perception that there is white before us cannot be false, the perception that what is white is this or that may be false. (3) Third comes the perception of the universal attributes which accompany the concomitant objects to which the special sensibles attach (I mean e.g. of movement and magnitude); it is in respect of these that the greatest amount of sense-illusion is possible."(Book III)

Imagination, according to this model, lays out things in the senses.

Homer,(c.800-900 BC)The Iliad and Odyssey

Odyssey

Panpsychism and panexperientialism can be traced to, at least, Homer's Iliad. Just reading the book allows us to experience what a different focus of consciousness feels like. It is a way of being, Being an Homeric Greek, distinct from being a modern man. Both states of consciousness result in different ways of experiencing the world.

As we read the Iliad, we are drawn into the book through the images it creates in us and the feelings it evokes in us through the meter and the language. The reader becomes the book. 'The reader became the book, and the summer night was like the conscious being of the book' (Wallace Stevens). That experience of becoming the book, of loosing yourself in the book, is the experience of a different aspect of consciousness, being an Homeric Greek.

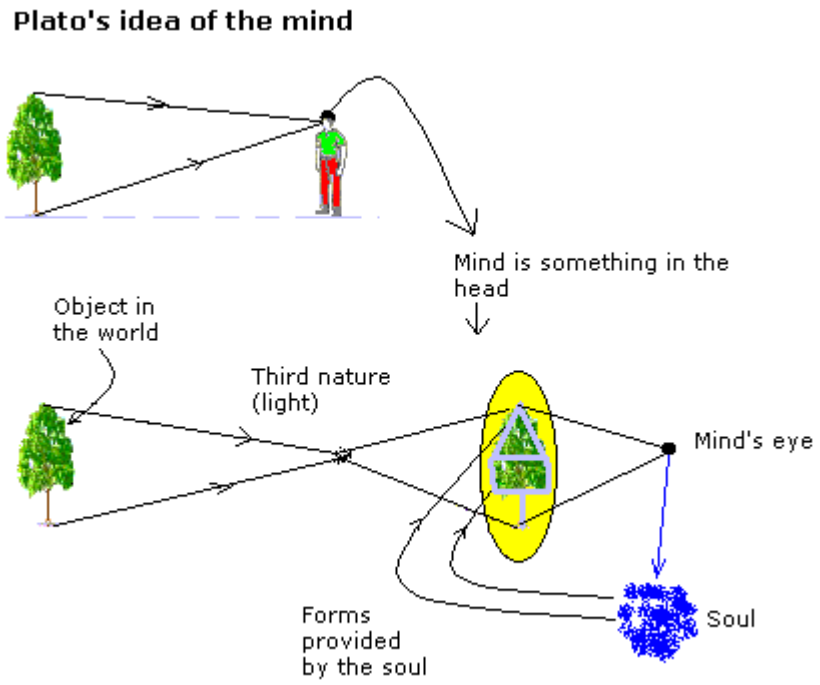
Homer frequently ascribes even our emotions to the world around us. The ancients do not just fear but fear grips them, for example: "So spake Athene, and pale fear gat hold of them all. The arms flew from their hands in their terror and fell all upon the ground, as the goddess uttered her voice" (Odyssey book XXIV).

The German classicist Bruno Snell, in 'The Discovery of the Mind' provides us with 'a convincing account of the enormous change in... human personality which took place during the centuries covered by Homer (to) Socrates.'(The London Times Literary Supplement). Snells book establishes two disinct aspects of consciousness. He says 'The experience of Homer differs from our own'(p.v). 'For Homer, psyche is the force which keeps the human being alive'(p.8). When the psyche leaves, the owner loses consciousness. The Homeric 'psyche' is where pan-pychism originates. It begins in a conception of consciousness as a force that is seperate from the body. Snell compares Homer to the tragedy of Orestes, which focuses on the individual. Homer concentrates on the action(process) and the situation in preference to the agent'(p.211) Orestes is in a different state of consciousness, 'a new state of consciousness'(p.211).

Plato (427-347BC)

The Republic http://www.constitution.org/pla/repub_00.htm Especially book VI http://www.constitution.org/pla/repub_06.htm

Plato's most interesting contributions to consciousness studies are in book VI of *The Republic*. His idea of the mind is illustrated below:



He believes that light activates pre-existing capabilities in the eyes:

"Sight being, as I conceive, in the eyes, and he who has eyes wanting to see; color being also present in them, still unless there be a third nature specially adapted to the purpose, the owner of the eyes will see nothing and the colors will be invisible."

However, it is in the metaphor of **the divided line** that Plato introduces a fascinating account of the relationships and properties of things. He points out that analysis deals in terms of the relationships of pure forms:

"And do you not know also that although they make use of the visible forms and reason about them, they are thinking not of these, but of the ideals which they resemble; not of the figures which they draw, but of the absolute square and the absolute diameter, and so on -- the forms which they draw or make, and which have shadows and reflections in water of their own, are converted by them into images, but they are really seeking to behold the things themselves, which can only be seen with the eye of the mind?"

Notice how he introduces the notion of a mind's eye observing mental content arranged as geometrical forms. He proposes that through this mode of ideas we gain understanding:

"And the habit which is concerned with geometry and the cognate sciences I suppose that you would term understanding, and not reason, as being intermediate between opinion and reason."

However, the understanding can also contemplate knowledge:

"..I understand you to say that knowledge and being, which the science of dialectic contemplates, are clearer than the notions of the arts, as they are termed, which proceed from hypotheses only: these are also contemplated by the understanding, and not by the senses: yet, because they start from hypotheses and do not ascend to a principle, those who contemplate them appear to you not to exercise the higher reason upon them, although when a first principle is added to them they are cognizable by the higher reason. "

Plato's work is not usually discussed in this way but is extended to universals such as the idea of the colour red as a universal that can be applied to many specific instances of things.

Siddhartha Gautama c.500BC Buddhist Texts

Siddhartha Gautama was born about 563BC. He became known as 'Buddha' ('the awakened one') from the age of about thirty five. Buddha handed down a way of life that might lead, eventually, to an enlightened state called Nirvana. In the three centuries after his death Buddhism split into two factions, the Mahayana (greater raft or vehicle) and the Theravada (the way of the elders). The Mahayana use the slightly derogatory term Hinayana (lesser raft or vehicle) for Theravada Buddhism. Mahayana Buddhism gave rise to other sects such as Zen Buddhism in Japan and Vajrayana Buddhism in Tibet. Mahayana Buddhism is more like a religion, complete with god like entities whereas Theravada Buddhism is more like a philosophy.

Theravada Buddhist meditation is described in books called the Pali Canon which contains the 'Vinayas' that describe monastic life, the 'Suttas' which are the central teachings of Theravada Buddhism and the 'Abhidhamma' which is an analysis of the other two parts or 'pitakas'. Two meditational systems are described: the development of serenity (samathabhavana) and the development of insight (vipassanabhavana). The two systems are complementary, serenity meditation providing a steady foundation for the development of insight. As meditation proceeds the practitioner passes through a series of stages called 'jhanas'. There are four of these stages of meditation and then a final stage known as the stage of the 'immaterial jhanas'.

The Jhanas

The first jhana is a stage of preparation where the meditator rids themselves of the hindrances (sensual desire, ill will, sloth and torpor, restlessness and worry, and doubt). This is best achieved by seclusion. During the process of getting rid of the hindrances the meditator develops the five factors: applied thought, sustained thought, rapture, happiness and one-pointedness of mind. This is done by concentrating on a practice object until it can be easily visualised. Eventually the mediator experiences a luminous replica of the object called the counterpart sign (patibhaganimitta).

Applied thought involves examining, visualising and thinking about the object. Sustained thought involves always returning to the object, not drifting away from it. Rapture involves a

oneness with the object and is an ecstacy that helps absorption with and in the object. Happiness is the feeling of happiness that everyone has when something good happens (unlike rapture, which is a oneness with the object of contemplation). One-pointedness of mind is the ability to focus on a single thing without being distracted.

The second jhana involves attaining the first without effort, there is no need for applied or sustained thought, only rapture, happiness and one-pointedness of mind remain. The second jhana is achieved by contemplating the first jhana. The second jhana is a stage of effortless concentration.

The third jhana involves mindfulness and discernment. The mindfulness allows an object of meditation to be held effortlessly in the mind. The discernment consists of discerning the nature of the object without delusion and hence avoiding rapture.

In the fourth jhana mindfulness is maintained but the delusion of happiness is contemplated. Eventually mindfulness remains without pleasure or pain. In the fourth jhana the meditator achieves "purity of mindfulness due to equanimity" (upekkhasatiparisuddhi).

The Immaterial Jhanas

The first four jhanas will be familiar from earlier, Hindu meditational techniques. Once the fourth jhana has been achieved the meditator can embark on the immaterial jhanas. There are four immaterial jhanas: the base of boundless space, the base of boundless consciousness, the base of nothingness, and the base of neither-perception-nor-non-perception.

The base of boundless space is achieved by meditating on the absence of the meditation object. It is realised that the space occupied by the object is boundless and that the mind too is boundless space. The base of boundless consciousness involves a realisation that the boundless space is boundless consciousness. The base of nothingness is a realisation that the present does not exist, the meditator should "give attention to the present non-existence, voidness, secluded aspect of that same past consciousness belonging to the base consisting of boundless space" (Gunaratana 1988). The base of neither-perception-nor-non-perception is a realisation that nothing is perceived in the void.

In Theravada Buddhism the attainment of the fourth jhana and its immaterial jhanas represents a mastery of serenity meditation. This is a foundation for insight meditation.

Buddhism is very practical and eschews delusions. It is realised that serenity meditation is a state of mind, a steady foundation that might, nowadays be called a physiological state. It is through insight meditation where the practitioner becomes a philosopher that enlightenment is obtained.

Further reading:

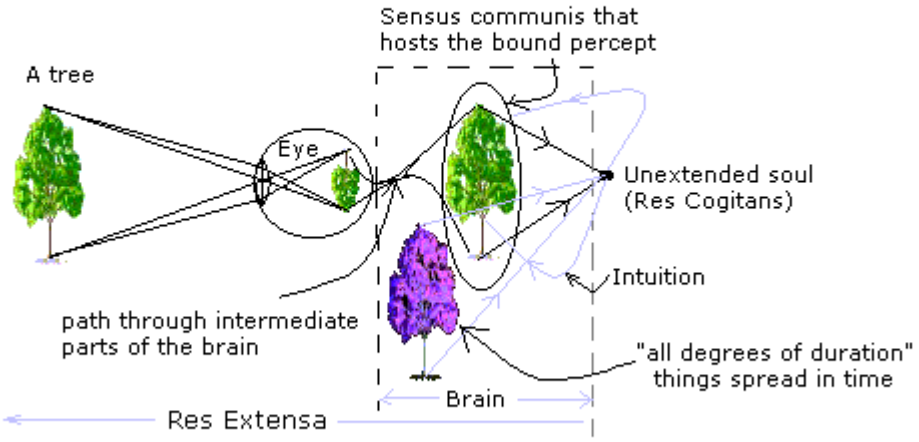
The Buddhist Publication Society. Especially: The Jhanas In Theravada Buddhist Meditation by Henepola Gunaratana. The Wheel Publication No. 351/353 ISBN 955-24-0035-X. 1988 Buddhist Publication Society. http://www.accesstoinsight.org/lib/bps/index.html

Seventeenth and Eighteenth Century Philosophy

Rene Descartes (1596-1650)

Descartes was also known as Cartesius. He had an empirical approach to consciousness and the mind, describing in his *Meditations on First Philosophy* (1641) what it is like to be human. His idea of perception is summarised in the diagram below.

Descartes idea of perception



Dubitability

Descartes is probably most famous for his statement:

"But immediately upon this I observed that, whilst I thus wished to think that all was false, it was absolutely necessary that I, who thus thought, should be somewhat; and as I observed that this truth, I think, therefore I am (COGITO ERGO SUM), was so certain and of such evidence that no ground of doubt, however extravagant, could be alleged by the sceptics capable of shaking it, I concluded that I might, without scruple, accept it as the first principle of the philosophy of which I was in search."

Descartes is clear that what he means by *thought* is all the things that occur in experience, whether dreams, sensations, symbols etc.:

"5. Of my thoughts some are, as it were, images of things, and to these alone properly belongs the name IDEA; as when I think [represent to my mind] a man, a chimera, the sky, an angel or God. Others, again, have certain other forms; as when I will, fear, affirm, or deny, I always, indeed, apprehend something as the object of my thought, but I also embrace in thought something more than the representation of the object; and of this class of thoughts some are called volitions or affections, and others judgments." (Meditation III).

He repeats this general description of thought in many places in the Meditations and elsewhere. What Descartes is saying is that his meditator has thoughts; that there are thoughts and this cannot be doubted when and where they occur (Russell (1945) makes this clear).

Needless to say the basic *cogito* put forward by Descartes has provoked endless debate, much of it based on the false premise that Descartes was presenting an inference or argument rather than just saying that thought certainly exists. However, the extent to which the philosopher can go beyond this certainty to concepts such as God, science or the soul is highly problematical.

The description of thoughts and mind

Descartes uses the words "ideas" and "imagination" in a rather unusual fashion. The word "idea" he defines as follows:

"5. Of my thoughts some are, as it were, images of things, and to these alone properly belongs the name IDEA; as when I think [represent to my mind] a man, a chimera, the sky, an angel or God. Others, again, have certain other forms; as when I will, fear, affirm, or deny, I always, indeed, apprehend something as the object of my thought, but I also embrace in thought something more than the representation of the object; and of this class of thoughts some are called volitions or affections, and others judgments." (Meditation III).

As will be seen later, Descartes regards his mind as an unextended thing (a point) so "images of things" or "IDEAS" require some way of being extended. In the *Treatise on Man* (see below) he is explicit that ideas are extended things in the brain, on the surface of the "common sense". In *Rules for the Direction of the Mind* he notes that we "receive ideas from the common sensibility", an extended part of the brain. This usage of the term "ideas" is very strange to the modern reader and the source of many mistaken interpretations. It should be noted that occasionally Descartes uses the term 'idea' according to its usual meaning where it is almost interchangeable with 'thought' in general but usually he means a representation laid out in the brain.

Descartes considers the imagination to be the way that the mind "turns towards the body" (by which Descartes means the part of the brain in the body called the senses communis):

"3. I remark, besides, that this power of imagination which I possess, in as far as it differs from the power of conceiving, is in no way necessary to my [nature or] essence, that is, to the essence of my mind; for although I did not possess it, I should still remain the same that I now am, from which it seems we may conclude that it depends on something different from the mind. And I easily understand that, if some body exists, with which my mind is so conjoined and united as to be able, as it were, to consider it when it chooses, it may thus imagine corporeal objects; so that this mode of thinking differs from pure intellection only in this respect, that the mind in conceiving turns in some way upon itself, and considers some one of the ideas it possesses within itself; but in imagining it turns toward the body, and contemplates in it some object conformed to the idea which it either of itself conceived or apprehended by sense." Meditations VI

So ideas, where they become imagined images of things were thought by Descartes to involve a phase of creating a form in the brain.

Descartes gives a clear description of his experience as a container that allows length,

breadth, depth, continuity and time with contents arranged within it:

"2. But before considering whether such objects as I conceive exist without me, I must examine their ideas in so far as these are to be found in my consciousness, and discover which of them are distinct and which confused.

3. In the first place, I distinctly imagine that quantity which the philosophers commonly call continuous, or the extension in length, breadth, and depth that is in this quantity, or rather in the object to which it is attributed. Further, I can enumerate in it many diverse parts, and attribute to each of these all sorts of sizes, figures, situations, and local motions; and, in fine, I can assign to each of these motions all degrees of duration."(Meditation V).

He points out that sensation occurs by way of the brain, conceptualising the brain as the place in the body where the extended experiences are found : Meditations VI:

"20. I remark, in the next place, that the mind does not immediately receive the impression from all the parts of the body, but only from the brain, or perhaps even from one small part of it, viz., that in which the common sense (senses communis) is said to be, which as often as it is affected in the same way gives rise to the same perception in the mind, although meanwhile the other parts of the body may be diversely disposed, as is proved by innumerable experiments, which it is unnecessary here to enumerate."

He finds that both imaginings and perceptions are extended things and hence in the (brain part) of the body. The area of extended things is called the *res extensa*, it includes the brain, body and world beyond. He also considers the origin of intuitions, suggesting that they can enter the mind without being consciously created: Meditations VI, 10 :

"10. Moreover, I find in myself diverse faculties of thinking that have each their special mode: for example, I find I possess the faculties of imagining and perceiving, without which I can indeed clearly and distinctly conceive myself as entire, but I cannot reciprocally conceive them without conceiving myself, that is to say, without an intelligent substance in which they reside, for [in the notion we have of them, or to use the terms of the schools] in their formal concept, they comprise some sort of intellection; whence I perceive that they are distinct from myself as modes are from things. I remark likewise certain other faculties, as the power of changing place, of assuming diverse figures, and the like, that cannot be conceived and cannot therefore exist, any more than the preceding, apart from a substance in which they inhere. It is very evident, however, that these faculties, if they really exist, must belong to some corporeal or extended substance, since in their clear and distinct concept there is contained some sort of extension, but no intellection at all. Further, I cannot doubt but that there is in me a certain passive faculty of perception, that is, of receiving and taking knowledge of the ideas of sensible things; but this would be useless to me, if there did not also exist in me, or in some other thing, another active faculty capable of forming and producing those ideas. But this active faculty cannot be in me [in as far as I am but a thinking thing], seeing that it does not presuppose thought, and also that those ideas are frequently produced in my mind without my contributing to it in any way, and even frequently contrary to my will. This faculty must therefore exist in some substance different from me, in which all the objective reality of the ideas that are produced by this faculty is contained formally or eminently, as I before remarked; and this substance is either a body, that is to say, a corporeal nature in which is contained formally [and in effect] all that is objectively [and by representation] in those ideas; or it is God himself, or some other creature, of a rank superior

to body, in which the same is contained eminently. But as God is no deceiver, it is manifest that he does not of himself and immediately communicate those ideas to me, nor even by the intervention of any creature in which their objective reality is not formally, but only eminently, contained. For as he has given me no faculty whereby I can discover this to be the case, but, on the contrary, a very strong inclination to believe that those ideas arise from corporeal objects, I do not see how he could be vindicated from the charge of deceit, if in truth they proceeded from any other source, or were produced by other causes than corporeal things: and accordingly it must be concluded, that corporeal objects exist. Nevertheless, they are not perhaps exactly such as we perceive by the senses, for their comprehension by the senses is, in many instances, very obscure and confused; but it is at least necessary to admit that all which I clearly and distinctly conceive as in them, that is, generally speaking all that is comprehended in the object of speculative geometry, really exists external to me. "

He considers that the mind itself is the thing that generates thoughts and is not extended (occupies no space). This 'mind' is known as the *res cogitans*. The mind works on the imaginings and perceptions that exist in that part of the body called the brain. This is Descartes' dualism: it is the proposition that there is an unextended place called the mind that acts upon the extended things in the brain. Meditations VI, 9:

"... And although I may, or rather, as I will shortly say, although I certainly do possess a body with which I am very closely conjoined; nevertheless, because, on the one hand, I have a clear and distinct idea of myself, in as far as I am only a thinking and unextended thing, and as, on the other hand, I possess a distinct idea of body, in as far as it is only an extended and unthinking thing, it is certain that I, [that is, my mind, by which I am what I am], is entirely and truly distinct from my body, and may exist without it."

Notice that the intellection associated with ideas is part of an "active faculty capable of forming and producing those ideas" that has a "corporeal nature" (it is in the brain). This suggests that the "thinking" in the passage above applies only to those thoughts that are unextended, however, it is difficult to find a definition of these particular thoughts.

"Rules for the Direction of the Mind" demonstrates Descartes' dualism. He describes the brain as the part of the body that contains images or phantasies of the world but believes that there is a further, spiritual mind that processes the images in the brain:

"My fourth supposition is that the power of movement, in fact the nerves, originate in the brain, where the phantasy is seated; and that the phantasy moves them in various ways, as the external sense <organ> moves the <organ of> common sensibility, or as the whole pen is moved by its tip. This illustration also shows how it is that the phantasy can cause various movements in the nerves, although it has not images of these formed in itself, but certain other images, of which these movements are possible effects. For the pen as a whole does not move in the same way as its tip; indeed, the greater part of the pen seems to go along with an altogether different, contrary motion. This enables us to understand how the movements of all other animals are accomplished, although we suppose them to have no consciousness (rerum cognitio) but only a bodily <organ of> phantasy; and furthermore, how it is that in ourselves those operations are performed which occur without any aid of reason.

My fifth and last supposition is that the power of cognition properly so called is purely spiritual, and is just as distinct from the body as a whole as blood is from bone or a hand from an eye; and that it is a single power. Sometimes it receives images from the common

sensibility at the same time as the phantasy does; sometimes it applies itself to the images preserved in memory; sometimes it forms new images, and these so occupy the imagination that often it is not able at the same time to receive ideas from the common sensibility, or to pass them on to the locomotive power in the way that the body left to itself -would. "

Descartes sums up his concept of a point soul seeing forms in the world via forms in the sensus communis in *Passions of the Soul*, 35:

"By this means the two images which are in the brain form but one upon the gland, which, acting immediately upon the soul, causes it to see the form in the mind".

Anatomical and physiological ideas

In his *Treatise on Man* Descartes summarises his ideas on how we perceive and react to things as well as how consciousness is achieved anatomically and physiologically. The 'Treatise' was written at a time when even galvanic electricity was unknown. The excerpt given below covers Descartes' analysis of perception and stimulus-response processing.

Fig. 1

"Thus for example [in Fig 1], if fire A is close to foot B, the tiny parts of this fire (which, as you know, move about very rapidly) have the power also to move the area of skin which they touch. In this way they pull the tiny fibre *cc* which you see attached to it, and simultaneously open the entrance to the pore *de*, located opposite the point where this fiber terminates - just as when you pull one end of a string, you cause a bell hanging at the other end to ring at the

same time.

When the entrance to the pore or small tube *de* is opened in this way, the animal spirits from cavity F enter and are carried through it - some to muscles which serve to pull the foot away from the fire, some to muscles which turn the eyes and head to look at it, and some to muscles which make the hands move and the whole body turn in order to protect it.

Now I maintain that when God unites a rational soul to this machine (in a way that I intend to explain later) he will place its principle seat in the brain, and will make its nature such that the soul will have different sensations corresponding to the different ways in which the entrances to the pores in the internal surface of the brain are opened by means of nerves.

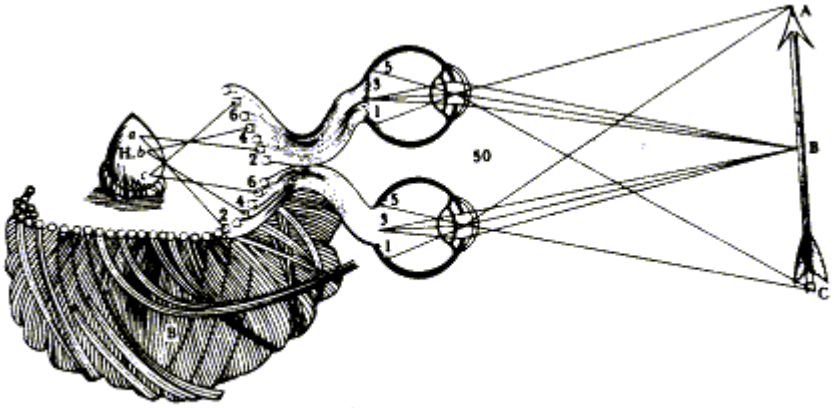


Fig. 2

In order to see clearly how ideas are formed of the objects which strike the senses, observe in this diagram [fig 2] the tiny fibres 12, 34, 56, and the like, which make up the optic nerve and stretch from the back of the eye at 1, 3, 5 to the internal surface of the brain at 2, 4, 6. Now assume that these fibres are so arranged that if the rays coming, for example, from point A of the object happen to press upon the back of the eye at point 1, they pull the whole of fibre 12 and enlarge the opening of the tiny tube marked 2. In the same way, the rays which come from point B enlarge the opening of the tiny tube 4, and likewise for the others. We have already described how, depending on the different ways in which the points 1, 3, 5 are pressed by these rays, a figure is traced on the back of the eye corresponding to that of the object ABC. Similarly it is obvious that, depending on the different ways in which the tiny tubes 2, 4, 6 are opened by the fibres 12, 34, 56 etc., a corresponding figure must also be traced on the internal surface of the brain.

.....

And note that by 'figures' I mean not only things which somehow represent the position of the edges and surfaces of objects, but also anything which, as I said above, can give the soul occasion to perceive movement, size, distance, colours, sounds, smells and other such qualities. And I also include anything that can make the sould feel pleasure, pain, hunger, thirts, joy, sadness and other such passions.

...

Now among these figures, it is not those imprinted on the external sense organs, or on the

internal surface of the brain, which should be taken to be ideas - but only those which are traced in the spirits on the surface of gland H (*where the seat of the imagination and the 'common sense' is located*). That is to say, it is only the latter figures which should be taken to be the forms or images which the rational soul united to this machine will consider directly when it imagines some object or perceives it by the senses.

And note that I say 'imagines or perceives by the senses'. For I wish to apply the term 'idea' generally to all impressions which the spirits can receive as they leave gland H. These are to be attributed to the 'common' sense when they depend on the presence of objects; but they may also proceed from many other causes (as I shall explain later), and they should then be attributed to the imagination. "

The *common sense* is referred to by philosophers as the *senses communis*. Descartes considered this to be the place where all the sensations were bound together and proposed the pineal gland for this role. This was in the days before the concept of 'dominance' of parts of the brain had been developed so Descartes reasoned that only a single organ could host a bound representation.

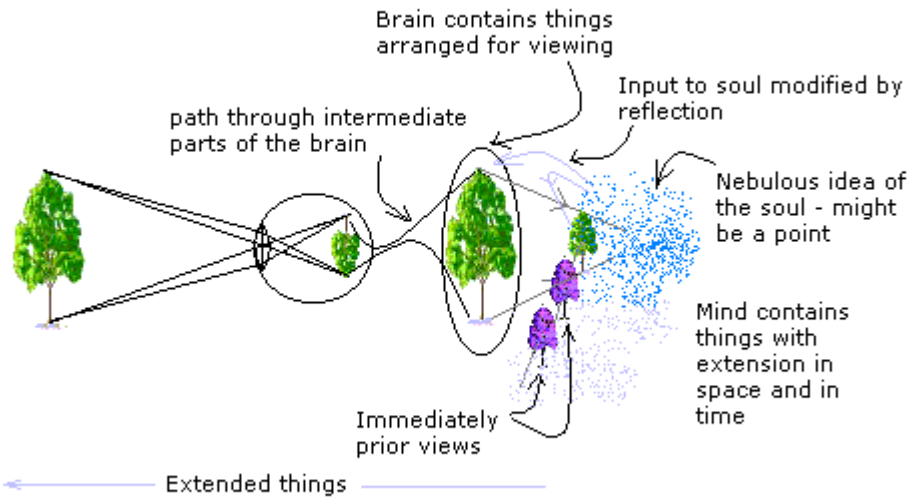
Notice how Descartes is explicit about ideas being **traced in the spirits on the surface of the gland**. Notice also how the rational soul will consider forms on the common sense **directly**.

Descartes believed that animals are not conscious because, although he thought they possessed the stimulus-response loop in the same way as humans he believed that they do not possess a soul.

John Locke (1632-1704)

Locke's most important philosophical work on the human mind was "An Essay Concerning Human Understanding" written in 1689. His idea of perception is summarised in the diagram below:

Locke's idea of perception



Locke is an Indirect Realist, admitting of external objects but describing these as represented within the mind. The objects themselves are thought to have a form and properties that are the *archetype* of the object and these give rise in the brain and mind to derived copies called *ektypa*.

Like Descartes, he believes that people have souls that produce thoughts. Locke considers that sensations make their way from the senses to the brain where they are laid out for understanding as a 'view':

"And if these organs, or the nerves which are the conduits to convey them from without to their audience in the brain,- the mind's presence-room (as I may so call it)- are any of them so disordered as not to perform their functions, they have no postern to be admitted by; no other way to bring themselves into view, and be perceived by the understanding." (Chapter III, 1).

He considers that what is sensed becomes a mental thing: Chapter IX: Of Perception paragraph 1:

"This is certain, that whatever alterations are made in the body, if they reach not the mind; whatever impressions are made on the outward parts, if they are not taken notice of within, there is no perception. Fire may burn our bodies with no other effect than it does a billet, unless the motion be continued to the brain, and there the sense of heat, or idea of pain, be produced in the mind; wherein consists actual perception. "

Locke calls the contents of consciousness "ideas" (cf: Descartes, Malebranche) and regards sensation, imagination etc. as being similar or even alike. Chapter I: Of Ideas in general, and their Original:

"1. Idea is the object of thinking. Every man being conscious to himself that he thinks; and that which his mind is applied about whilst thinking being the ideas that are there, it is past doubt that men have in their minds several ideas,- such as are those expressed by the words whiteness, hardness, sweetness, thinking, motion, man, elephant, army, drunkenness, and others: it is in the first place then to be inquired, How he comes by them?

I know it is a received doctrine, that men have native ideas, and original characters, stamped upon their minds in their very first being. This opinion I have at large examined already; and, I suppose what I have said in the foregoing Book will be much more easily admitted, when I have shown whence the understanding may get all the ideas it has; and by what ways and degrees they may come into the mind;- for which I shall appeal to every one's own observation and experience.

2. All ideas come from sensation or reflection. Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas:- How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer, in one word, from EXPERIENCE. In that all our knowledge is founded; and from that it ultimately derives itself. Our observation employed either, about external sensible objects, or about the internal operations of our minds perceived and reflected on by ourselves, is that which supplies our understandings with all the materials of thinking. These two are the fountains of knowledge, from whence all the ideas we have, or can naturally have, do spring.

3. The objects of sensation one source of ideas. First, our Senses, conversant about particular sensible objects, do convey into the mind several distinct perceptions of things, according to those various ways wherein those objects do affect them. And thus we come by those ideas we have of yellow, white, heat, cold, soft, hard, bitter, sweet, and all those which we call sensible qualities; which when I say the senses convey into the mind, I mean, they from external objects convey into the mind what produces there those perceptions. This great source of most of the ideas we have, depending wholly upon our senses, and derived by them to the understanding, I call SENSATION.

4. The operations of our minds, the other source of them. Secondly, the other fountain from which experience furnisheth the understanding with ideas is,- the perception of the operations of our own mind within us, as it is employed about the ideas it has got;- which operations, when the soul comes to reflect on and consider, do furnish the understanding with another set of ideas, which could not be had from things without. And such are perception, thinking, doubting, believing, reasoning, knowing, willing, and all the different actings of our own minds;- which we being conscious of, and observing in ourselves, do from these receive into our understandings as distinct ideas as we do from bodies affecting our senses. This source of ideas every man has wholly in himself; and though it be not sense, as having nothing to do with external objects, yet it is very like it, and might properly enough be called internal sense. But as I call the other SENSATION, so I Call this REFLECTION, the ideas it affords being such only as the mind gets by reflecting on its own operations within itself. By reflection then, in the following part of this discourse, I would be understood to mean, that notice which the mind takes of its own operations, and the manner of them, by reason whereof there come to be ideas of these operations in the understanding. These two, I say, viz. external material things, as the objects of SENSATION, and the operations of our own minds within, as the objects of REFLECTION, are to me the only originals from whence all our ideas take their beginnings. The term operations here I use in a large sense, as comprehending not barely the actions of the mind about its ideas, but some sort of passions arising sometimes from them, such as is the satisfaction or uneasiness arising from any thought.

5. All our ideas are of the one or the other of these. The understanding seems to me not to have the least glimmering of any ideas which it doth not receive from one of these two. External objects furnish the mind with the ideas of sensible qualities, which are all those different perceptions they produce in us; and the mind furnishes the understanding with ideas of its own operations. "

He calls ideas that come directly from the senses *primary qualities* and those that come from reflection upon these he calls *secondary qualities*:

"9. Primary qualities of bodies. Qualities thus considered in bodies are, First, such as are utterly inseparable from the body, in what state soever it be; and such as in all the alterations and changes it suffers, all the force can be used upon it, it constantly keeps; and such as sense constantly finds in every particle of matter which has bulk enough to be perceived; and the mind finds inseparable from every particle of matter, though less than to make itself singly be perceived by our senses: ..... These I call original or primary qualities of body, which I think we may observe to produce simple ideas in us, viz. solidity, extension, figure, motion or rest, and number. 10. Secondary qualities of bodies. Secondly, such qualities which in truth are nothing in the objects themselves but power to produce various sensations in us by their primary qualities....." (Chapter VIII).

He gives examples of secondary qualities:

"13. How secondary qualities produce their ideas. After the same manner, that the ideas of these original qualities are produced in us, we may conceive that the ideas of secondary qualities are also produced, viz. by the operation of insensible particles on our senses. .....v.g. that a violet, by the impulse of such insensible particles of matter, of peculiar figures and bulks, and in different degrees and modifications of their motions, causes the ideas of the blue colour, and sweet scent of that flower to be produced in our minds. It being no more impossible to conceive that God should annex such ideas to such motions, with which they have no similitude, than that he should annex the idea of pain to the motion of a piece of steel dividing our flesh, with which that idea hath no resemblance." (Chapter VIII).

He argues against all conscious experience being in mental space (does not consider that taste might be on the tongue or a smell come from a cheese): Chapter XIII: Complex Ideas of Simple Modes:- and First, of the Simple Modes of the Idea of Space - paragraph 25:

"I shall not now argue with those men, who take the measure and possibility of all being only from their narrow and gross imaginations: but having here to do only with those who conclude the essence of body to be extension, because they say they cannot imagine any sensible quality of any body without extension,- I shall desire them to consider, that, had they reflected on their ideas of tastes and smells as much as on those of sight and touch; nay, had they examined their ideas of hunger and thirst, and several other pains, they would have found that they included in them no idea of extension at all, which is but an affection of body, as well as the rest, discoverable by our senses, which are scarce acute enough to look into the pure essences of things."

Locke understood the "specious" or extended present but conflates this with longer periods of time: Chapter XIV. Idea of Duration and its Simple Modes - paragraph 1:

"Duration is fleeting extension. There is another sort of distance, or length, the idea whereof we get not from the permanent parts of space, but from the fleeting and perpetually perishing parts of succession. This we call duration; the simple modes whereof are any different lengths of it whereof we have distinct ideas, as hours, days, years, &c., time and eternity."

Locke is uncertain about whether extended ideas are viewed from an unextended soul.

"He that considers how hardly sensation is, in our thoughts, reconcilable to extended matter; or existence to anything that has no extension at all, will confess that he is very far from certainly knowing what his soul is. It is a point which seems to me to be put out of the reach of our knowledge: and he who will give himself leave to consider freely, and look into the dark and intricate part of each hypothesis, will scarce find his reason able to determine him fixedly for or against the soul's materiality. Since, on which side soever he views it, either as an unextended substance, or as a thinking extended matter, the difficulty to conceive either will, whilst either alone is in his thoughts, still drive him to the contrary side."(Chapter III, 6).

David Hume (1711-1776)

Hume (1739-40). A Treatise of Human Nature: Being An Attempt to Introduce the Experimental Method of Reasoning Into Moral Subjects. http://www.class.uidaho.edu/mickelsen/ToC/hume%20treatise%20ToC.htm

Hume represents a type of pure empiricism where certainty is only assigned to present experience. As we can only directly know the mind he works within this constraint. He admits that there can be consistent bodies of knowledge within experience and would probably regard himself as an Indirect Realist but with the caveat that the things that are inferred to be outside the mind, in the physical world, could be no more than inferences within the mind.

Hume has a clear concept of mental space and time that is informed by the senses:

"The idea of space is convey'd to the mind by two senses, the sight and touch; nor does anything ever appear extended, that is not either visible or tangible. That compound impression, which represents extension, consists of several lesser impressions, that are indivisible to the eye or feeling, and may be call'd impressions of atoms or corpuscles endow'd with colour and solidity. But this is not all. 'Tis not only requisite, that these atoms shou'd be colour'd or tangible, in order to discover themselves to our senses; 'tis also necessary we shou'd preserve the idea of their colour or tangibility in order to comprehend them by our imagination. There is nothing but the idea of their colour or tangibility, which can render them conceivable by the mind. Upon the removal of the ideas of these sensible qualities, they are utterly annihilated to the thought or imagination.'

Now such as the parts are, such is the whole. If a point be not consider'd as colour'd or tangible, it can convey to us no idea; and consequently the idea of extension, which is compos'd of the ideas of these points, can never possibly exist. But if the idea of extension really can exist, as we are conscious it does, its parts must also exist; and in order to that, must be consider'd as colour'd or tangible. We have therefore no idea of space or extension, but when we regard it as an object either of our sight or feeling.

The same reasoning will prove, that the indivisible moments of time must be fill'd with some real object or existence, whose succession forms the duration, and makes it be conceivable by the mind."

In common with Locke and Eastern Philosophy, Hume considers reflection and sensation to be similar, perhaps identical:

"Thus it appears, that the belief or assent, which always attends the memory and senses, is nothing but the vivacity of those perceptions they present; and that this alone distinguishes them from the imagination. To believe is in this case to feel an immediate impression of the senses, or a repetition of that impression in the memory. 'Tis merely the force and liveliness of the perception, which constitutes the first act of the judgment, and lays the foundation of that reasoning, which we build upon it, when we trace the relation of cause and effect."

Hume considers that the origin of sensation can never be known, believing that the canvass of the mind contains our view of the world whatever the ultimate source of the images within the view and that we can construct consistent bodies of knowledge within these constraints:

"As to those impressions, which arise from the senses, their ultimate cause is, in my opinion, perfectly inexplicable by human reason, and 'twill always be impossible to decide with certainty, whether they arise immediately from the object, or are produc'd by the creative power of the mind, or are deriv'd from the author of our being. Nor is such a question any way material to our present purpose. We may draw inferences from the coherence of our perceptions, whether they be true or false; whether they represent nature justly, or be mere

illusions of the senses."

It may be possible to trace the origins of Jackson's Knowledge Argument in Hume's work:

" Suppose therefore a person to have enjoyed his sight for thirty years, and to have become perfectly well acquainted with colours of all kinds, excepting one particular shade of blue, for instance, which it never has been his fortune to meet with. Let all the different shades of that colour, except that single one, be plac'd before him, descending gradually from the deepest to the lightest; 'tis plain, that he will perceive a blank, where that shade is wanting, said will be sensible, that there is a greater distance in that place betwixt the contiguous colours, than in any other. Now I ask, whether 'tis possible for him, from his own imagination, to supply this deficiency, and raise up to himself the idea of that particular shade, tho' it had never been conveyed to him by his senses? I believe i here are few but will be of opinion that he can; and this may serve as a proof, that the simple ideas are not always derived from the correspondent impressions; tho' the instance is so particular and singular, that 'tis scarce worth our observing, and does not merit that for it alone we should alter our general maxim."

David Hume (1748) An Enquiry Concerning Human Understanding
http://www.infidels.org/library/historical/david_hume/human_understanding.html

Hume's view of Locke and Malebranche:

"The fame of Cicero flourishes at present; but that of Aristotle is utterly decayed. La Bruyere passes the seas, and still maintains his reputation: But the glory of Malebranche is confined to his own nation, and to his own age. And Addison, perhaps, will be read with pleasure, when Locke shall be entirely forgotten."

He is clear about relational knowledge in space and time:

"13. .. But though our thought seems to possess this unbounded liberty, we shall find, upon a nearer examination, that it is really confined within very narrow limits, and that all this creative power of the mind amounts to no more than the faculty of compounding, transposing, augmenting, or diminishing the materials afforded us by the senses and experience. When we think of a golden mountain, we only join two consistent ideas, gold, and mountain, with which we were formerly acquainted."

...

19. Though it be too obvious to escape observation, that different ideas are connected together; I do not find that any philosopher has attempted to enumerate or class all the principles of association; a subject, however, that seems worthy of curiosity. To me, there appear to be only three principles of connexion among ideas, namely, Resemblance, Contiguity in time or place, and Cause or Effect."

He is also clear that, although we experience the output of processes, we do not experience the processes themselves:

"29. It must certainly be allowed, that nature has kept us at a great distance from all her secrets, and has afforded us only the knowledge of a few superficial qualities of objects; while she conceals from us those powers and principles on which the influence of those

objects entirely depends. Our senses inform us of the colour, weight, and consistence of bread; but neither sense nor reason can ever inform us of those qualities which fit it for the nourishment and support of a human body. Sight or feeling conveys an idea of the actual motion of bodies; but as to that wonderful force or power, which would carry on a moving body for ever in a continued change of place, and which bodies never lose but by communicating it to others; of this we cannot form the most distant conception. ..

58. ... All events seem entirely loose and separate. One event follows another; but we never can observe any tie between them. They seem conjoined, but never connected. And as we can have no idea of any thing which never appeared to our outward sense or inward sentiment, the necessary conclusion seems to be that we have no idea of connexion or power at all, and that these words are absolutely without any meaning, when employed either in philosophical reasonings or common life. "

Our idea of process is not a direct experience but seems to originate from remembering the repetition of events:

"59 ..It appears, then, that this idea of a necessary connexion among events arises from a number of similar instances which occur of the constant conjunction of these events; nor can that idea ever be suggested by any one of these instances, surveyed in all possible lights and positions. But there is nothing in a number of instances, different from every single instance, which is supposed to be exactly similar; except only, that after a repetition of similar instances, the mind is carried by habit, upon the appearance of one event, to expect its usual attendant, and to believe that it will exist."

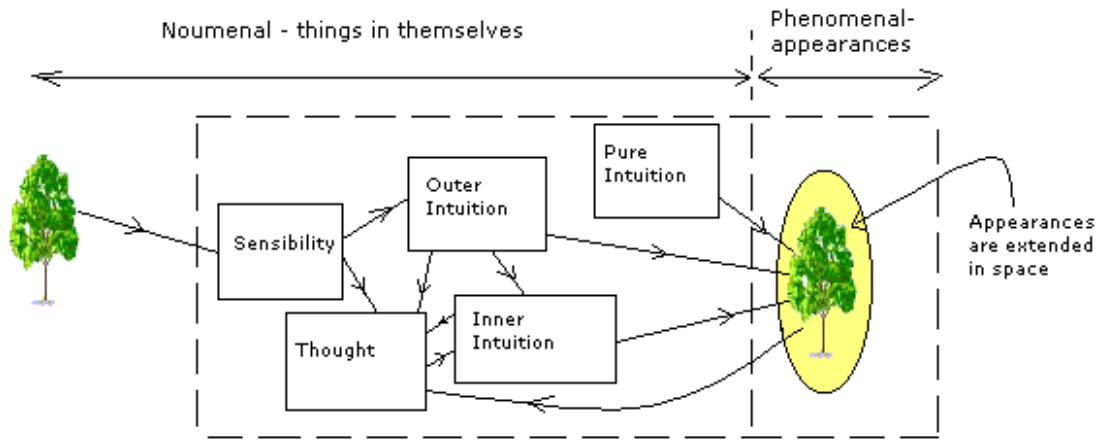
Immanuel Kant (1724-1804)

Kant's greatest work on the subject of consciousness and the mind is Critique of Pure Reason (1781). Kant describes his objective in this work as discovering the axioms ("a priori concepts") and then the processes of 'understanding'.

P12 "This enquiry, which is somewhat deeply grounded, has two sides. The one refers to the objects of pure understanding, and is intended to expound and render intelligible the objective validity of its a priori concepts. It is therefore essential to my purposes. The other seeks to investigate the pure understanding itself, its possibility and the cognitive faculties upon which it rests; and so deals with it in its subjective aspect. Although this latter exposition is of great importance for my chief purpose, it does not form an essential part of it. For the chief question is always simply this: - what and how much can the understanding and reason know apart from all experience?"

Kant's idea of perception and mind is summarised in the illustration below:

Kant's idea of perception and mind



'Experience' is simply accepted. Kant believes that the physical world exists but is not known directly:

P 24 "For we are brought to the conclusion that we can never transcend the limits of possible experience, though that is precisely what this science is concerned, above all else, to achieve. This situation yields, however, just the very experiment by which, indirectly, we are enabled to prove the truth of this first estimate of our a priori knowledge of reason, namely, that such knowledge has to do only with appearances, and must leave the thing in itself as indeed real per se, but as not known by us. "

Kant is clear about the form and content of conscious experience. He notes that we can only experience things that have appearance and 'form' - content and geometrical arrangement.

P65-66 "IN whatever manner and by whatever means a mode of knowledge may relate to objects, intuition is that through which it is in immediate relation to them, and to which all thought as a means is directed. But intuition takes place only in so far as the object is given to us. This again is only possible, to man at least, in so far as the mind is affected in a certain way. The capacity (receptivity) for receiving representations through the mode in which we are affected by objects, is entitled sensibility. Objects are given to us by means of sensibility, and it alone yields us intuitions; they are thought through the understanding, and from the understanding arise concepts. But all thought must, directly or indirectly, by way of certain characters relate ultimately to intuitions, and therefore, with us, to sensibility, because in no other way can an object be given to us. The effect of an object upon the faculty of representation, so far as we are affected by it, is sensation. That intuition which is in relation to the object through sensation, is entitled empirical. The undetermined object of an empirical intuition is entitled appearance. That in the appearance which corresponds to sensation I term its matter; but that which so determines the manifold of appearance that it allows of being ordered in certain relations, I term the form of appearance. That in which alone the sensations can be posited and ordered in a certain form, cannot itself be sensation; and therefore, while the matter of all appearance is given to us a posteriori only, its form must lie ready for the sensations a priori in the mind, and so must allow of being considered apart from all sensation. "

Furthermore he realises that experience exists without much content. That consciousness depends on form:

P66 "The pure form of sensible intuitions in general, in which all the manifold of intuition is intuited in certain relations, must be found in the mind a priori. This pure form of sensibility may also itself be called pure intuition. Thus, if I take away from the representation of a body that which the understanding thinks in regard to it, substance, force, divisibility, etc. , and likewise what belongs to sensation, impenetrability, hardness, colour, etc. , something still remains over from this empirical intuition, namely, extension and figure. These belong to pure intuition, which, even without any actual object of the senses or of sensation, exists in the mind a priori as a mere form of sensibility. The science of all principles of a priori sensibility I call transcendental aesthetic."

Kant proposes that space exists in our experience and that experience could not exist without it (apodeictic means 'incontrovertible):

P 68 "1. Space is not an empirical concept which has been derived from outer experiences.

For in order that certain sensations be referred to something outside me (that is, to something in another region of space from that in which I find myself), and similarly in order that I may be able to represent them as outside and alongside one another, and accordingly as not only different but as in different places, the representation of space must be presupposed. The representation of space cannot, therefore, be empirically obtained from the relations of outer appearance. On the contrary, this outer experience is itself possible at all only through that representation. 2. Space is a necessary a priori representation, which underlies all outer intuitions. We can never represent to ourselves the absence of space, though we can quite well think it as empty of objects. It must therefore be regarded as the condition of the possibility of appearances, and not as a determina- tion dependent upon them. It is an a priori representation, which necessarily underlies outer appearances. * 3. The apodeictic certainty of all geometrical propositions and the possibility of their a priori construction is grounded in this a priori necessity of space. ....."

He is equally clear about the necessity of time as part of experience but he has no clear exposition of the (specious present) extended present:

P 74 "1. Time is not an empirical concept that has been derived from any experience. For neither coexistence nor succession would ever come within our perception, if the representation of time were not presupposed as underlying them a priori. Only on the presupposition of time can we represent to ourselves a number of things as existing at one and the same time (simultaneously) or at different times (successively). They are connected with the appearances only as effects accidentally added by the particular constitution of the sense organs. Accordingly, they are not a priori representations, but are grounded in sensation, and, indeed, in the case of taste, even upon feeling (pleasure and pain), as an effect of sensation. Further, no one can have a priori a representation of a colour or of any taste; whereas, since space concerns only the pure form of intuition, and therefore involves no sensation whatsoever, and nothing empirical, all kinds and determinations of space can and must be represented a priori, if concepts of figures and of their relations are to arise. Through space alone is it possible that things should be outer objects to us. ..2. 3.. 4.. 5..."

Kant has a model of experience as a succession of 3D instants, based on conventional 18th century thinking, allowing his reason to overcome his observation. He says of time that:

P 79 " It is nothing but the form of our inner intuition. If we take away from our inner intuition the peculiar condition of our sensibility, the concept of time likewise vanishes; it does not inhere in the objects, but merely in the subject which intuits them. I can indeed say that my representations follow one another; but this is only to say that we are conscious of them as in a time sequence, that is, in conformity with the form of inner sense. Time is not, therefore, something in itself, nor is it an objective determination inherent in things."

This analysis is strange because if uses the geometric term "form" but then uses the processing term "succession".

Gottfried Wilhelm Leibniz (1646-1716)

Leibniz is one of the first to notice that there is a problem with the proposition that computational machines could be conscious:

"One is obliged to admit that perception and what depends upon it is inexplicable on

mechanical principles, that is, by figures and motions. In imagining that there is a machine whose construction would enable it to think, to sense, and to have perception, one could conceive it enlarged while retaining the same proportions, so that one could enter into it, just like into a windmill. Supposing this, one should, when visiting within it, find only parts pushing one another, and never anything by which to explain a perception. Thus it is in the simple substance, and not in the composite or in the machine, that one must look for perception." Monadology, 17.

Leibniz considered that the world was composed of "monads":

"1. The Monad, of which we shall here speak, is nothing but a simple substance, which enters into compounds. By 'simple' is meant 'without parts.' (Theod. 10.)

2. And there must be simple substances, since there are compounds; for a compound is nothing but a collection or aggregatum of simple things.

3. Now where there are no parts, there can be neither extension nor form [figure] nor divisibility. These Monads are the real atoms of nature and, in a word, the elements of things. " (Monadology 1714).

These monads are considered to be capable of perception through the meeting of things at a point:

"They cannot have shapes, because then they would have parts; and therefore one monad in itself, and at a moment, cannot be distinguished from another except by its internal qualities and actions; which can only be its *perceptions* (that is, the representations of the composite, or of what is external, in the simple), or its *appetitions* (its tending to move from one perception to another, that is), which are the principles of change. For the simplicity of a substance does not in any way rule out a multiplicity in the modifications which must exist together in one simple substance; and those modifications must consist in the variety of its relationships to things outside it - like the way in which in a *centre*, or a *point*, although it is completely simple, there are an infinity of angles formed which meet in it." (Principles of Nature and Grace 1714).

Leibniz also describes this in his "New System":

"It is only atoms of substance, that is to say real unities absolutely devoid of parts, that can be the sources of actions, and the absolute first principles of the composition of things, and as it were the ultimate elements in the analysis of substances <substantial things>. They might be called *metaphysical points*; they have *something of the nature of life* and a kind of *perception*, and *mathematical points* are their *point of view* for expressing the universe."(New System (11) 1695).

Having identified perception with metaphysical points Leibniz realises that there is a problem connecting the points with the world (cf: epiphenomenalism):

"Having decided these things, I thought I had reached port, but when I set myself to think about the union of the soul with the body I was as it were carried back into the open sea. For I could find no way of explaining how the body can make something pass over into the soul or vice versa, or how one created substance can communicate with another."(New System (12) 1695).

Leibniz devises a theory of "pre-established harmony" to overcome this epiphenomenalism. He discusses how two separate clocks could come to tell the same time and proposes that this could be due to mutual influence of one clock on the other ("the way of influence"), continual adjustment by a workman ("the way of assistance") or by making the clocks so well that they are always in agreement ("the way of pre-established agreement" or harmony). He considers each of these alternatives for harmonising the perceptions with the world and concludes that only the third is viable:

"Thus there remains only my theory, *the way of pre-established harmony*, set up by a contrivance of divine foreknowledge, which formed each of these substances from the outset in so perfect, so regular, and so exact a manner, that merely by following out its own laws, which were given to it when it was brought into being, each substance is nevertheless in harmony with the other, just as if there were a mutual influence between them, or as if in addition to his general concurrence God were continually operating upon them. (Third Explanation of the New System (5), 1696)."

This means that he must explain how perceptions involving the world take place:

"Because of the plenitude of the world everything is linked, and every body acts to a greater or lesser extent on every other body in proportion to distance, and is affected by it in return. It therefore follows that every monad is a living mirror, or a mirror endowed with internal activity, representing the universe in accordance with its own point of view, and as orderly as the universe itself. The perceptions of monads arise one out of another by the laws of appetite, or of the *final causes of good and evil* (which are prominent perceptions, orderly or disorderly), just as changes in bodies or in external phenomena arise one from another by the laws of *efficient causes*, of motion that is. Thus there is perfect *harmony* between the perceptions of the monad and the motions of bodies, pre-established from the outset, between the system of efficient causes and that of final causes. And it is that harmony that the agreement or physical union between the soul and body consists, without either of them being able to change the laws of the other." (Principles of Nature and Grace (3) 1714).

The "laws of appetite" are defined as:

"The action of the internal principle which brings about change, or the passage from one perception to another, can be called *appetition*. In fact appetite cannot always attain in its entirety the whole of the perception towards which it tends, but it always obtains some part of it, and attains new perceptions. Monadology 15.

Leibniz thought animals had souls but not minds:

"But *true* reasoning depends on necessary or eternal truths like those of logic, numbers, and geometry, which make indubitable connections between ideas, and conclusions which are inevitable. Animals in which such conclusions are never perceived are called *brutes*; but those which recognise such necessary truths are what are rightly called *rational animals* and their souls are called *minds*. (Principles of Nature and Grace (5) 1714).

Minds allow reflection and awareness:

"And it is by the knowledge of necessary truths, and by the abstractions they involve, that we are raised to *acts of reflection*, which make us aware of what we call *myself*, and make us think of this or that thing as in *ourselves*. And in this way, by thinking of ourselves, we think

of being, of substance, of simples and composites, of the immaterial - and, by realising that what is limited in us is limitless in him, of God himself. And so these *acts of reflection* provide the principle objects of our reasonings." Monadology, 30.

George Berkeley (1685 - 1753)

A Treatise on the Principles of Human Knowledge. 1710

http://darkwing.uoregon.edu/~rbear/berkeley.html#treatise

Berkeley introduces the Principles of Human Knowledge with a diatribe against abstract ideas. He uses the abstract ideas of animals as an example:

"Introduction. 9.....The constituent parts of the abstract idea of animal are body, life, sense, and spontaneous motion. By body is meant body without any particular shape or figure, there being no one shape or figure common to all animals, without covering, either of hair, or feathers, or scales, &c., nor yet naked: hair, feathers, scales, and nakedness being the distinguishing properties of particular animals, and for that reason left out of the abstract idea. Upon the same account the spontaneous motion must be neither walking, nor flying, nor creeping; it is nevertheless a motion, but what that motion is it is not easy to conceive.

He then declares that such abstractions cannot be imagined. He emphasises that ideas are "represented to myself" and have shape and colour:

"Introduction. 10. Whether others have this wonderful faculty of abstracting their ideas, they best can tell: for myself, I find indeed I have a faculty of imagining, or representing to myself, the ideas of those particular things I have perceived, and of variously compounding and dividing them. I can imagine a man with two heads, or the upper parts of a man joined to the body of a horse. I can consider the hand, the eye, the nose, each by itself abstracted or separated from the rest of the body. But then whatever hand or eye I imagine, it must have some particular shape and colour. Likewise the idea of man that I frame to myself must be either of a white, or a black, or a tawny, a straight, or a crooked, a tall, or a low, or a middle-sized man. I cannot by any effort of thought conceive the abstract idea above described. And it is equally impossible for me to form the abstract idea of motion distinct from the body moving, and which is neither swift nor slow, curvilinear nor rectilinear; and the like may be said of all other abstract general ideas whatsoever."

This concept of ideas as extended things, or representations, is typical of the usage amongst philosophers in the 17th and 18th century and can cause confusion in modern readers. Berkeley considers that words that are used to describe classes of things in the abstract can only be conceived as particular cases:

"Introduction. 15... Thus, when I demonstrate any proposition concerning triangles, it is to be supposed that I have in view the universal idea of a triangle; which ought not to be understood as if I could frame an idea of a triangle which was neither equilateral, nor scalenon, nor equicrural; but only that the particular triangle I consider, whether of this or that sort it matters not, doth equally stand for and represent all rectilinear triangles whatsoever, and is in that sense universal. All which seems very plain and not to include any difficulty in it.

Intriguingly, he considers that language is used to directly excite emotions as well as to communicate ideas:

"Introduction. 20. ... I entreat the reader to reflect with himself, and see if it doth not often

happen, either in hearing or reading a discourse, that the passions of fear, love, hatred, admiration, disdain, and the like, arise immediately in his mind upon the perception of certain words, without any ideas coming between.

Berkeley considers that extension is a quality of mind:

"11. Again, great and small, swift and slow, are allowed to exist nowhere without the mind, being entirely relative, and changing as the frame or position of the organs of sense varies. The extension therefore which exists without the mind is neither great nor small, the motion neither swift nor slow, that is, they are nothing at all. But, say you, they are extension in general, and motion in general: thus we see how much the tenet of extended movable substances existing without the mind depends on the strange doctrine of abstract ideas."

He notes that the rate at which things pass may be related to the mind:

"14..... Is it not as reasonable to say that motion is not without the mind, since if the succession of ideas in the mind become swifter, the motion, it is acknowledged, shall appear slower without any alteration in any external object?

Berkeley raises the issue of whether objects exist without being perceived. He bases his argument on the concept of perception being the perceiving of "our own ideas or sensations":

"4. It is indeed an opinion strangely prevailing amongst men, that houses, mountains, rivers, and in a word all sensible objects, have an existence, natural or real, distinct from their being perceived by the understanding. But, with how great an assurance and acquiescence soever this principle may be entertained in the world, yet whoever shall find in his heart to call it in question may, if I mistake not, perceive it to involve a manifest contradiction. For, what are the fore-mentioned objects but the things we perceive by sense? and what do we perceive besides our own ideas or sensations? and is it not plainly repugnant that any one of these, or any combination of them, should exist unperceived?"

He further explains this concept in terms of some Eternal Spirit allowing continued existence. Berkeley is clear that the contents of the mind have "colour, figure, motion, smell, taste etc.":

"7. From what has been said it follows there is not any other Substance than Spirit, or that which perceives. But, for the fuller proof of this point, let it be considered the sensible qualities are colour, figure, motion, smell, taste, etc., i.e. the ideas perceived by sense. Now, for an idea to exist in an unperceiving thing is a manifest contradiction, for to have an idea is all one as to perceive; that therefore wherein colour, figure, and the like qualities exist must perceive them; hence it is clear there can be no unthinking substance or substratum of those ideas."

He elaborates the concept that there is no unthinking substance or substratum for ideas and all is mind:

"18. But, though it were possible that solid, figured, movable substances may exist without the mind, corresponding to the ideas we have of bodies, yet how is it possible for us to know this? Either we must know it by sense or by reason. As for our senses, by them we have the knowledge only of our sensations, ideas, or those things that are immediately perceived by

sense, call them what you will: but they do not inform us that things exist without the mind, or unperceived, like to those which are perceived. This the materialists themselves acknowledge. It remains therefore that if we have any knowledge at all of external things, it must be by reason, inferring their existence from what is immediately perceived by sense. But what reason can induce us to believe the existence of bodies without the mind, from what we perceive, since the very patrons of Matter themselves do not pretend there is any necessary connexion betwixt them and our ideas? I say it is granted on all hands (and what happens in dreams, phrensies, and the like, puts it beyond dispute) that it is possible we might be affected with all the ideas we have now, though there were no bodies existing without resembling them. Hence, it is evident the supposition of external bodies is not necessary for the producing our ideas; since it is granted they are produced sometimes, and might possibly be produced always in the same order, we see them in at present, without their concurrence. "

and stresses that there is no apparent connection between mind and the proposed material substrate of ideas:

"19. But, though we might possibly have all our sensations without them, yet perhaps it may be thought easier to conceive and explain the manner of their production, by supposing external bodies in their likeness rather than otherwise; and so it might be at least probable there are such things as bodies that excite their ideas in our minds. But neither can this be said; for, though we give the materialists their external bodies, they by their own confession are never the nearer knowing how our ideas are produced; since they own themselves unable to comprehend in what manner body can act upon spirit, or how it is possible it should imprint any idea in the mind. .....

Berkeley makes a crucial observation, that had also been noticed by Descartes, that ideas are passive:

"25. All our ideas, sensations, notions, or the things which we perceive, by whatsoever names they may be distinguished, are visibly inactive- there is nothing of power or agency included in them. So that one idea or object of thought cannot produce or make any alteration in another. To be satisfied of the truth of this, there is nothing else requisite but a bare observation of our ideas. For, since they and every part of them exist only in the mind, it follows that there is nothing in them but what is perceived: but whoever shall attend to his ideas, whether of sense or reflexion, will not perceive in them any power or activity; there is, therefore, no such thing contained in them. A little attention will discover to us that the very being of an idea implies passiveness and inertness in it, insomuch that it is impossible for an idea to do anything, or, strictly speaking, to be the cause of anything: neither can it be the resemblance or pattern of any active being, as is evident from sect. 8. Whence it plainly follows that extension, figure, and motion cannot be the cause of our sensations. To say, therefore, that these are the effects of powers resulting from the configuration, number, motion, and size of corpuscles, must certainly be false.

He considers that "the cause of ideas is an incorporeal active substance or Spirit (26)".

He summarises the concept of an Eternal Spirit that governs real things and a representational mind that copies the form of the world as follows:

"33. The ideas imprinted on the Senses by the Author of nature are called real things; and those excited in the imagination being less regular, vivid, and constant, are more properly

termed ideas, or images of things, which they copy and represent. But then our sensations, be they never so vivid and distinct, are nevertheless ideas, that is, they exist in the mind, or are perceived by it, as truly as the ideas of its own framing. The ideas of Sense are allowed to have more reality in them, that is, to be more strong, orderly, and coherent than the creatures of the mind; but this is no argument that they exist without the mind. They are also less dependent on the spirit, or thinking substance which perceives them, in that they are excited by the will of another and more powerful spirit; yet still they are ideas, and certainly no idea, whether faint or strong, can exist otherwise than in a mind perceiving it.

Berkeley considers that the concept of distance is a concept in the mind and also that dreams can be compared directly with sensations:

"42. Thirdly, it will be objected that we see things actually without or at distance from us, and which consequently do not exist in the mind; it being absurd that those things which are seen at the distance of several miles should be as near to us as our own thoughts. In answer to this, I desire it may be considered that in a dream we do oft perceive things as existing at a great distance off, and yet for all that, those things are acknowledged to have their existence only in the mind."

He considers that ideas can be extended without the mind being extended:

"49. Fifthly, it may perhaps be objected that if extension and figure exist only in the mind, it follows that the mind is extended and figured; since extension is a mode or attribute which (to speak with the schools) is predicated of the subject in which it exists. I answer, those qualities are in the mind only as they are perceived by it- that is, not by way of mode or attribute, but only by way of idea; and it no more follows the soul or mind is extended, because extension exists in it alone, than it does that it is red or blue, because those colours are on all hands acknowledged to exist in it, and nowhere else. As to what philosophers say of subject and mode, that seems very groundless and unintelligible. For instance, in this proposition "a die is hard, extended, and square," they will have it that the word die denotes a subject or substance, distinct from the hardness, extension, and figure which are predicated of it, and in which they exist. This I cannot comprehend: to me a die seems to be nothing distinct from those things which are termed its modes or accidents. And, to say a die is hard, extended, and square is not to attribute those qualities to a subject distinct from and supporting them, but only an explication of the meaning of the word die.

Berkeley proposes that time is related to the succession of ideas:

"98. For my own part, whenever I attempt to frame a simple idea of time, abstracted from the succession of ideas in my mind, which flows uniformly and is participated by all beings, I am lost and embrangled in inextricable difficulties. I have no notion of it at all, only I hear others say it is infinitely divisible, and speak of it in such a manner as leads me to entertain odd thoughts of my existence; since that doctrine lays one under an absolute necessity of thinking, either that he passes away innumerable ages without a thought, or else that he is annihilated every moment of his life, both which seem equally absurd. Time therefore being nothing, abstracted from the sucession of ideas in our minds, it follows that the duration of any finite spirit must be estimated by the number of ideas or actions succeeding each other in that same spirit or mind. Hence, it is a plain consequence that the soul always thinks; and in truth whoever shall go about to divide in his thoughts, or abstract the existence of a spirit from its cogitation, will, I believe, find it no easy task.

"99. So likewise when we attempt to abstract extension and motion from all other qualities, and consider them by themselves, we presently lose sight of them, and run into great extravagances. All which depend on a twofold abstraction; first, it is supposed that extension, for example, may be abstracted from all other sensible qualities; and secondly, that the entity of extension may be abstracted from its being perceived. But, whoever shall reflect, and take care to understand what he says, will, if I mistake not, acknowledge that all sensible qualities are alike sensations and alike real; that where the extension is, there is the colour, too, i.e., in his mind, and that their archetypes can exist only in some other mind; and that the objects of sense are nothing but those sensations combined, blended, or (if one may so speak) concreted together; none of all which can be supposed to exist unperceived."

He regards "spirit" as something separate from ideas and attempts to answer the charge that as spirit is not an idea it cannot be known:

"139. But it will be objected that, if there is no idea signified by the terms soul, spirit, and substance, they are wholly insignificant, or have no meaning in them. I answer, those words do mean or signify a real thing, which is neither an idea nor like an idea, but that which perceives ideas, and wills, and reasons about them. ....

Thomas Reid (1710-1796)

Thomas Reid is generally regarded as the founder of Direct Realism. Reid was a Presbyterian minister for the living of Newmachar near Aberdeen from 1737. He is explicit about the 'directness' of his realism:

"It is therefore acknowledged by this philosopher to be a natural instinct or prepossession, a universal and primary opinion of all men, a primary instinct of nature, that the objects which we immediately perceive by our senses are not images in our minds, but external objects, and that their existence is independent of us and our perception. (Thomas Reid Essays, 14)"

In common with Descartes and Malebranche, Reid considers that the mind itself is an unextended thing:

".. I take it for granted, upon the testimony of common sense, that my mind is a substance-that is, a permanent subject of thought; and my reason convinces me that it is an unextended and invisible substance; and hence I infer that there cannot be in it anything that resembles extension (Inquiry)".

Reid is also anxious to equate the unextended mind with the soul:

"The soul, without being present to the images of the things perceived, could not possibly perceive them. A living substance can only there perceive, where it is present, either to the things themselves, (as the omnipresent God is to the whole universe,) or to the images of things, as the soul is in its proper sensorium."

Reid's Direct Realism is therefore the idea that the physical objects in the world are in some way presented directly to a soul. This approach is known as "Natural Dualism".

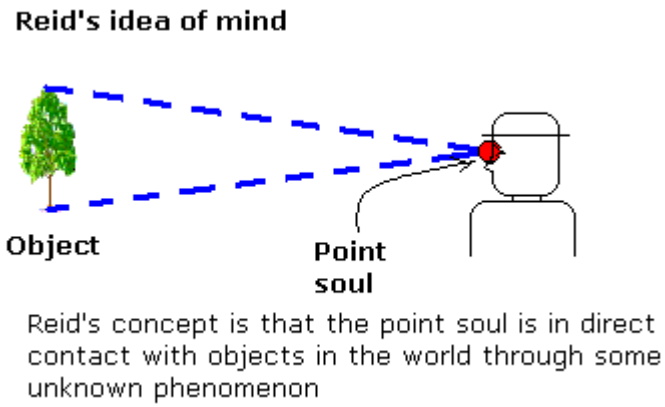
Reid's views show his knowledge of Aristotle's ideas:

"When we perceive an object by our senses, there is, first, some impression made by the object upon the organ of sense, either immediately, or by means of some medium. By this, an impression is made upon the brain, in consequence of which we feel some sensation. " (Reid 1785)

He differs from Aristotle because he believes that the content of phenomenal consciousness is things in themselves, not signals derived from things in the brain. However, he has no idea how such a phenomenon could occur:

"How a sensation should instantly make us conceive and believe the existence of an external thing altogether unlike it, I do not pretend to know; and when I say that the one suggests the other, I mean not to explain the manner of their connection, but to express a fact, which everyone may be conscious of namely, that, by a law of our nature, such a conception and belief constantly and immediately follow the sensation." (Reid 1764).

Reid's idea of mind is almost impossible to illustrate because it lacks sufficient physical definition. It is like naive realism but without any communication by light between object and observer. Reid was largely ignored until the rise of modern Direct Realism.



Reading between the lines, it seems that Reid is voicing the ancient intuition that the observer and the content of an observation are directly connected in some way. As will be seen later, this intuition cannot distinguish between a direct connection with the world itself and a direct connection with signals from the world beyond the body that are formed into a virtual reality in the brain.

References

- Descartes, R. (1628). Rules For The Direction of The Mind. http://faculty.uccb.ns.ca/philosophy/kbryson/rulesfor.htm
- Descartes, R. (1637). DISCOURSE ON THE METHOD OF RIGHTLY CONDUCTING THE REASON, AND SEEKING TRUTH IN THE SCIENCES. http://www.gutenberg.org/dirs/etext93/dcart10.txt
- Descartes, R. (1641). Meditations on First Philosophy. http://oregonstate.edu/instruct/phl302/texts/descartes/meditations/Meditation1.html

- Descartes, R. (1664) "Treatise on Man". Translated by John Cottingham, et al. The Philosophical Writings of Descartes, Vol. 1 (Cambridge: Cambridge University Press, 1985) 99-108. http://lrc.csun.edu/~battias/454/descartes/

- Kant, I. (1781) Critique of Pure Reason. Trans. Norman Kemp Smith with preface by Howard Caygill. Pub: Palgrave Macmillan. http://www.hkbu.edu.hk/~ppp/cpr/toc.html

- Locke, J. (1689). An Essay Concerning Human Understanding http://www.arts.cuhk.edu.hk/Philosophy/Locke/echu/

- Russell, B. (1945). A History of Western Philosophy. New York: Simon and Schuster.

- Reid, T. (1785). Essays on the Intellectual Powers of Man. Edited by Brookes, Derek. Edinburgh: Edinburgh University Press, 2002.

- Reid, T. (1764). An Inquiry into the Human Mind on the Principles of Common Sense. Edited by Brookes, Derek. Edinburgh: Edinburgh University Press, 1997.

Further Reading

See: THOMAS REID at LoveToKnow. http://54.1911encyclopedia.org/R/RE/REID_THOMAS.htm

- Consciousness in Descartes

Nineteenth and twentieth century philosophy of consciousness

The nineteenth and twentieth centuries witnessed a confident use of nineteenth century scientific ideas amongst philosophers of mind and a few philosophers such as Whitehead were also coming to terms with modern science.

ER Clay

ER Clay deserves a mention in the catalogue of important nineteenth century philosophers of consciousness for the quotation from his work given in William James' classic text *The Principles of Psychology*:

"The relation of experience to time has not been profoundly studied. Its objects are given as being of the present, but the part of time referred to by the datum is a very different thing from the conterminous of the past and future which philosophy denotes by the name Present. The present to which the datum refers is really a part of the past -- a recent past -- delusively given as being a time that intervenes between the past and the future. Let it be named the specious present, and let the past, that is given as being the past, be known as the obvious past. All the notes of a bar of a song seem to the listener to be contained in the present. All the changes of place of a meteor seem to the beholder to be contained in the present. At the instant of the termination of such series, no part of the time measured by them seems to be a past. Time, then, considered relatively to human apprehension, consists of four parts, viz., the obvious past, the specious present, the real present, and the future. Omitting the specious present, it consists of three . . . nonentities -- the past, which does not exist, the future, which does not exist, and their conterminous, the present; the faculty from which it proceeds lies to us in the fiction of the specious present."

Clay provides an eloquent description of the extended, or *specious*, present, mentioning both the way that consciousness seems to occupy a duration of time and the way that events within conscious experience have their own durations so that they snap out of existence when they end. This description in itself allows us to see how McTaggart's "A Series" might be constructed from the overlapping extended present's of events.

Clay's use of the pejorative term "specious" for the way that experience has a duration was necessary in the nineteenth century but now we know that it was the nineteenth century idea of physical time that was specious. A neutral term for experience laid out in time might be the "extended present".

Alfred North Whitehead

The Concept of Nature. Cambridge: Cambridge University Press (1920): 49-73.

Many twentieth century philosophers have taken the nineteenth century idea of space and time as the framework within which their descriptions of experience are elaborated. Whitehead was a mathematician and philosopher who understood the limitations of this framework and pointed out that our failure to understand and overcome these limitations was probably at the root of our failure to understand consciousness. He traces the problem to the

nineteenth century view of time and space and rails against materialists who elevate nineteenth century scientific doctrine above observational and scientific reality.

He also believed that mind and nature are part of the same phenomena:

"What I am essentially protesting against is the bifurcation of nature into two systems of reality, which, in so far as they are real, are real in different senses. One reality would be the entities such as electrons which are the study of speculative physics. This would be the reality which is there for knowledge; although on this theory it is never known. For what is known is the other sort of reality, which is the byplay of the mind. Thus there would be two natures, one is the conjecture and the other is the dream.

"Another way of phrasing this theory which I am arguing against is to bifurcate nature into two divisions, (31) namely into the nature apprehended in awareness and the nature which is the cause of awareness. The nature which is the fact apprehended in awareness holds within it the greenness of the trees, the song of the birds, the warmth of the sun, the hardness of the chairs, and the feel of the velvet. The nature which is the cause of awareness is the conjectured system of molecules and electrons which so affects the mind as to produce the awareness of apparent nature. The meeting point of these two natures is the mind, the causal nature being influent and the apparent nature being effluent."

He argued that science is about the relations between things:

"The understanding which is sought by science is an understanding of relations within nature. "

Whitehead was aware of the way that the simultaneity of events is of crucial importance to phenomenal experience:

"The general fact is the whole simultaneous occurrence of nature which is now for sense-awareness. This general fact is what I have called the discernible. But in future I will call it a 'duration,' meaning thereby a certain whole of nature which is limited only by the property of being a simultaneity. Further in obedience to the principle of comprising within nature the whole terminus of sense-awareness, simultaneity must not be conceived as an irrelevant mental concept imposed upon nature. Our sense-awareness posits for immediate discernment a certain whole, here called a 'duration'; thus a duration is a definite natural entity. A duration is discriminated as a complex of partial events, and the natural entities which are components of this complex are thereby said to be 'simultaneous with this duration.' Also in a derivative sense they are simultaneous with each other in respect to this duration. Thus simultaneity is a definite natural relation. The word' duration' is perhaps unfortunate in so far as it suggests a mere abstract stretch of time. This is not what I mean. A duration is a concrete slab of nature limited by simultaneity which is an essential factor disclosed in sense-awareness."

Whitehead also stresses the role of the extended, or 'specious', present in sense awareness:

"It is important to distinguish simultaneity from instantaneousness. I lay no stress on the mere current usage of the two terms. There are two concepts which I want to distinguish, and one I call simultaneity and the other instantaneousness. I hope that the words are judiciously chosen; but it really does not matter so long as I succeed in explaining my meaning. Simultaneity is the property of a group of natural elements which in some sense are components of a duration. A duration can be all nature present as the immediate fact posited

by sense-awareness. A duration retains within itself the passage of nature. There are within it antecedents and consequents which are also durations which may be the complete specious presents of quicker consciousnesses. In other words a duration retains temporal thickness. Any concept of all nature as immediately known is always a concept of some duration though it may be enlarged in its temporal thickness beyond the possible specious present of any being known to us as existing within nature. Thus simultaneity is an ultimate factor in nature, immediate for sense-awareness.

So a set of events that are extended in time constitutes conscious experience. He then defines continuity in terms of overlapping durations:

"The continuity of nature arises from extension. Every event extends over other events, and every event is extended over by other events. Thus in the special case of durations which are now the only events directly under consideration, every duration is part of other durations; and every duration has other durations which are parts of it."

That experience exists as whole durations that overlap means that the overlapping durations can be considered to be composed of moments or instants and these can be assigned to a series which we call 'time':

"Such an ordered series of moments is what we mean by time defined as a series. Each element of the series exhibits an instantaneous; state of nature, Evidently this serial time is the result of an intellectual process of (65) abstraction."

Processes can occur within a duration of sense awareness so things can change within the extended present of a conscious interval.

"Sense-awareness and thought are themselves processes as well as their termini in nature."

So Whitehead's durations of sense awareness both contain processes and are phenomena in their own right. A movement can be both a succession of changes of position and a quality of motion over the whole duration that contains it.

One disturbing feature of his analysis is that he does not mention the way that durations are attached to events; Clay states that the extension in time of an event disappears when the event ceases.

Whitehead recognised a possible problem with Aristotle's system of categories. Whitehead suggested substituting his category of relation for Aristotle's category of substance, giving us a different conception of being. This allowed Whitehead to postulate a conception of consciousness that avoided an infinite regress and the need for accounting for awareness as a product of our physical senses. Thus, a diiferent approach was recognized, one that rivaled the post-Cartesian approach to understanding the world. It is Whitehead's encounter with Aristotle that allowed him to formulate a different possible solution to the problem of consciousness and one that falls squarely in the domain of panpsychism.

Edmund Husserl

Husserl accepts the materialist paradigm and has been influential in Marxist and post-Marxist

philosophy. Husserl writes in a style that presents a multitude of views, many of which are opposed to each other. He is also rather obscure when concepts become difficult, an example of this postmodern penchant for confusion is given below:

"The genuine intentional synthesis is discovered in the synthesis of several acts into one act, such that, in a unique manner of binding one meaning to another, there emerges not merely a whole, an amalgam whose parts are meanings, but rather a single meaning in which these meanings themselves are contained, but in a meaningful way. With this the problems of correlation, too, already announce themselves; and thus, in fact, this work contains the first, though of course very imperfect, beginnings of "phenomenology."" (Husserl 1937).

Husserl seems to be largely a Humean in the sense that he gives precedence to mental experience as the only thing that may be known directly and hence certainly. He regards the components of experience as part of consciousness, so the intention to move, the movement and the sensation of movement are bound or 'bracketed' together into a single meaning.

"In my perceptual field I find myself holding sway as ego through my organs and generally through everything belonging to me as an ego in my ego-acts and faculties. However, though the objects of the life-world, if they are to show their very own being, necessarily show themselves as physical bodies, this does not mean that they show themselves only in this way; and [similarly] we, though we are related through the living body to all objects which exist for us, are not related to them solely as a living body. Thus if it is a question of objects in the perceptual field, we are perceptually also in the field; and the same is true, in modification, of every intuitive field, and even of every nonintuitive one, since we are obviously capable of "representing" to ourselves everything which is non-intuitively before us (though we are sometimes temporally limited in this). [Being related] "through the living body" clearly does not mean merely [being related] "as a physical body"; rather, the expression refers to the kinesthetic, to functioning as an ego in this peculiar way, primarily through seeing, hearing, etc.; and of course other modes of the ego belong to this (for example, lifting, carrying, pushing, and the like). "

It should be noted that Husserl believes we *perform* acts of perception and that we should refrain from judgement about where the things in perception are located or their nature. This suspenson of judgement is called *epoche* and derives from ancient Greek skepticism.

Despite an affection for long sentences with dubious meanings Husserl seems to share Locke's view that experience is extended in time. He is obscure about whether he believes consciousness itself is a process that initiates action. Husserl uses a linguistic argument to justify the idea of consciousness as a form of action:

"2. Whatever becomes accessible to us through reflection has a noteworthy universal character: that of being consciousness of something, of having something as an object of consciousness, or correlatively, to be aware of it we are speaking here of intentionality. This is the essential character of mental life in the full sense of the word, and is thus simply inseparable from it. It is, for example, inseparable from the perceiving that reflection reveals to us, that it is of this or that; just as the process of remembering is, in itself, remembering or recalling of this or that; just as thinking is thinking of this or that thought, fearing is of something, love is of something; and so on. We can also bring in here the language we use in speaking of appearing or having something appear."(Husserl 1928)

Intentionality is mentioned but not described. Intentionality is a process and Husserl seems to be suggesting that consciousness is a process but he does not describe any consciousness of the transformation that is this process. He simply assumes, as a cornerstone of his approach, that consciousness is a process:

"5. The Purely Mental in Experience of the Self and of Community. The All-Embracing Description of Intentional Processes." (Husserl 1928).

then, not surprisingly, fails to find any processes within it and changes his view of consciousness to that of observation:

"... But I <must> immediately add that the universality of the phenomenological epoche as practiced by the phenomenologist from the very beginning the universality in which he or she becomes the mere impartial observer of the totality of his conscious life-process brings about not only a thematic purification of the individual processes of consciousness and thereby discloses its noematic components;" (Husserl 1928)

He calls the contents of perception the perceptual *noema*. Husserl seems to be aware of the problem of the extended present:

"How can we account for the fact that a presently occurring experience in one's consciousness called "recollection" makes us conscious of a not-present event and indeed makes us aware of it as past? And how is it that in the "remembered" moment, that sense can be included in an evidential way with the sense: "have earlier perceived"? How are we to understand the fact that a perceptual, that is to say, bodily characterized present can at the same time contain a co-presence with the sense of a perceivability that goes beyond the <immediate> perceivedness? How are we to understand the fact that the actual perceptual present as a totality does not close out the world but rather always carries within itself the sense of an infinite plus ultra <more beyond>?"(Husserl 1928)

But is vague about whether mental time is a continuum or has three components of remembered past, present and some sort of intuition of the future. His rejection of the possibility of describing the mind through the spatio-temporal models of the physical sciences limits his interpretation of mental space and time.

Husserl, E. (1928) The Amsterdam Lectures. PSYCHOLOGICAL AND TRANSCENDENTAL PHENOMENOLOGY AND THE CONFRONTATION WITH HEIDEGGER (1927-1931). edited and translated by Thomas Sheehan and Richard E. Palmer. http://www.stanford.edu/dept/relstud/faculty/sheehan.bak/TSbookcontents.html

Husserl, E. (1937). The Crisis of European Sciences and Transcendental Phenomenology. An Introduction to Phenomenology. (The Crisis of European Sciences and Transcendental Phenomenology (1954) publ. Northwestern University Press, Evanston, 1970. Sections 22 - 25 and 57 - 68, 53 pages in all.) http://www.marxists.org/reference/subject/philosophy/works/ge/husserl.htm

Daniel Clement Dennett (1942 -)

Dennett is well known for his "Multiple Drafts Model" of consciousness. The Multiple Drafts Theory or Model of Consciousness is a theory of consciousness based upon the proposal that the brain acts as an information processor. The Theory is described in depth in the book Consciousness Explained, written by Dennett in 1991. It proposes a form of strong AI.

Dennet describes his theory (CE p117) as **operationalist**, as Dennett says: "There is no reality of conscious experience independent of the effects of various vehicles of content on subsequent action (and hence, of course, on memory)." (Not to be confused with 'instrumentalism').

Dennett's starting point in the development of the Multiple Drafts theory is a description of the phi illusion. In this experiment two different coloured lights, with an angular separation of a few degrees at the eye, are flashed in succession. If the interval between the flashes is less than a second or so the first light that is flashed appears to move across to the position of the second light. Furthermore the light seems to change colour as it moves across the visual field. A green light will appear to turn red as it seems to move across to the position of a red light. Dennett asks how we could see the light change colour before the second light is observed.

An example of the phi illusion in the format described by Dennett is shown here: phi illusion (use the 'test' option to select the simple phi demonstration).

Dennett explains the change of colour of the light in terms of either Orwellian or Stalinesque hypotheses. In the Orwellian hypothesis the subject develops a narrative about the movement of the lights after the event. In the Stalinesque hypothesis the subject's brain would have a delay in which the movement of the green light towards the red light could be modelled after the sensory information from the red light had been received. He then says that it does not matter which hypothesis applies because: "the Multiple Drafts model goes on to claim that the brain does not bother 'constructing' any representations that go to the trouble of 'filling in' the blanks. That would be a waste of time and (shall we say?) paint. The judgement is already in so we can get on with other tasks!"

According to the Multiple Drafts theory there are a variety of sensory inputs from a given event and also a variety of interpretations of these inputs. The sensory inputs arrive in the brain and are interpreted at different times so a given event can give rise to a succession of discriminations. As soon as each discrimination is accomplished it becomes available for eliciting a behaviour. A wide range of behaviours may occur ranging from reactions to the event such as running away to descriptions of the experience of the event etc.

At different times after the event a person is able to relate different stories of what happened depending upon the extent to which the event has been analysed. Dennett compares this with a 'Cartesian Theatre' model of consciousness in which events suddenly appear on some sort of mental screen and then disappear as quickly. He provides numerous examples to show that events are analysed over a period of time rather than instantaneously.

Although Multiple Drafts is described as a model or theory of consciousness that differs from other models, Dennett points out that even Descartes was aware that reactions to an event

could occur over a period of time with reflexes occurring first and judgements later. What makes Multiple Drafts different is that Dennett, in different sections of Consciousness Explained, either denies that normal conscious experiences actually occur or describes these as emerging in some unspecified way from the sheer complexity of information processing in the brain. His emergentism is clear when he defends the Multiple Drafts Model from Searle's chinese room argument by saying of the critics: They just can't imagine how understanding could be a property that emerges from lots of distributed quasi-understanding in a large system (CE p439).

As an example of denial of conscious experience Dennett denies that there is any internal experience of colour, instead he says that qualia in general are "mechanically accomplished dispositions to react". This view originates in Dennett's belief in the method of heterophenomenology in which narrative is thought to be the most crucial tool for investigating consciouness. However, Dennett does not deny conscious experience (see below).

The origin of this operationalist appoach can be seen in Dennett's immediately earlier work. Dennett (1988) redefines consciousness in terms of access consciousness alone, he argues that "Everything real has properties, and since I don't deny the reality of conscious experience, I grant that conscious experience has properties". Having related all consciousness to properties he then declares that these properties are actually judgements of properties. He considers judgements of the properties of consciousness to be identical to the properties themselves. He writes:

"The infallibilist line on qualia treats them as properties of one's experience one cannot in principle misdiscover, and this is a mysterious doctrine (at least as mysterious as papal infal libility) unless we shift the emphasis a little and treat qualia as logical constructs out of subjects' qualia-judgments: a subject's experience has the quale F if and only if the subject judges his experience to have quale F."

Having identified "properties" with "judgement of properties" he can then show that the judgements are insubstantial, hence the properties are insubstantial and hence the qualia are insubstantial or even non-existent. Dennett concludes that qualia can be rejected as non-existent:

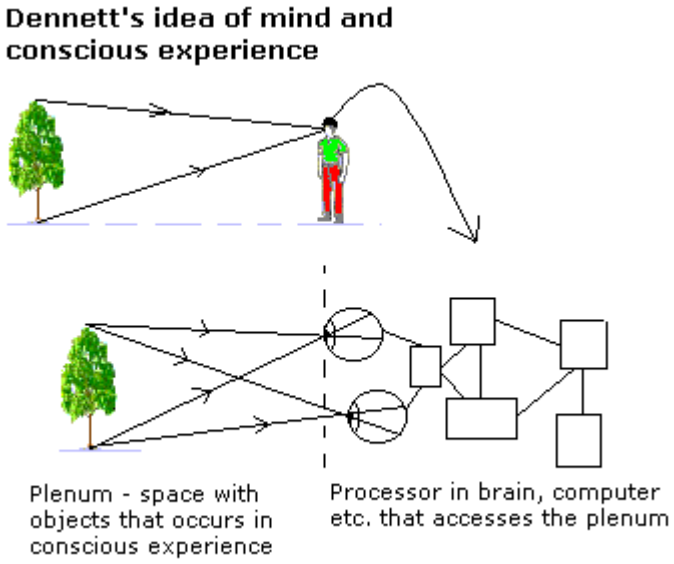
"So when we look one last time at our original characterization of qualia, as ineffable, intrinsic, private, directly apprehensible properties of experience, we find that there is nothing to fill the bill. In their place are relatively or practically ineffable public properties we can refer to indirectly via reference to our private property-detectors-- private only in the sense of idiosyncratic. And insofar as we wish to cling to our subjective authority about the occurrence within us of states of certain types or with certain properties, we can have some authority--not infallibility or incorrigibility, but something better than sheer guessing--but only if we restrict ourselves to relational, extrinsic properties like the power of certain internal states of ours to provoke acts of apparent re- identification. So contrary to what seems obvious at first blush, there simply are no qualia at all. " (Dennett 1988)

This identification of qualia with judgements rather than experience is the key to the Multiple Drafts Model, once accepted there is only a need to explain behaviour rather than personal experience itself.

The origin of this identification of qualia with judgements can be seen in *Consciousness Explained* p407-408. Dennett considers the experiences of someone looking at the world, and describes his idea of the relationship between conscious experience, mind and representation:

> "It seemed to him, according to the text, as if his mind - his visual field - were filled with intricate details of gold-green buds and wiggling branches, but although this is how it seemed this was an illusion. No such "plenum" ever came into his mind; the plenum remained out in the world where it didn't have to be represented, but could just be. When we marvel, in those moments of heightened self-consciousness, at the glorious richness of our conscious experience, the richness we marvel at is actually the richness of the world outside, in all its ravishing detail. It does not "enter" our conscious minds, but is simply available"

For Dennett minds have no "plenum", no space with objects in it, the plenum is things outside the mind. Dennett considers mind to be processes. In his imaginary dialogue with 'Otto' in *Consciousness Explained* Dennett has Otto say "Are you denying then that consciousness is a plenum?" to which he replies "Yes indeed. That's part of whatI am denying. Consciousness is gappy and sparse, and doesn't contain half of what people think is there!". (CE p366). Unfortunately Dennett's assertion is difficult to understand because even half a plenum is a plenum, perhaps his remarks given above that 'conscious experience' has a plenum but 'mind' does not, explain his equivocation. More than one thing at an instant defines a space or "plenum" so the denial of a plenum would seem to be equivalent to denying that conscious experience exists.



Dennett makes a sharp distinction between information in the world and information in the brain. The information in the world seems to be allowed to be a plenum that can enter conscious experience but ceases to be a plenum in the mind. In contrast, according to Dennett the information in the brain is a "logical space":

> "So we do have a way of making sense of the idea of phenomenal space - as a logical space. This is a space into which or in which nothing is literally projected; its

> properties are simply constituted by the beliefs of the (heterophenomenological) subject."

Although how a "logical space" differs from a real space if it contains several things at an instant is not explained and how this "logical space" appears like phenomenal space at each instant is also not covered.

Dennett also attacks "Cartesian materialism" which he defines very precisely as the idea that there is a Cartesian theatre in the brain:

> Lets call the idea of such a centered locus in the brain *Cartesian materialism*, since its the view you arrive at when you discard Descarte's dualism but fail to discard the imagery of a central (but material) Theater where "it all comes together". The pineal gland would be one candidate for such a Cartesian Theater, but there are others that have been suggested - the anterior cingulate, the reticular formation, various places in the frontal lobes. Cartesian materialism is the view that there is a crucial finish line or boundary somewhere in the brain, marking a place where the order of arrival equals the order of "presentation" in experience because what *happens* there is what you are conscious of."(CE p107)

It seems that Dennett is unaware of earlier uses of the term "Cartesian materialism" meaning the concept that the mind is in the brain and co-opts the term for his own use.

Dennett(1998) describes consciousness as distributed in time and space: "Consciousness doesn't have to happen at an instant; it is much better to think of it as distributed in both space and time." but, unlike Descartes, Broad or Whitehead uses an early materialist conception of time to describe it.

References

Daniel C Dennett. (1988). Quining Qualia. in A. Marcel and E. Bisiach, eds, Consciousness in Modern Science, Oxford University Press 1988. Reprinted in W. Lycan, ed., Mind and Cognition: A Reader, MIT Press, 1990, A. Goldman, ed. Readings in Philosophy and Cognitive Science, MIT Press, 1993. http://ase.tufts.edu/cogstud/papers/quinqual.htm

Dennett, D. C., 1998, The Myth of Double Transduction in S. R. Hameroff , A. W. Kaszniak, and A. C. Scott, eds., Toward a Science of Consciousness, II , Cambridge, MA: MIT Press/A Bradford Book, pp97-107.

Daniel C Dennett. (1991). Consciousness Explained. Little, Brown & Co. USA. Available as a Penguin Book.

Dennett, D. and Kinsbourne, M. (1992) Time and the Observer: the Where and When of Consciousness in the Brain. (1992) Behavioral and Brain Sciences, 15, 183-247, 1992. Reprinted in The Philosopher's Annual, Grim, Mar and Williams, eds., vol. XV-1992, 1994, pp. 23-68; Noel Sheehy and Tony Chapman, eds., Cognitive Science, Vol. I, Elgar, 1995, pp.210-274.http://ase.tufts.edu/cogstud/papers/time&obs.htm

Ned Block (1942-)

Ned Block is in the NYU Department of Philosophy.

Two types of consciousness

According to Block[1], "Phenomenal consciousness is experience; the phenomenally conscious aspect of a state is what it is like to be in that state. The mark of access-consciousness, by contrast, is availability for use in reasoning and rationally guiding speech and action." Block feels that it is *possible* to have phenomenal consciousness and access consciousness independently of each other, but in general they do interact.

There is no generally agreed upon way of categorizing different types of consciousness. Block's distinction between phenomenal consciousness and access consciousness tries to distinguish between conscious states that either do or do not directly involve the control of thought and action.

Phenomenal consciousness. According to Block, phenomenal consciousness results from sensory experiences such as hearing, smelling, tasting, and having pains. Block groups together as phenomenal consciousness **experiences** such as sensations, feelings, perceptions, thoughts, wants and emotions. Block excludes from phenomenal consciousness anything having to do with cognition, intentionality, or with "properties definable in a computer program".

Access consciousness. Access consciousness is available for use in reasoning and for direct conscious control of action and speech. For Block, the "report ability" of access consciousness is of great practical importance. Also, access consciousness **must** be "representational" because only representational content can figure in reasoning. Examples of access consciousness are thoughts, beliefs, and desires.

A potential source of confusion is that some phenomenal consciousness is also representational. The key distinction to keep in mind about representational content that Block would place in the access consciousness category is that the reason it is placed in the access consciousness category is because of its representational aspect. Elements of phenomenal consciousness are assigned to the phenomenal consciousness category because of their phenomenal content.

Reaction

An immediate point of controversy for Block's attempt to divide consciousness into the subdivisions of phenomenal consciousness and access consciousness is that some people view the mind as resulting (in its entirety) from fundamentally computational processes. This computational view of mind implies that ALL of consciousness is "definable in a computer program", so Block's attempt to describe some consciousness as phenomenal consciousness cannot succeed in identifying a distinct category of conscious states. This viewpoint is highly contentious however, see The problem of machine and digital consciousness for a discussion

As mentioned above, Block feels that phenomenal consciousness and access consciousness normally interact, but it is possible to have access consciousness without phenomenal consciousness. In particular, believes that zombies are possible and a robot could exist that is

"computationally identical to a person" while having no phenomenal consciousness. Similarly, Block feels that you can have an animal with phenomenal consciousness but no access consciousness.

Block shares Chalmers' belief that we can have conscious experiences that are not possible to produce by any type of computational algorithm and that the source of such experiences is "the hard problem" of consciousness. To functionalists Block's position with respect to consciousness is analogous to that of Vitalists who defined Life as being in a category distinct from all possible physical processes. To those who support phenomenal consciousness the functionalist viewpoint is like believing in a flat earth, flat earthers see the world through biblical cosmology and functionalists view it through nineteenth century science. Biologists refute Vitalism by describing the physical processes that account for Life. Cosmologists refute biblical cosmology by describing modern physics. In order to refute Block's claim about the distinction between phenomenal consciousness and access consciousness, it is up to biologists and artificial consciousness researchers to describe computational algorithms that account for consciousness. In order to refute functionalism philosophers and scientists draw attention to the fact that they are trying to explain an internal state of a conscious observer, something that cannot be explained in terms of the external behaviour of machines.

Why are some neurobiologists and computer scientists sure that Block's division of consciousness is wrong? What is the source of Block's certainty that there are non-computational forms of consciousness? One example of phenomenal consciousness discussed by Block is a loud noise that you do not consciously notice because you are paying attention to something else. Block is sure that you were aware of the noise (phenomenal consciousness) but just not "consciously aware" (access consciousness). Many scientists would say that in this case, you were not "consciously aware" of the noise, but it is almost certain that portions of your unconscious brain activity responded to the noise (you could electrically record activity in the primary auditory cortex that is clearly a response to action potentials arriving from the ears due to sound waves from the noise). This suggests that Block's controversial "non-computational" category of phenomenal consciousness includes brain activity that others would categorize as being unconscious, not conscious. Some unconscious brain activity can begin to contribute to consciousness when the focus of one's conscious awareness shifts. This suggests that some of what Block calls phenomenal consciousness is brain activity that can either take place outside of consciousness or as part of consciousness, depending on other things that might be going on in the brain at the same time. If so, we can ask why the consciously experienced version of this kind of brain activity is computational while the unconscious version is not. On the other hand many authors (Eddington, Broad, Penrose, McFadden, Zeh etc) would point out that brain activity could be both computational and phenomenal.

Block stresses that he makes use of introspection to distinguish between phenomenal consciousness and access consciousness. Presumably this means that when the loud noise was not noticed, it was not accessed by introspection. Block has thus defined a category of consciousness that is outside of our "conscious awareness" (although he says we are "aware" of it in some other way) and not accessed by introspection. Maybe it is this inaccessibility of some cases of phenomenal consciousness that motivate Block's idea that such forms of consciousness cannot be computational. When experiences are accessible to introspection and available for inclusion in reasoning processes, we can begin to imagine computational

algorithms for the generation of the content of those experience. However, it is difficult to imagine how the content could become the same as the form of our experience.

Forms of phenomenal consciousness that are open to introspection

In his 1995 article, Block went on to discuss the more interesting cases such as if upon starting to "pay attention to" the load noise (see above) that was previously ignored, the experiencer noticed that there had been *some* earlier experience of the noise, just not of the type that we "pay attention to"; a type of experience that had been just "on the edge" of access consciousness.

In Ned Block's entry for "Consciousness" in the 2004 Oxford Companion to the Mind[2], he discusses another example that he feels distinguishes between phenomenal consciousness and access consciousness.

> "Liss[3] presented subjects with 4 letters in two circumstances,
>
> long, e.g. 40 msec, followed by a â€œmaskâ€□ known to make stimuli hard to identify
>
> or
>
> short, e.g. 9 msec, without a mask.
>
> Subjects could identify 3 of the 4 letters on average in the short case but said they were weak and fuzzy. In the long case, they could identify only one letter, but said they could see them all and that the letters were sharper, brighter and higher in contrast. This experiment suggests a double dissociation: the short stimuli were phenomenally poor but perceptually and conceptually OK, whereas the long stimuli were phenomenally sharp but perceptually or conceptually poor, as reflected in the low reportability."

This experiment demonstrates a distinction between

> i) reportability of names of the letters
>
> and
>
> ii) perceptual sharpness of the image.

Block's definitions of these two types of consciousness leads us to the conclusion that a non-computational process can present us with phenomenal consciousness of the forms of the letters, while we can imagine an additional computational algorithm for extracting the names of the letters from their form (this is why computer programs can perform character recognition). The ability of a computer to perform character recognition does not imply that it has phenomenal consciousness or that it need share our ability to be consciously aware of the forms of letters that it can algorithmically match to their names.

Reactions

If Block's distinction between phenomenal consciousness and access consciousness is correct, then it has important implications for attempts by neuroscientists to identify the neural correlates of consciousness and for attempts by computer scientists to produce artificial

consciousness in man-made devices such as robots. In particular, Block seems to suggest that non-computational mechanisms for producing the subjective experiences of phenomenal consciousness must be found in order to account for the richness of human consciousness or for there to be a way to rationally endow man-made machines with a similarly rich scope of personal experiences of "what it is like to be in conscious states". Other philosophers of consciousness such as John Searle have similarly suggested that there is something fundamental about subjective experience that cannot be captured by conventional computer programs. This has led to proposals by physicists such as Penrose, Stapp, McFadden etc. for non-digital versions of machines with artificial consciousness.

Many advocates of the idea that there is a fundamentally computational basis of mind feel that the phenomenal aspects of consciousness do not lie outside of the bounds of what can be accomplished by computation[4]. Some of the conflict over the importance of the distinction between phenomenal consciousness and access consciousness centers on just what is meant by terms such as "computation", "program" and "algorithm". In practical terms, how can we know if it is within the power of "computation", "program" or "algorithm" to produce human-like consciousness? There is a problem of verification; can we ever really know if we have a correct biological account of the mechanistic basis of conscious experience and how can we ever know if a robot has phenomenal consciousness? Although of course, such misgivings apply both to those who believe that digital consciousness is possible and those who disagree.

Block's justification of access and phenomenal consciousness uses a nineteenth century idea of the world so cannot be easily sustained against attack from functionalists and eliminativists. However he has clearly described a persistent division in the science and philosophy of consciousness that dates from the time of Aristotle. Aristotle considers this division in terms of those who consider that the soul originates movement and those who consider it to be cognitive, Descartes has the res cogitans and res extensa, Kant has the noumenal and phenomenal, Whitehead has the apparent and causative etc. and even Dennett has the reflex and emergent.

References

1. ^ Block, N. (1995). ON A CONFUSION ABOUT A FUNCTION OF CONSCIOUSNESS. **Behavioral and Brain Sciences** 18 (2): 227-287.

2. ^ Block, N. (2004). "Consciousness" (in R. Gregory (ed.) **Oxford Companion to the Mind**, second edition 2004).

3. ^ Liss, P., (1968). Does backward masking by visual noise stop stimulus processing? **Perception & Psychophysics** 4, 328-330.

4. ^ For a short account, see the Wikipedia entry for phenomenal and access consciousness. Charles Siewert provides a more detailed analysis in his article "Consciousness and Intentionality" in The Stanford Encyclopedia of the Philosophy of Mind.

5. ^ "What is it like to be a bat?" by Thomas Nagel in **The Philosophical Review** LXXXIII, 4 (1974): 435-50.

6. ^ ***On Certainty*** by Ludwig Wittgenstein. Publisher: Harper Perennial (1972) ISBN: 0061316865.

7. ^ Güven Güzeldere described such intuition about the distinctions between phenomenal consciousness and access consciousness as *segregationist intuition*. See "The many faces of consciousness: a field guide" in **THE NATURE OF CONCIOUSNESS; PHILOSOPHICAL DEBATES** Publisher: The MIT Press (1997) ISBN: 0262522101.

Francis Crick (1916 - 2004)

Francis Crick (1994) The Astonishing Hypothesis. The Scientific Search for the Soul. Simon & Schuster Ltd. London.

Crick begins this book with a statement about his opinion of the insignificance of human beings:

"The Astonishing Hypothesis is that "You", your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules. As Lewis Carroll's Alice might have phrased it: "you're nothing but a pack of neurons". This hypothesis is so alien to the ideas of most people alive today that it can truly be called astonishing."

Crick is not a philosopher so might be forgiven the derogatory "no more than..", as a scientist he realises that the assembly of nerve cells that form a brain is highly complex and difficult to understand.

He suggests that the hypothesis is "so surprising" for three reasons:

"The first is that many people are reluctant to accept what is often called the "reductionist approach" - that a complex system can be explained by the behaviour of its parts and their interactions with each other."

.....

"The second reason why the Astonishing Hypothesis seems so strange is the nature of consciousness. We have, for example, a vivid internal picture of the external world. It might seem a category mistake to believe this is merely another way of talking about the behavior of neurons, but we have just seen that arguments of this type are not always to be trusted."

.....

"The third reason why the Astonishing Hypothesis seems strange springs from our undeniable feeling that Free Will is free. ... I believe that if we solve the problem of awareness (or consciousness), the explanation of Free Will is likely to be easier to solve."

Crick believes that many phenomena in the brain are "emergent" with the vague implication that consciousness may also be emergent. He defines this term in the following way:

"The scientific meaning of emergent, or at least the one I use, assumes that, while the whole may not be the simple sum of the separate parts, its behavior can, at least in principle, be understood from the nature and behavior of its parts plus the knowledge of how all these parts

interact."

He wants to avoid the philosophical debates about the nature of consciousness:

"1. Everyone has a rough idea of what is meant by consciousness. It is better to avoid a precise definition of consciousness because of the dangers of premature definition.

"Footnote: If this seems like cheating, try defining for me the word gene. So much is now known about genes that any simple definition is likely to be inadequate. How much more difficult, then, to define a biological term when rather little is known about it."

This is an odd standpoint because any brief review of the ideas of philosophers shows that a good deal is known about phenomenal consciousness. The problem lies in explaining such a bizarre experience, not in defining it.

He then elaborates a further four points covering general features of consciousness and avoiding various types of speculation about consciousness. Excluded are: "what consciousness is for", speculations about consciousness in lower animals and the "self-referential aspect of consciousness"; included are the concept of consciousness in "higher mammals".

As a guide for the scientific investigation of consciousness he puts forward three basic ideas:

""1. Not all the operations of the brain correspond to consciousness.

"2. Consciousness involves some form of memory, probably a very short term one.

"3. Consciousness is closely associated with attention."

The operations of the brain that do correspond to consciousness are the "neural correlates of consciousness" a term that probably predates Crick's work. Crick shows the openness of ideal science when he concludes with:

"The Astonishing Hypothesis may be proved correct. Alternatively some view closer to the religious one may become more plausible. There is always a third possibility: that the facts support a new, alternative way of looking at the mind-brain problem that is significantly different from the rather crude materialistic view many neuroscientists hold today and also from the religious point of view."

David J Chalmers

Review of "The Conscious Mind: In Search of a Fundamental Theory". Oxford University Press. 1996.

Chalmers is perhaps most famous for his "hard problem" of consciousness:

"... I find myself absorbed in an orange sensation, and *something is going on*. There is something that needs explaining, even after we have explained the process of discrimination: there is the *experience*."p xii

...."This might be seen as a Great Divide in the study of consciousness. If you hold that an answer to the "easy" problems explains everything that needs to be explained, then you get one sort of theory; if you hold that there is a further "hard" problem then you get another."p xiii

Chalmers describes mind as having "phenomenal" and "psychological" aspects.

"At the root of all this lie two quite distinct concepts of mind. The first is the *phenomenal* concept of mind. This is the concept of mind as conscious experience, and of a mental state as a consciously experienced mental state. ... The second is the *psychological* concept of mind. This is the concept of mind as the causal or explanatory basis for behaviour." p11

Chalmers proposes that consciousness can be explained by a form of "Naturalistic Dualism" that is supported by the following argument:

"In particular, the failure of logical supervenience directly implies that materialism is false: there are features of the world over and above the physical features. The basic argument for this goes as follows: 1. In our world there are conscious experiences. 2. There is a logically possible world physically identical to ours, in which the positive facts about consciousness in our world do not hold. 3. Therefore facts about consciousness are further facts about our world, over and above the physical facts. 4. So materialism is false.

Chalmers describes his naturalistic dualism:

"The dualism implied here is instead a kind of *property* dualism: conscious experience involves properties of an individual that are not entailed by the physical properties of that individual. Consciousness is a *feature* of the world over and above the physical features of the world. This is not to say that it is a separate "substance"; the issue of what it would take to constitute a dualism of substances seems quite unclear to me. All we know is that there are properties of individuals in this world - the phenomenal properties - that are ontologically independent of physical properties." p125

To substantiate his argument he proposes that "zombie" worlds, in which people would behave like us but not be conscious, are logically possible and that worlds that are physically identical to ours, but where conscious experiences are inverted, are logically possible.

Chalmers' argument about the possibility of zombies runs as follows:

A zombie is defined as "...someone or something physically identical to me (or to any other conscious being), but lacking conscious experiences altogether". Chalmers considers that silicon based devices or an entity based on the population of china could lack conscious experience although being able to perform the same functions as a person. He then makes a logical leap to suggest that these examples show that something physically identical to a conscious person could not be conscious:

"But given that it is conceptually coherent that the group-mind set-up or my silicon isomorph could lack conscious experience, it follows that my zombie twin is an equally coherent possibility."p97

In the inverted spectrum argument Chalmers argues that it is logically possible to imagine a world that is physically identical to ours yet where conscious beings experience an inverted

spectrum. This assertion is defended on the basis of the elementary science of colour vision.

Unfortunately, without any definite proposal for how conscious experience is realised it seems premature to declare that the zombie and inverted spectrum arguments are correct. Chalmers approaches the problem of the realization of conscious experience when discussing "information".

Chalmers is aware that phenomenal consciousness includes information that is related to information in the physical world:

"A conscious experience is a realization of an information state; a phenomenal judgement is explained by another realization of the same information state. And in a sense, postulating a phenomenal aspect of information is all we need to do to make sure those judgements are truly correct; there really *is* a qualitative aspect to this information, showing up directly in phenomenology and not just a system of judgements."p 292

Unfortunately he does not explain what a phenomenal "realization of an information state" means. This leads him to consider any information state as potentially capable of conscious experience. He notes that "We find information everywhere, not just in systems that we standardly take to be conscious." and asks whether a thermostat could be conscious. He poses the question "As we move along the scale from fish and slugs through simple neural networks all the way to thermostats, where should consciousness wink out?".

He answers the objection that there may not be any *room* for consciousness in a thermostat by saying that "If consciousness is not logically supervenient, we should not expect to have to find "room" for consciousness in a system's organization; consciousness is quite distinct from the processing properties of the system". He concludes the thermostat article by declaring that:

"While it *could* be the case that experience winks in at a particular point, any specific point seems arbitrary, so a theory that avoids having to make this decision gains a certain simplicity."

This set of ideas leads to the possibility of panpsychism:

"If there is experience associated with thermostats, there is probably experience *everywhere*: wherever there is a causal interaction, there is information, and wherever there is information there is experience." p297

However, Chalmers states that:

"Personally, I am much more confident of naturalistic dualism than I am of panpsychism. The latter issue seems to be very much open. But I hope to have said enough to show that we ought to take the possibility of some sort of panpsychism seriously..." p299

He then postulates that "Phenomenal properties have an intrinsic nature, one that is not exhausted by their location in an information space, and it seems that a purely informational view of the world leaves no room for these intrinsic qualities.". This leads him to suggest that the world is more than just information, that we "*need* some intrinsic nature in the world, to ground information states". This leads him to propose that:

"So the suggestion is that the information spaces required by physics are themselves

grounded in phenomenal and protophenomenal properties. Each instantiation of such an information space is in fact a *phenomenal* (or protophenomenal) realization. Every time a feature such as mass and charge is realized, there is an intrinsic property, or *microphenomenal* property for short. We will have a set of basic microphenomenal spaces, one for each fundamental physical property, and it is these spaces that will ground the information spaces that physics requires." p305

So Chalmers takes the proposal of panpsychism, based on the idea that all information spaces might be conscious, to "ground" the information space. Again, any description of how phenomenal consciousness is actually realized in an information space is missing.

Chalmers' explanation of information seems to mystify it, in physics information is arrangements of things, in maths or digital transmission it is usually arrangements of the same thing. For instance 11011 is an arrangement of ones and zeroes along a line - the information has not replaced reality it is simply a way of using reality to represent something else. As Zurek put it: "there is no information without representation". Hence it is difficult to see why microphenomena should be required to instantiate information when the information is already instantiated.

The concept of information as something that can be transmitted from place to place and also as a property of a substance is at the heart of Chalmer's analysis. He states that:

"We have no way to peek inside a dog's brain, for instance, and observe the presence or absence of conscious experience. The status of this problem is controversial, but the mere *prima facie* existence of the problem is sufficient to defeat an epistemological argument, parallel to those above, for the logical supervenience of consciousness. By contrast there is not even a *prima facie* problem of other biologies, or other economies. Those facts are straightforwardly publically accessible, precisely because they are fixed by the physical facts." p74

The patterns of things that comprise "biologies" are, according to this, "physical facts". But from the argument about panpsychism above, physical facts are not grounded, they are information that must be instantiated in some way through "microphenomenal" properties. Chalmers seems to be arguing that nothing logically supervenes on the physical because nothing logically supervenes on mind and physical things are mind.

He introduces the idea of *organizational invariance* as the key feature of a conscious system and declares that a set of beer cans could be conscious:

"I claim that conscious experience arises from fine-grained functional organization. More specifically, I will argue for a *principle of organizational invariance*, holding that given any system that has conscious experiences, then any system that has the same fine-grained functional organization will have qualitatively identical experiences. According to this principle, consciousness is an organizational invariant: a property that remains constant over all functional isomorphs of a given system. Whether the organization is realized in silicon chips, in the population of China, or in beer cans and ping-pong balls does not matter. As long as the functional organisation is right, conscious experience will be determined." p249

Chalmers idea of qualia as a flow of beer cans

Experience of blue Experience of red

Conscious experience is a function. It could occur in a system of beer cans. Is this like phenomenal blue?

Does the difference between the qualia depend

It is intriguing that he considers "functional organisation", or the flow of information in the system, to be sufficient to determine consciousness (ie: invariant arrangements of states in space are unnecessary).

See elementary information theory for a discussion of supervenience in information systems.

The Neuroscience of Consciousness

"All parts of the brain may well be involved in normal conscious processes but the indispensable substratum of consciousness lies outside the cerebral cortex, probably in the diencephalon" Penfield 1937.

"The brain stem-thalamocortical axis supports the state, but not the detailed contents of consciousness, which are produced by cortex" Baars et al 1998.

Introduction

It is recommended that readers review "The philosophical problem" before reading the sections on the neuroscience of consciousness.

One of the most exciting discoveries of neuroscience is that nearly all of the brain performs functions that are not part of conscious experience. In everyday life we are usually unaware of breathing or heartbeats yet there are parts of the brain dedicated to these functions. When we pick up a pencil we have no experience of the fine control of individual muscles yet large areas of cortex and cerebellum implement this. Things do not appear as greyscale and then have the colour poured into them although this strange colour addition is done in the visual cortex. Most of the brain is non-conscious but how is the "ghost in the machine", the mind, created by and linked into the non-conscious brain?

Although most of the processes in the brain are non-conscious there can be little doubt that the output of sensory processes contribute to experience. For example, although we do not experience the process of adding colour to visual data in cortical area V4 we do experience coloured forms and although we have little inkling of the hugely complex creation of words in the temporal/frontal lobes we do experience verbal thoughts. Our experience is an integrated output of most of the brain processes that deal with sensation as well as dreams, thoughts and emotions. But how and where does this experience occur?

The substrate of experience

Quantum mechanical events in the world give rise to signals that travel from these events to the sense organs and the brain. The signals have a state that is related to the properties of the original QM event. Some of these signals form phenomenal consciousness and some are used in the processes of access consciousness. According to neuroscience the signals are physical things such as electromagnetic fields, distributions of chemicals, electrical impulses etc.

The signals used in access consciousness are used in the processes that mediate between stimulus and response. These processes have been investigated in depth. The signals within the processes consist of physical stimuli, the electrical impulses in the cell bodies and axons of nerve cells, the electrical fields in the dendrites of nerve cells, and various chemical signals that connect nerve cells.

The signals that compose phenomenal consciousness have not been elucidated. Perhaps the least likely signals for this role are electrical impulses in nerve fibres because they are distributed unevenly in time and space and can even be absent for relatively long periods. Furthermore, electrical impulses cannot be easily superimposed on one another. There are

many other possibilities however, such as: the electrical fields on the dendrites of neurons, the fields of chemicals spreading out from synapses, the radio-frequency emissions of action potentials, events in the microtubules in cells, the depolarisations of glia, the varying fields measured by EEG devices, the quantum superposition of brain states etc...

Phenomenal consciousness could exist in the dendritic field of ten neurons receiving 100,000 synapses or as an oscillation of fields over the whole brain. The substrate of phenomenal consciousness could be staring us in the face as a state of the whole brain or be like a needle in a haystack, lurking in a tiny region of brain, unsuspected and undiscovered.

Given that there is no widely accepted theory of phenomenal consciousness Crick (1994) and Crick and Koch (1998)approached the problem of the location of the substrate of consciousness by proposing that scientists search for the **Neural Correlates of Consciousness**. These neural correlates consist of events in the brain that accompany events in conscious experience.

References:

Crick, F. (1994). The Astonishing Hypothesis. New York: Scribners.

Crick, F. & Koch, C. (1998).Consciousness and Neuroscience. Cerebral Cortex, 8:97-107, 1998 http://www.klab.caltech.edu/~koch/crick-koch-cc-97.html

Neuroanatomy

General layout of the CNS

The Central Nervous System (CNS) consists of the spinal cord, the brain and the retina.

The CNS consists of two major groups of active cells, the **neurons** and the **glia**. The neurons conduct short impulses of electricity along their membranes called '**action potentials** and encode data as frequency modulated signals (ie: different intensities of stimulation are converted into different rates of firing). The glia modify the connections between neurons and can respond to neuron activity by a change of voltage across their membranes. Glia also have many other roles such as sustaining neurons and providing electrical insulation.

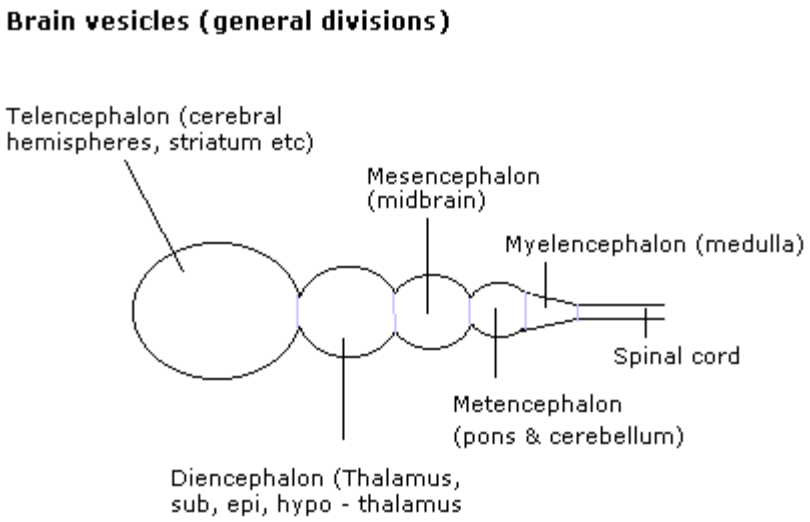
Neurons have three principal parts: the **cell body**, the **dendrites** and the **axon**. Impulses flow from the cell body to the axon. The axon can be over a metre long and bundles of axons form **nerve fibres**. Where an axon makes contact with the dendrites or cell body of another neuron there is a special sort of junction called a **synapse**. Transmission of data across synapses is usually mediated by chemical signals.

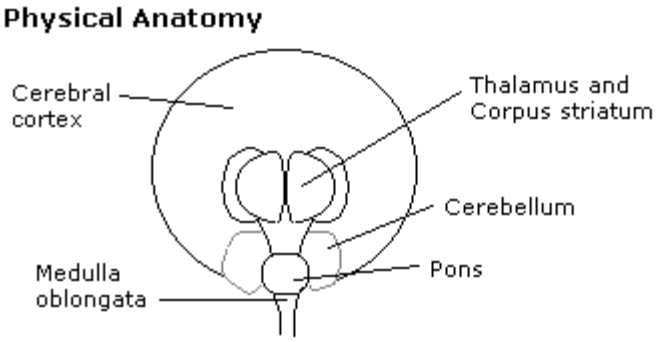
Areas of the brain where there are many cell bodies have a beige/grey tinge and are called **grey matter**. Areas that contain mainly nerve fibres are called **white matter**. Masses of grey matter outside of the surface of the cerebral cortex or the cerebellum are called **nuclei**.

The brain is of central interest in consciousness studies because consciousness persists even when the spinal cord is sectioned at the neck.

The brain can be divided into five distinct divisions or '*vesicles* on the basis of embryological development. These are the myelencephalon, metencephalon, mesencephalon, diencephalon

and telencephalon (See the illustration below).





Myelencephalon: Medulla oblongata.

Metencephalon: pons and cerebellum.

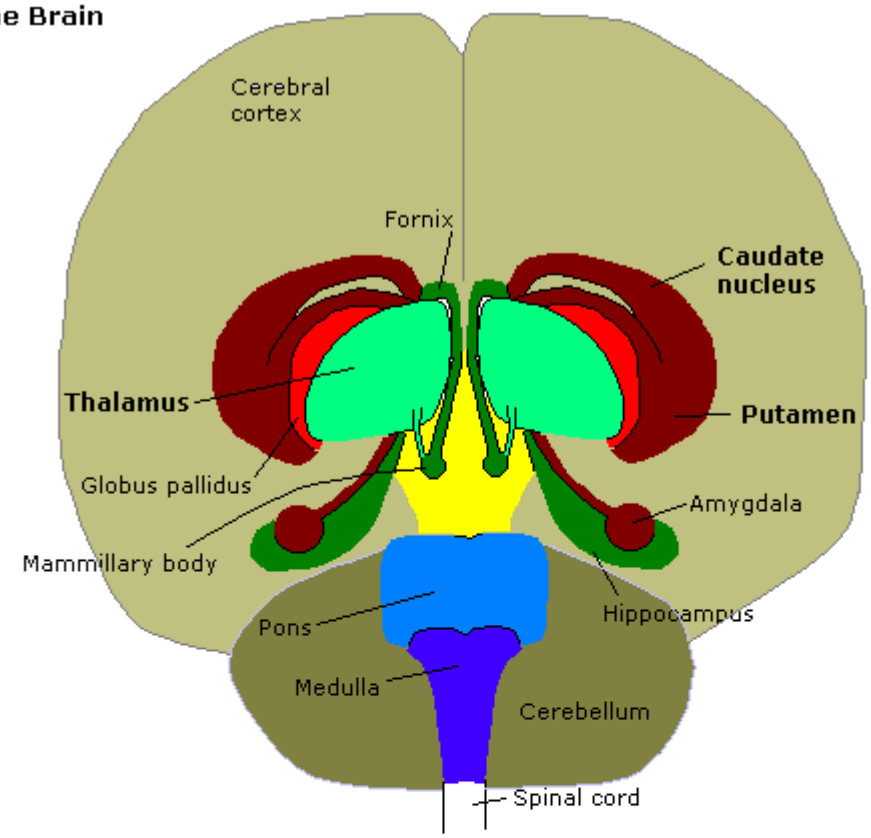
Mesencephalon: midbrain (tectum containing the superior colliculus and inferior colliculus, red nucleus, substantia nigra, cerebellar peduncles.

Diencephalon: thalamus, epithalamus, hypothalamus, subthalamus.

Telencephalon: corpus striatum, cerebral hemispheres.

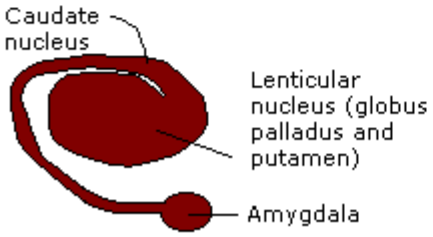
These divisions tend to obscure the physical anatomy of the brain which looks like a rod of spinal cord with a swelling at the top due to the thalamus and corpus striatum. Around the top of the rod is a globe of deeply indented cerebral cortex and at the back there is the puckered mass of cerebellum. The physical anatomy is shown in greater detail in the illustration below where the thalamus and corpus striatum have been splayed out to show more detail.

The Brain



The brain as viewed from the underside and front. The thalamus and Corpus Striatum (Putamen, caudate and amygdala) have been splayed out to show detail.

Corpus Striatum

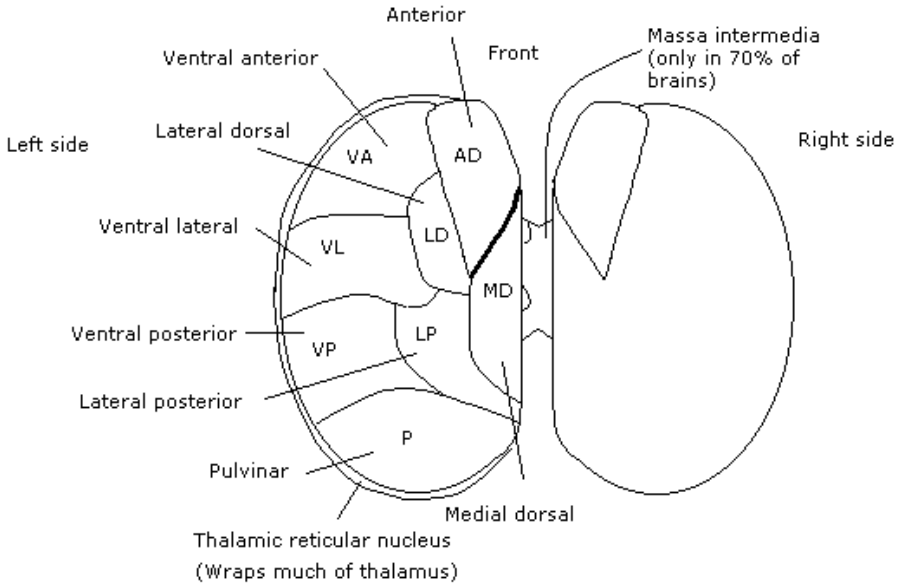


The thalamus is a complex organ with numerous nuclei. These are listed below:

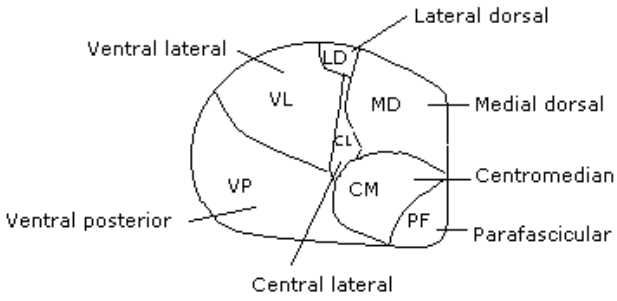
Type of Nucleus	Name	Abbrev	Function
Reticular	Reticular	R	Arousal
Intralaminar	Centromedian	CM	Arousal, attention, motivation, pain
	Parafascicular	Pf	
	Central lateral	CL	
	Paracentral	Pcn	
Intralaminar Midline	Reunions	Re	
	Paraventricular	Pv	
	Rhomboid		
Nonspecific	Pulvinar	P	Association
	Lateral dorsal	LD	
	Anterior	AD	
	Anteromedial	AM	
	Anteroventral	AV	
	Lateral posterior	LP	
	Medial Dorsal	MD	
Specific Thalamic Nuclei	Lateral geniculate	LGN	Vision
(Sensory Relays)	Medial geniculate	MGN	Auditory
	Ventral posterior	VP	General sensation
Specific Thalamic Nuclei	Ventral anterior	VA	Motor
(motor)	Ventral lateral	VL	Motor

The location of these nuclei is shown in the illustration below:

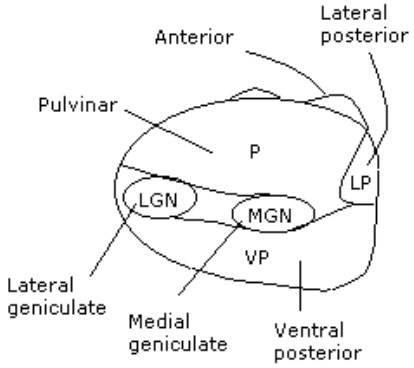
Thalamus Dorsal View (top view).



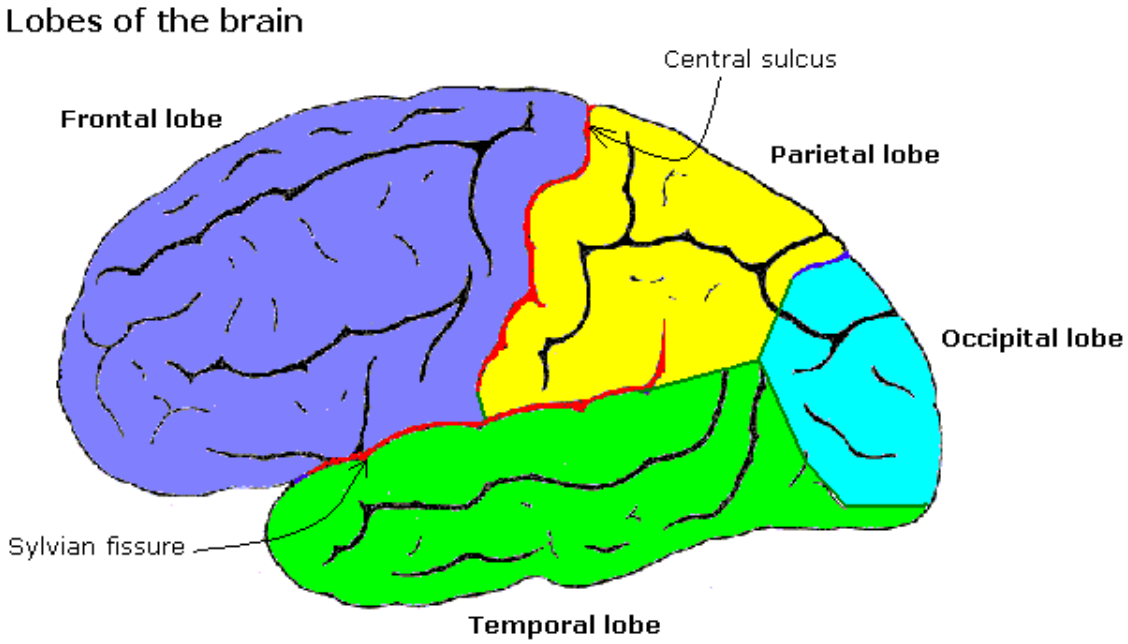
Mid-section



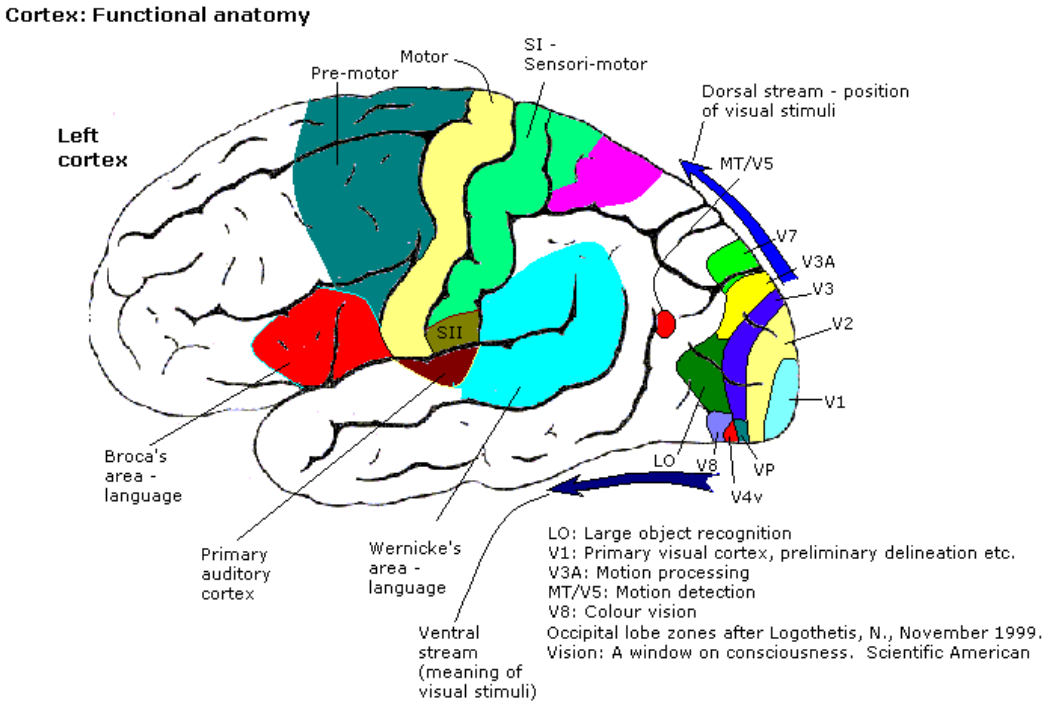
Rear view

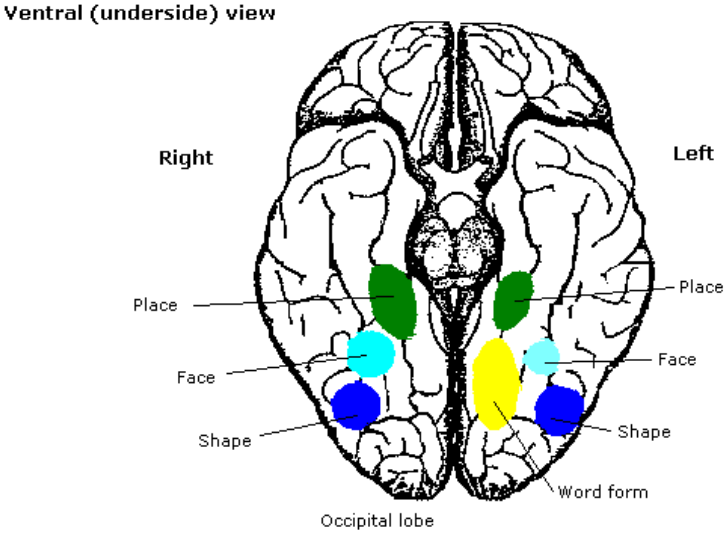


The cerebral hemispheres consist of a thin layer of nerve cell bodies on the surface (the cerebral cortex) with a mass of white, interconnecting fibres below (the cerebral medulla). Each hemisphere is divided into four principle **lobes** as shown in the illustration below:



The cortex is a set of interconnected processors. The general layout of the cortex with the location of the processors is shown in the illustration below:





The pathways in the brain tend to preserve the **topography** of the sense organs so that particular groups of cells on the retina, cochlear or body have corresponding groups of cells in the thalamus or cortex. The retina is said to have a topological mapping onto the thalamus so that the projection of the optic nerve is said to be **retinotopic**.

Nerve fibres that go to a part of the brain are called **afferents** and fibres that come from a part of the brain are called **efferents**.

The cortex and thalamus/striatum are intimately linked by millions of connecting fibres and there is also a direct connection from the motor cortex to the spinal cord.

Sensory pathways

Information from the sense organs travels along the appropriate sensory nerve (optic, auditory, spinal etc.) and once in the brain is divided into three principal paths that connect either with the thalamus, the cerebellum or the reticular formation.

There are thalamic nuclei for each broad type of sensation and these have reciprocal connections with specific areas of cortex that deal with the appropriate mode of sensation. The large mass of nerve fibres that mediate the connection between the thalamus and cortex are known as the thalamo-cortical and cortico-thalamic tracts. There tend to be more sensory nerve fibres returning from the cortex to the thalamus than connect from the thalamus to the cortex so it is difficult to determine whether the cortex is the destination of sensory data or a region that supplies extra processing power to thalamic nuclei.

The cerebellum mediates reflex control of complex movements and receives input from most of the sense organs.

The reticular formation is a group of loosely distributed neurons in the medulla, pons and mesencephalon. It receives a large amount of autonomic input and also input from all the sense organs. The intralaminar nuclei of the thalamus are the principal destination of reticular output to higher centres. In the most primitive vertebrates the reticular formation performs most of the higher control functions of the animal. The reticular formation is implicated in the maintenance of sleep-wake cycles and activates the higher centres. This activity has attracted the label **ascending reticular activating system** (ARAS) to describe how the activity of higher centres is controlled by reticular input. This title is unfortunate from the point of view of consciousness studies because it implies that conscious experience is a result of activating the cortex when it could be due to turning on or off particular systems all the way from the reticular formation to the cortex. Destruction of the reticular formation leads to coma.

Motor and output pathways

Motor control of the body below the skull is accomplished by three principle routes.

The motor cortex of the frontal lobes and related cortex in the parietal lobes can control movement directly via nerves known as the cortico-spinal tract (also called the pyramidal tract). The activity of the motor cortex is modified and controlled by a loop that passes through the corpus striatum, the substantia nigra and the subthalamic nucleus and returns to the cortex. These controlling nuclei are, along with the amygdala, known as the **basal ganglia**.

The cerebellum and the corpus striatum provide complex reflex control of the body through nerves that travel through the red nucleus and form the rubro-spinal tract.

The vestibular nucleus, which processes signals related to balance and posture, has direct connections with the periphery via the vestibulo-spinal tract.

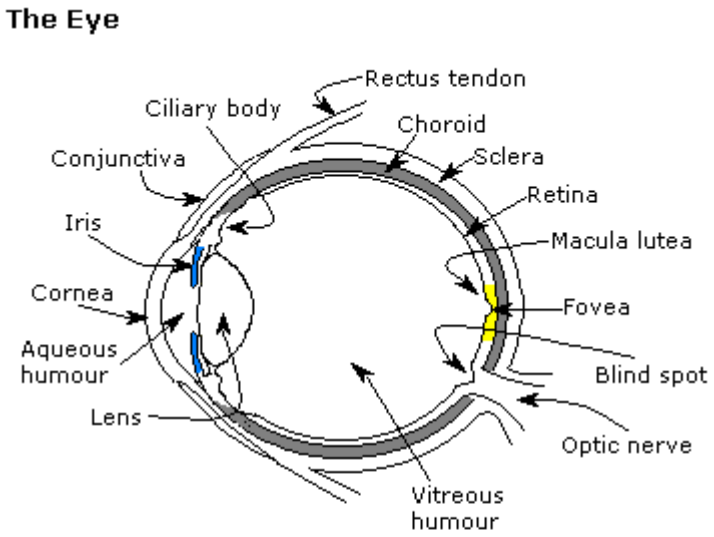
Apart from the routes for controlling motor activity there are also other outputs from the brain, for instance the autonomic nervous system is intimately linked with the reticular formation which has areas that control blood pressure, respiratory rhythm etc.

The neurophysiology of sensation and perception

Vision

The human eye

The eye is a remarkable optical instrument that is often poorly understood by students of consciousness. The most popular misconception is that there is a 'focus' within the eye through which all the light rays pass! The purpose of this article is to describe our knowledge of the optics of the eye so that such misconceptions can be avoided.



An inverted image is formed on the retina at the back of the eye

The eye consists of several surfaces at which refraction occurs: air-cornea, cornea-aqueous humour, aqueous humour-lens, lens-vitreous humour. The crude image forming capability of the eye can be represented quite accurately by the *reduced eye* model which involves a single optical surface (air-cornea). Optometrists use more accurate models such as the Gullstrand Schematic Eye, the Le Grand Theoretical and the LeGrand Simplified Eye.

The lens system at the front of the eye forms an inverted image on the retina.

The eye is about 23 mm deep from the front of the cornea to the back of the retina. The refractive index of the components of the lens system varies from about 1.33 to 1.39.

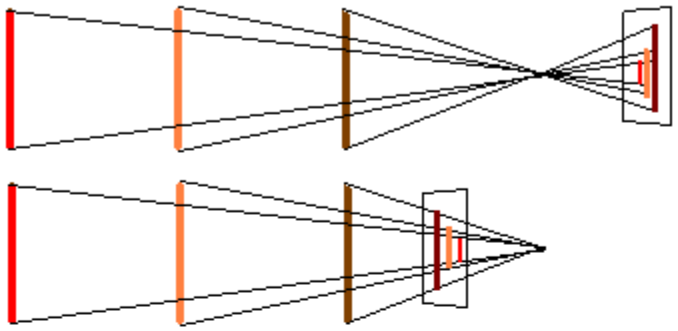
Light from every point of a field of view falls all over the surface of the eye. There is no 'point eye' and there is no ordered image between objects in the view and the retina except on the retina. The image on the eye has the form of an inverted mapping of 3D objects to a 2D surface. This is also the form of conscious experience so the images on the retinas are the closest physical analogues of phenomenal, visual, conscious experience (see Perspective below).

Perspective

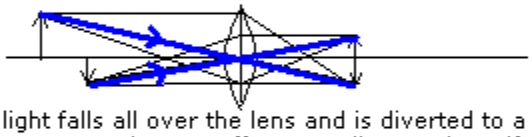
Perspective describes how light from three dimensional objects is mapped onto a two dimensional surface as a result of the action of lenses of the type found in the eye.

Perspective: mapping 3D shapes onto a 2D surface.

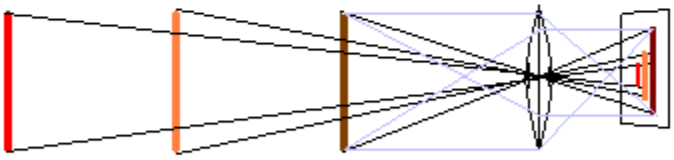
Perspective occurs when rays of light that are converging to a point or projected from a point are intercepted by a surface.

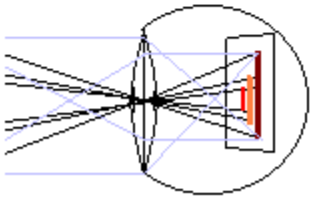


Lenses map incident light in a way that simulates convergence to a point at the centre of the lens.



Although light falls all over the lens and is diverted to a unique spot on the screen, the NET effect at a distance is as if the light goes through a point at the centre of the lens.



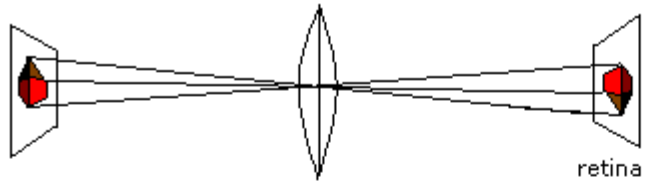


Schematic eye: the retina acts as a screen behind a lens

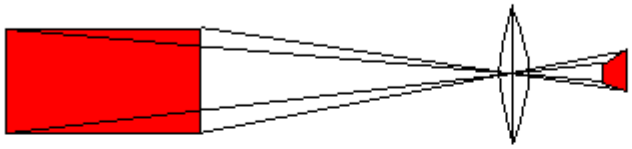
This causes familiar effects such as parallel lines meeting at infinity

Perspective is used by artists to create the impression of viewing a 3D scene. To do this they create a 2D image that is similar to the image on the retina that would be created by the 3D scene.

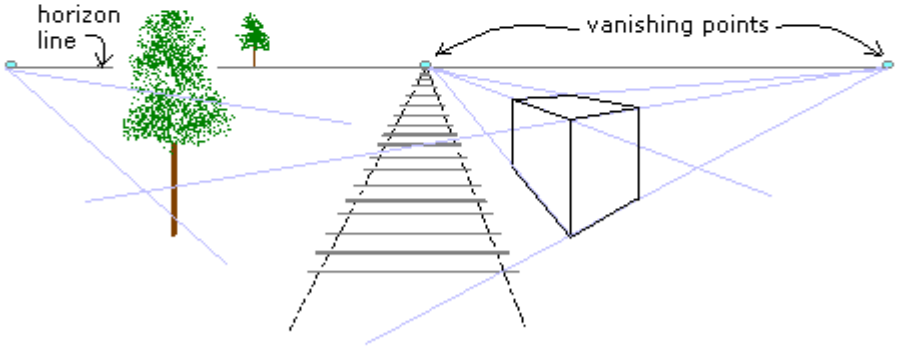
Artistic perspective: mapping 2D to 2D so it appears 3D



A 2D image forms a scaled replica on the retina.



So the problem confronting the artist is how to paint a 2D image so that it looks like the image on the back of the eye formed by 3D structures.



The solution is to make use of the way that when 3D is transformed to 2D parallel lines appear to meet at infinity. Each independent direction in space is given a "vanishing point" where parallel lines meet. A total of six vanishing points are possible ("six point perspective"). Artists frequently use two point or three point perspective (an example of three point is shown above).

Naive Realists and many Direct Realists believe that the 2D perspective view is the way things are actually arranged in the world. Of course, things in the world differ from images because they are arranged in three dimensions.

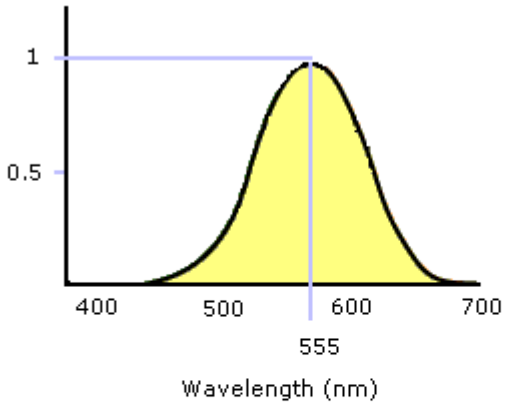
Colour

The colour of an object can be represented by its **spectral power distribution** which is a plot of the power available at each wavelength. The unit of light power is the watt but the unit that is used to measure subjective illumination is the **candela**. One candela is the illumination due to light of a wavelength of 555 nanometres and a radiant intensity of 1/683 watts per steradian in the direction being measured. A steradian is a solid angle at the centre of sphere of one metre radius that is subtended by one square metre of the surface. The curious number 1/683 occurs because the unit was originally based on light emitted from a square centimetre of molten platinum. The wavelength of 555 nm is chosen because this is the wavelength of

peak sensitivity for light adapted (photopic) vision over a large group of subjects. Light adapted vision is largely due to photosensitive cells in the retina called **cones**. The candela is fixed as a standard SI Unit for light at a wavelength of 555 nanometres.

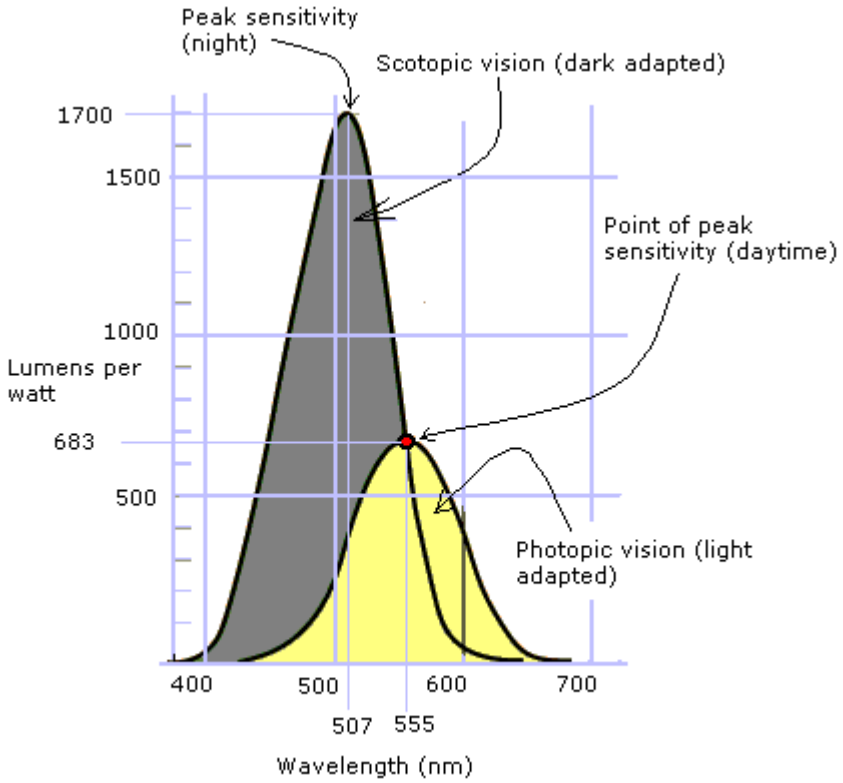
The **lumen** is a subjective measure of the flux of light energy passing through a solid angle (a steradian). 683 lumens of light at 555 nm are equivalent to a watt passing through the solid angle. At a wavelength of about 520 nm only 500 lumens of luminous flux occur per watt because the visual system is less sensitive at this wavelength. The curve of sensitivity of the visual system to light is known as the **V-lambda Curve**. At a wavelength of about 510 nm the same radiant intensity is seen as being half as bright as at a wavelength of 555 nm.

The V-lambda curve



The V-lambda curve is the curve of relative sensitivity of the visual system at different wavelengths. It is obtained from subjective comparisons of the brightness of a source at a test wavelength with the brightness of a source of the same power at the wavelength of peak sensitivity. The curve shown above is for photopic vision, another curve applies for scotopic vision.

Spectral luminous efficacy



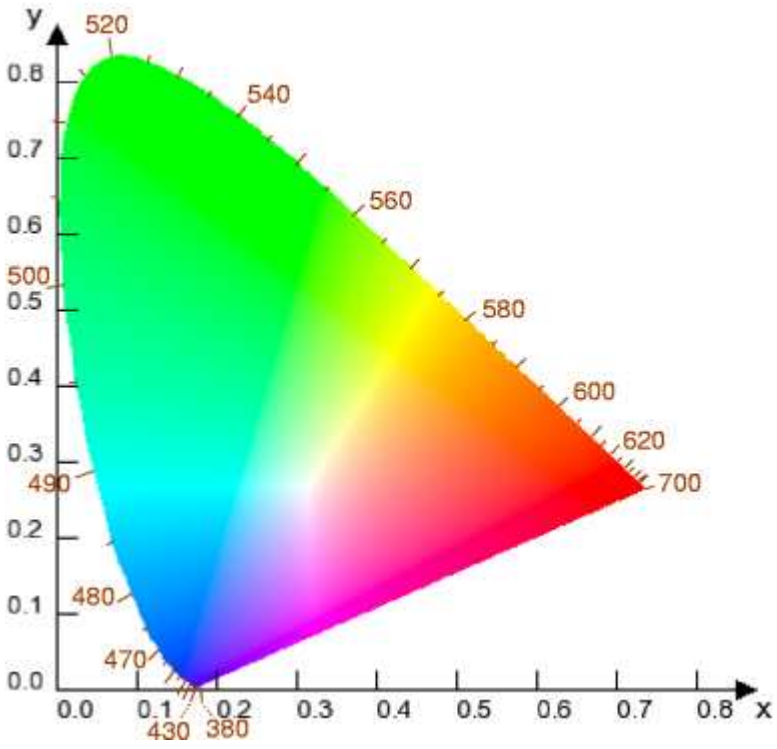
Dark adapted (scotopic) vision has a peak sensitivity at a wavelength of 507 nm and is largely due to photosensitive cells called **rods** in the retina. Spectral Luminous Efficacy Curves are also used to express how the sensitivity to light varies with wavelength.

Phenomenal colours are due to mixtures of **spectral colours** of varying intensities. A **spectral colour** corresponds to a wavelength of light found on the electromagnetic spectrum of visible light. Colours have three attributes: **brightness**, **saturation** and **hue**. The brightness of a colour depends on the illuminance and the reflectivity of the surface. The saturation depends on the amount of white present, for instance white and red make pink. The hue is similar to spectral colour but can consist of some combinations - for instance magenta is a hue but combines two spectral colours: red and blue. It should be noted that experiences that contain colour are dependent on the properties of the visual system as much as on the wavelengths of light being reflected.

Any set of three colours that can be added together to give white are known as **primary colours**. There are a large number of colours that can be combined to make white, or almost any other colour. This means that a set of surfaces that all appear white could reflect a wide range of different wavelengths of light.

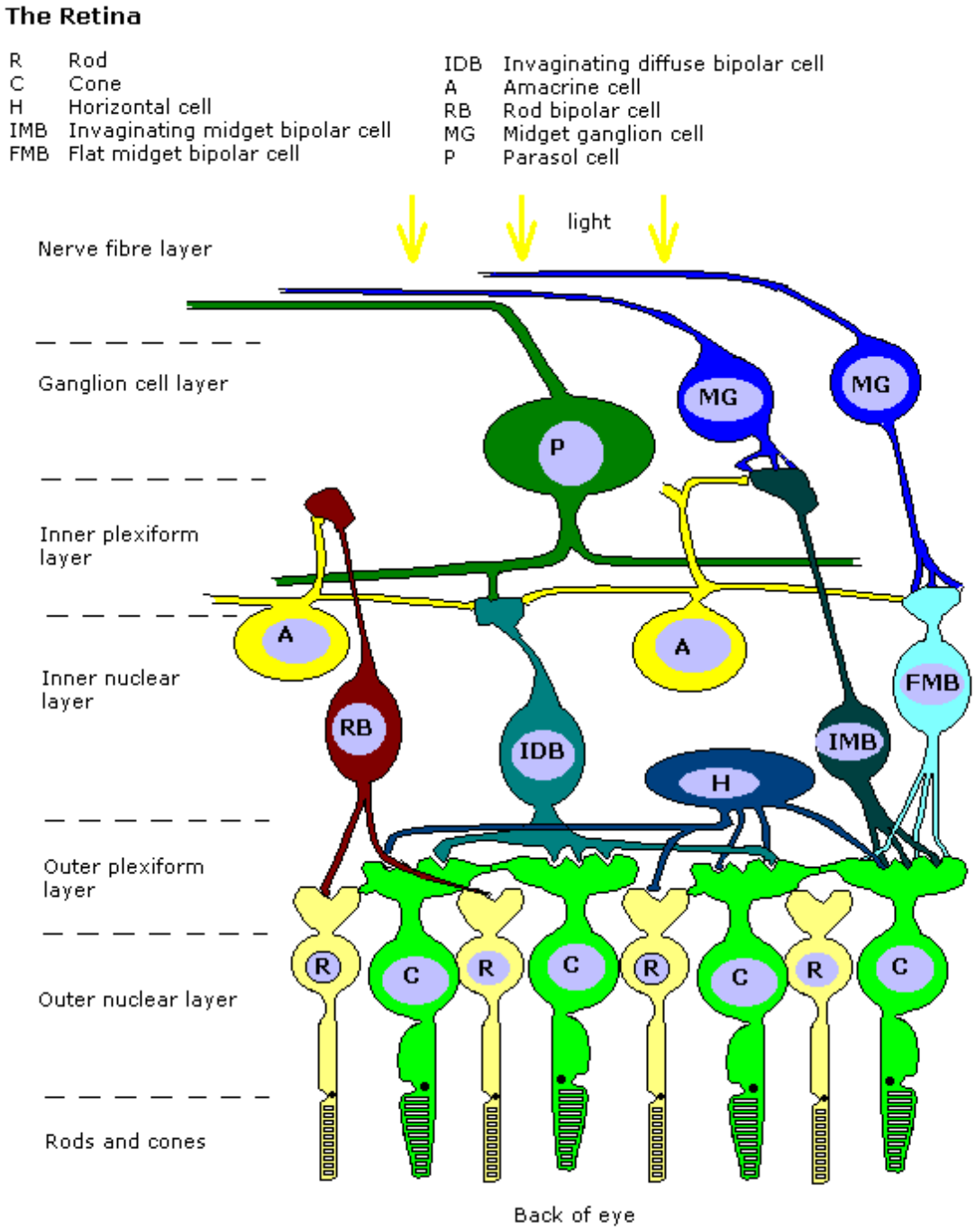
There are numerous systems for predicting how colours will combine to make other colours; the CIE Chromaticity Diagram, the Munsell Colour System and the Ostwald Colour System have all been used. The 1931 CIE Chromaticity Diagram is shown below:

See Chromaticity diagram for more information.



The retina

The retina contains photoreceptive cells called rods and cones and several types of neurons. The rods are generally sensitive to light and there are three varieties of cones sensitive to long, medium and short wavelengths of light (L, M and S type cones). Some of the ganglion cells in the retina (about 2%) are also slightly light sensitive and provide input for the control of circadian rhythms. A schematic diagram of the retina is shown below.



The photoreceptors hyperpolarise (their membrane potential becomes more negative) in

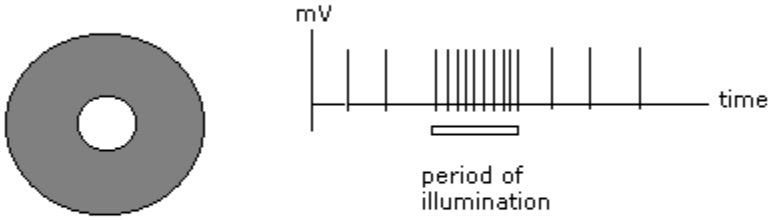
response to illumination. Bipolar cells make direct contact with the photoreceptors and come in two types, *on* and *off*. The on-bipolar cells are also known as *invaginating* bipolars and the off-bipolars as *flat bipolars*. On-bipolars depolarise when light falls on the photoreceptors and off-bipolars hyperpolarise. Action potentials do not occur in the bipolar or photoreceptor cells.

The retinal neurons perform considerable preprocessing before submitting information to the brain. The network of horizontal and ganglion neurons act to produce an output of action potentials that is sensitive to boundaries between areas of differing illumination (edge detection) and to motion.

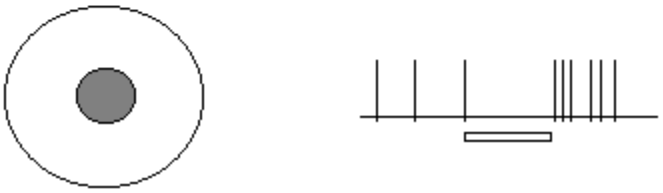
Kuffler in 1953 discovered that many retinal ganglion cells are responsive to differences in illumination on the retina. This **centre-surround** processing is shown in the illustration below.

Centre-Surround Ganglion Cells

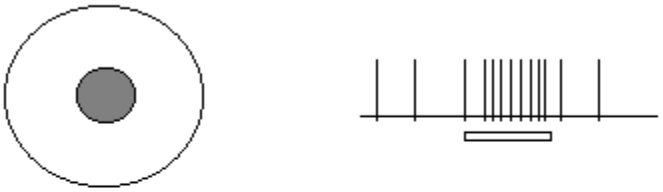
Off-centre and on-centre ganglion cells fire in response to illumination events on a circular area of retina.



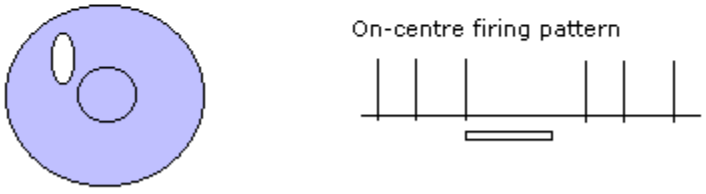
On-centre cells fire must rapidly when the centre of the circular area is illuminated and the periphery is dark.



On-centre cells are suppressed if the periphery is illuminated and the centre is dark. After intense suppression the firing rate rebounds.



Off-centre cells fire most when the periphery is illuminated and the centre is dark.

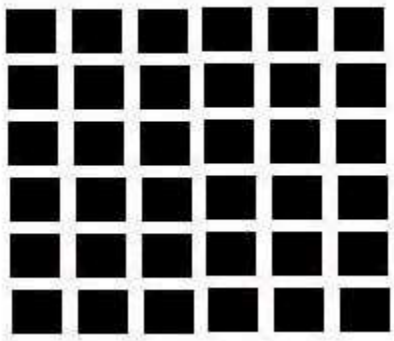


On-centre cells decrease firing rate if the periphery is illuminated.
Off-centre cells increase firing when the periphery is illuminated.

The centre-surround effect is due to **lateral inhibition** by horizontally arranged cells in the retina.

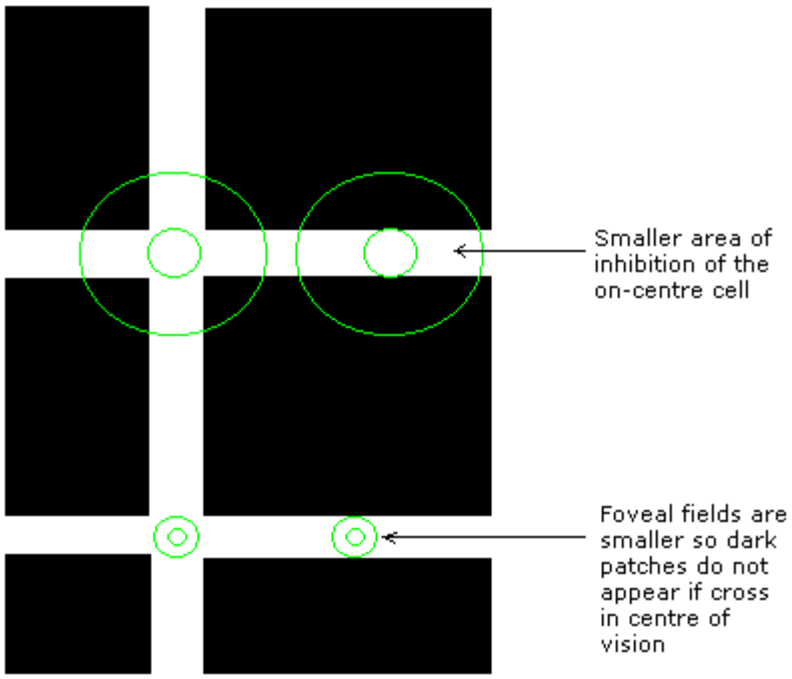
The structure of the response fields of ganglion cells is important in everyday processing and increases the definition of boundaries in the visual field. Sometimes it gives rise to effects that are not directly related to the physical content of the visual field. The most famous of these effects is the Hermann Illusion. The Hermann Grid Illusion is a set of black squares separated by white lines. Where the white lines cross it appears as if there are grey dots.

The Hermann Grid



The grey dots are due to the relative suppression of on-centre ganglion cells where the white lines cross. This is explained in the illustration below.

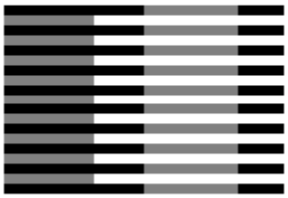
Centre-Surround and "illusions"



Notice how the grey dots disappear when the crossed white lines are at the centre of the visual field. This is due to way that ganglion cell fields are much smaller in the fovea.

There are many other retinal illusions. White's illusion is particularly strong and also due to centre-surround activity.

White's illusion



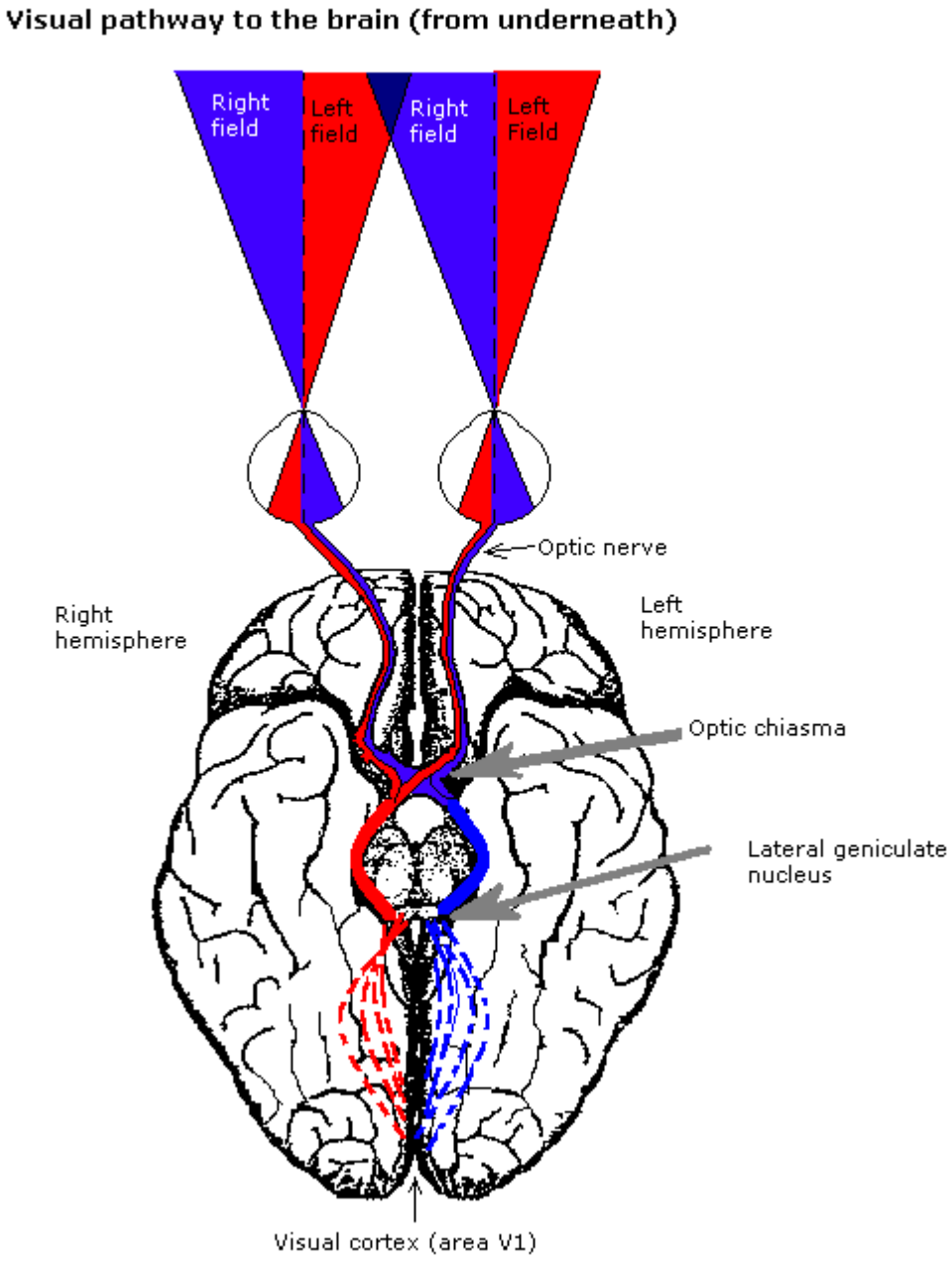
The grey lines really are the same shade of grey in the illustration. Mach's Illusion is another example of a centre-surround effect. Centre-surround effects can also occur with colour fields, red/green and yellow/blue contrasts having a similar effect to light/dark contrasts.

Lateral inhibition and the resultant centre-surround effect increases the number of cells that respond to boundaries and edges in the visual field. If it did not occur then small boundaries might be missed entirely if these fell on areas of the retina outside of the fovea. The result of this effect is everywhere in our normal visual phenomenal experience so not only is visual experience a mapping of 3D on to a 2D surface, it also contains shading and brightening at edges that will not be found by photometers that measure objective light intensities.

Photoreceptors become less responsive after continuous exposure to bright light. This gives rise to **afterimages**. Afterimages are usually of the opponent colour (white light gives a dark afterimage, yellow light gives a blue afterimage, red gives a green afterimage etc). Afterimages when the eyes are open are generally due to a lack of response to a particular frequency of light within the white light that bathes the retina.

It is clear that visual phenomenal experience is related more directly to the layout and type of activity in the retinal cells than to things in the visual field beyond the eye.

Visual pathways



The lateral geniculate nucleus

Retinal ganglion cells project to the Lateral Geniculate Nuclei which are small bumps on the back of the thalamus. (Only 10-15% of the input to the LGN comes from the retina, most (c.80%) comes from the visual cortex). The neurons in the LGN are arranged retinotopically so preserve the layout of events on the surface of the retina.

The LGN are arranged in 6 layers. The top two are known as Magnocellular layers (about 100,000 neurons with large cell bodies) and the bottom four are called Parvocellular layers (about 1,000,000 neurons with small cell bodies). Between the main layers are the Koniocellular layers that consist of large numbers of tiny neurons.

The left Lateral Geniculate Nucleus receives input from the right visual field and the right LGN receives input from the left visual field. Each nucleus receives input from both eyes but this input is segregated so that input from the eye on the same side goes to layers 1, 3, 5 and from the other side to layers 2,4, 6.

The magnocellular layers contain neurons that have a large receptive field, are sensitive to contrast, a transient reponse and are not colour sensitive. The parvocellular layers contains neurons that have small receptive fields, are colour sensitive, have a prolonged response and are less sensitive to contrast.

The LGN pathway from the retina is largely connected to the striate part of the visual cortex (cortical area V1) via a set of fibres called the optic radiation. There are reciprocal connections between the Thalamic Reticular Nucleus and the LGN. The LGN are also interconnected with the Superior Colliculus and brainstem.

The LGN may be involved in controlling which areas of the visual field are subjected to attention (O'Connor et al 2002).

The visual cortex

The input from the LGN goes mainly to area V1 of the cortex. The cortex is arranged in six layers and divided up into **columns**. Each column in the visual cortex corresponds to a particular area of the retina in one eye. The columns are arranged in rows called **hypercolumns**. Each column within a hypercolumn responds to a different orientation of an optical stimulus at a given location (so responds to edges/boundaries that are oriented in the visual field). Hypercolumns from each eye are arranged alternately and form a small block of cortex called a **pinwheel**. At the centre of each pinwheel are colour sensitive cells that are usually not orientation sensitive. These coincide with the "blobs" that are seen when visual cortex is viewed using cytochrome oxidase dependent stains. It is important to note that the "hypercolumns" merge into one another and respond to line stimuli that cover an area of retina so they may be physiological rather than anatomical entities.

The blind spot in each eye is represented by an area of visual cortex that only receives monocular input from the other eye (Tong & Engel 2001). The effect of the blind spot is illustrated below:

"Filling in" of the blind spot

Concentrate on the cross with the left eye whilst the right eye is closed, at some distances and tilts of the head the black circle disappears (similarly focussing on the black circle with the right eye can make the cross disappear).

When both eyes are used the cortical area representing the blind spot for the eye with the missing data is filled in with data from the other eye. When one eye is used the phenomenal experience contains the colour of the background.

Normally it seems that the blindspot is 'filled in' with background when one eye is used. However, Lou & Chen (2003) demonstrated that subjects could respond to quite complex figures in the blind spot, although how far they were investigating 'blindsight' rather than visual experience in the blind spot is difficult to determine.

Different layers in the visual cortex have outputs that go to different locations. Layer 6 sends nerve fibres to the Lateral Geniculate Nuclei and thalamus, layer 5 to superior colliculus and pons, layer 2 & 3 to other cortical areas.

There are two important outputs to other cortical areas, the **ventral stream** and the **dorsal stream**. The ventral stream processes colour, form and objects. It proceeds to the inferior (lower) temporal cortex. The dorsal stream processes motion, position and spatial relationships. It proceeds towards the parietal cortex. Lesions in the ventral stream can result in patients knowing where an object is located but being unable to enumerate its properties, on the other hand, lesions to the dorsal stream can result in patients being able to label an object but unable to tell exactly where it is located.

There is also a large output from the visual cortex back to the thalamus, this output contains more fibres than the thalamo-cortical input.

Depth perception

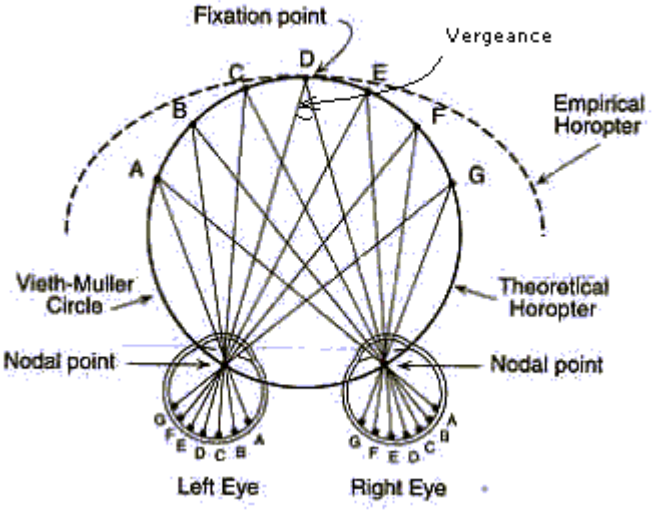
The world is three dimensional but the image on the back of the retinas is two dimensional. How does the brain give the subject a perception of depth?

Depth perception relies on **cues** which are data about the displacement of things relative to the body. These cues consist of:

- the convergence of the eyes

- the accommodation of the lens
- binocular disparity -the difference between the images on the retinas- this was first suggested by Wheatstone.
- motion parallax - distant objects move slower when the observer moves - first suggested by Helmholtz.
- optical flow - the rate of expansion/contraction of a scene with movement towards or away from it (Lee & Aronson 1974).
- binocular occlusion - parts of a scene are invisible to each eye.
- body motion provides cues about near objects.
- vanishing points - the convergence of parallel lines.
- numerous other cues such as size constancy, texture etc.

Binocular disparity has been most extensively studied as a source of depth cues. When the eyes converge to focus on an object in from of them there is very little disparity in the images of that object on the two retinas. The angle at the object formed between the lines that project back to the pupils is known as the **vergence** at the object. The sphere where all objects have



the same vergence is known as the **horopter**.

When the disparity between the retinas is small a single image occurs in phenomenal experience which is accompanied by a sensation of objects with depth. This is known as **stereopsis**. If the disparity between the retinas is large double vision ensues, this is known as **diplopia**. The curious feature of stereopsis is that we can see no more of the object than is visible on the retinas and certainly cannot see behind the object. Stereopsis is more like a stretching of 2D space than actual 3D.

In the review by Cutting and Vishton (1995) the contributions of each type of cue is discussed. Cutting and Vishton also present evidence that there are several zones of depth perception that are informed by different sets of cues. These are **personal space**, which is the zone of things within arms reach, **action space**, which is the zone in which we interact and where our motions have a large impact on the perceived layout, and **vista space** which is the zone beyond about 30m that is informed by long range cues.

The interesting feature of perceptual space is that it is not seen. The sides of a solid object appear as intrusions or lateral extensions in 2D space, when we close an eye that has access to the side of the object and then open it again the side grows out into 2D space. The lack of 'seeing' depth is also evident when we close one eye when looking at a vista - nothing seems to change even though stereopsis has gone. This leaves the problem of what it is that constitutes the 'feeling' of depth. We have feelings that we can fall into space or move into it or around in it. Depth seems to be defined by premotor modelling and the potential for occupancy by our bodies and limbs. As such it involves qualia that are different from those of vision and more akin to those that accompany movement, as an example, if you reach out to touch something, move the hand back, then consider the distance to the object it is evident that a feeling of the movement is still present. Is depth a quale of movement modelled during the extended present of perception?

References

- Cutting, J.E. & Vishton, P.M. (1995) Perceiving layout and knowing distances: The integration, relative potency, and contextual use of different information about depth. In W. Epstein & S. Rogers (eds.) Handbook of perception and cognition, Vol 5; Perception of space and motion. (pp. 69-117). San Diego, CA: Academic Press. http://pmvish.people.wm.edu/cutting&vishton1995.pdf

- Gregory, R.L. (1997). Knowledge in perception and illusion. From: Phil. Trans. R. Soc. Lond. B (1997) 352, 1121â€“1128. http://www.richardgregory.org/papers/knowl_illusion/knowledge-in-perception.pdf

- Hubel, D.H. (1981). EVOLUTION OF IDEAS ON THE PRIMARY VISUAL CORTEX, 1955-1978: A BIASED HISTORICAL ACCOUNT. http://nobelprize.org/medicine/laureates/1981/hubel-lecture.pdf

- Lou, L. & Chen, J. (2003). Attention and Blind-Spot Phenomenology. PSYCHE, 9(02), January 2003. http://psyche.cs.monash.edu.au/v9/psyche-9-02-lou.html

- O'Connor, D.H., Fukui, M.M., Pinsk, M.A. & Kastner, S. (2002). Attention modulates responses in the human lateral geniculate nucleus. Nature Neuroscience 5, 1203 - 1209 (2002). http://www.nature.com/neuro/journal/v5/n11/full/nn957.html#B34

- Tong, F., & Engel, S. A. (2001). Interocular rivalry revealed in the human cortical blind-spot representation. Nature, 411, 195-199. http://www.psy.vanderbilt.edu/tonglab/publications/Tong&Engel2001.pdf

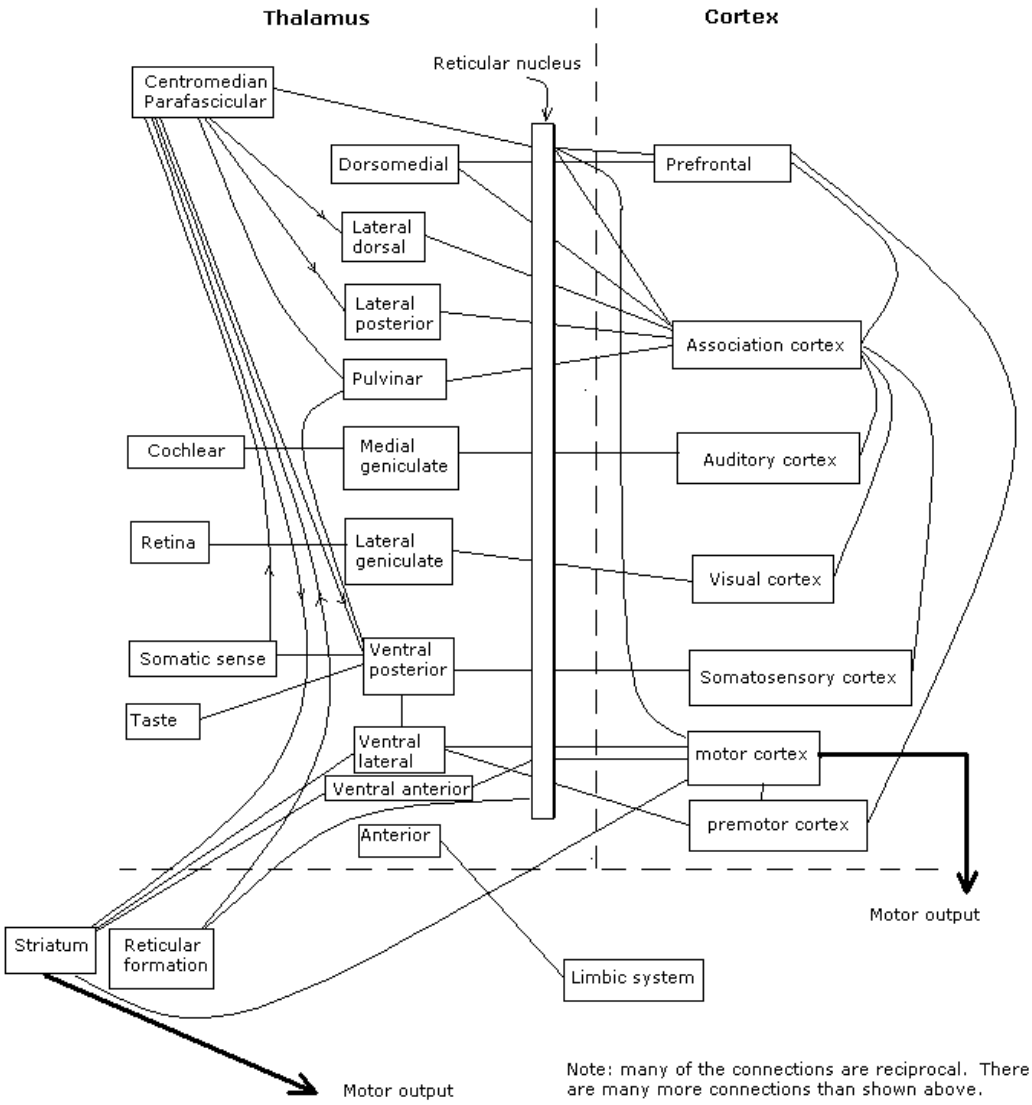
- Tong, F. (2003). PRIMARY VISUAL CORTEX AND VISUAL AWARENESS. Nature Reviews of Neuroscience. 4:219-229. http://www.psy.vanderbilt.edu/tonglab/publications/Tong_NRN2003.pdf

The Cortex and Thalamus

The cortex and consciousness

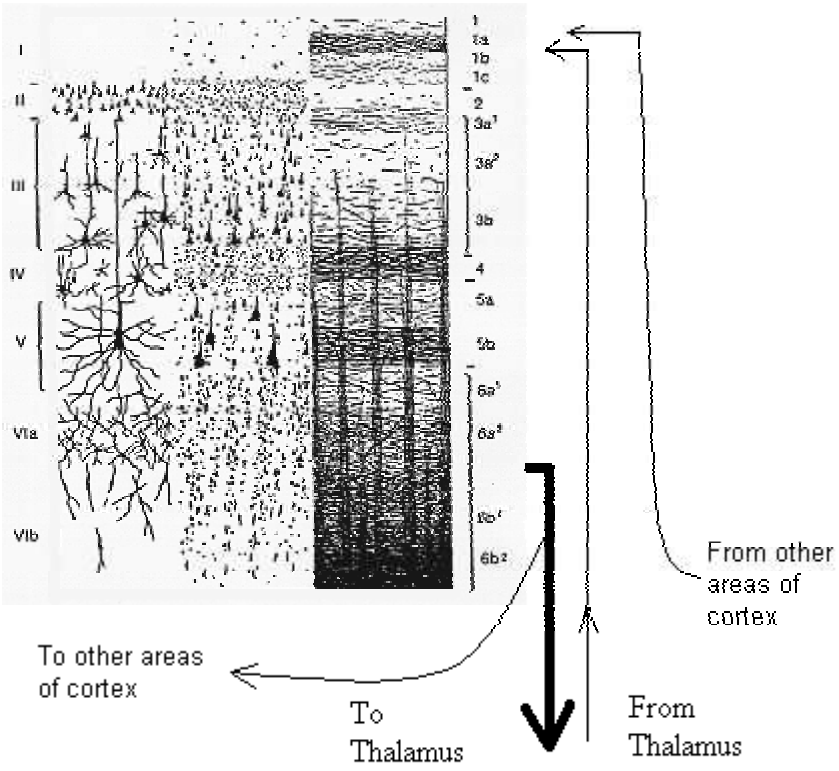
The cerebral cortex consists of a set of specialised areas that process different aspects of sensation and motor control. There are about ten times as many nerve fibres going from the cortex to the thalamus as there are from the thalamus to the cortex (Destexhe 2000).

The sensory processors of the diencephalon and telencephalon showing the two synergistic processor networks.



Histologically the cerebral cortex is a layer of greyish neurons overlying a huge mass of white nerve fibres, the cerebral medulla. The cortex consists of six main layers. The upper layers receive input from the relays in the thalamus such as the lateral geniculate, from the

thalamus in general and from other areas of cortex plus a few specialised inputs from other locations. The lower layers give rise to output fibres that largely connect with the thalamus and other areas of cortex although particular specialised processors in the cortex may also have direct connections elsewhere such as to motor nuclei.



The cerebral cortex has many functions and is divided up into numerous separate processors. The most important function of the cortex from the point of view of consciousness studies is that it creates models. These models are most easily experienced when there is a lack of sensory input such as in dreaming, day dreaming, lucid dreaming or experiencing imaginary speech (thinking). In ordinary waking life the modelling processes create a model of the world around us and within us based on sense data and associated data. This model consists of overlapping sounds, images, smells etc. and is a combination of perceptual fields from all the senses.

There is considerable evidence that the parts of the brain that deal with imagining (modelling) things are also the parts that deal with perception (ie: modelling the world). The overlap between imagination and normal perception is not complete because, as Tong(2003), in a review of visual consciousness, put it: "Internally generated experiences share some, but not all, of the phenomenal properties of actual perception". There is also considerable overlap between the areas used for imaginary speech (thought) and actual speech, areas dealing with the control of sensation and of the tongue etc. being used in actual speech but not in imagined speech (Fu et al 2002). Kreiman et al (2000) investigated the activity of single neurons in humans and also found that the brain activity evoked by visual imagination overlapped that which occurs upon direct stimulation by the same image.

Our conscious experience consists of the output of the cortical modelling processes. The cerebral cortex itself appears to be non-conscious. The evidence for the non-conscious nature of the cerebral cortex is reinforced by lesion studies that show that up to 60% of the cerebral cortex can be removed without abolishing consciousness. Either hemisphere can be removed or much of the front or back of the cerebral cortex can be cut off yet consciousness persists. The cerebral cortex is often assumed to be the "seat" of consciousness because this collection of organs is relatively large in humans but the truth seems to be that the cortex is a collection of processors that provide an input to experience. There is also a substantial amount of neurophysiological evidence that the cortex is non-conscious.

Libet et al (1967) found that there could be cerebral cortical activity in response to weak stimulation of the skin without any conscious awareness of the stimulus. This work provides a neurophysiological basis for subliminal (non-conscious) perception and also shows that large areas of the cerebral cortex can be active without conscious experience. The insensitivity of experience to cortical activity has been further confirmed by Libet et al (1979). They electrically stimulated the cerebral cortex of conscious patients and discovered that the stimulus must be continued for about 0.5 seconds for subjects to report a conscious experience of the stimulation. What is the cortex doing in the 0.5 seconds between the start of stimulation and the report of awareness of the stimulation? It is probably synchronising its various processors and creating a waking dream, a structured set of events that accounts for the activity.

The 'Attentional Blink' (Raymond et al 1992) is also consistent with the concept of the cerebral cortex being a device that creates models. In the 'Attentional Blink' the identification of an object impairs the identification of a second object that is presented within 0.5 seconds of the first. Raymond et al used a stream of letters (11 letters per second) and the identification of a first letter impaired the identification of a subsequent 'probe' letter in the stream. If the probe letter followed the first letter within about 180 msecs it could easily be identified, suggesting that chunks of about 180 msecs of data stream are modelled together. Christmann & Leuthold (2004) have theorised that the 'Attentional Blink' involves perceptual and central components of visual processing. This is supported by the fMRI studies of Marois et al (2004) who presented subjects with faces mounted on scenes of places. The scenes of places often went undetected by subjects but they activated regions of the medial temporal cortex involved in high-level scene representations, the parahippocampal place area (PPA). When the scenes of places were detected by the subjects there was activity in the frontal cortex and the PPA activity was increased. These experiments are consistent with the idea of a cerebral cortex that is a multiprocessor system that creates consistent models of the environment for presentation to some other part of the brain.

Bregman's (1990) auditory continuity illusion is another example of how sensory events are modelled. If a pure tone is followed by broadband noise and the noise followed by the same pure tone it seems as if the tone occurs throughout the period of noise. If the noise is not followed by the pure tone there is no sound of the tone during the period of noise. This effect is similar to the results found by Libet because a delay of several hundred milliseconds between sensory stimulation and conscious experience is needed to account for the apparent rewriting of history after the second tone appears.

The 0.5 second delay required for the cortex to model an event has implications for the role of conscious experience in the control of our lives. If experience is always 0.5 seconds behind

the true present instant then how can we be said to control anything? The brain must be acting automatically whilst performing most tasks. The 0.5 second delay also seems to contradict our everyday experience. We certainly feel like we are aware of things in less than 0.5 seconds, for example, the direct stimulation of sense organs seems to be experienced much more rapidly than the delayed experience of cortical stimulation. In fact subjects report that they are conscious of stimuli, such as being touched or seeing flashing lights, within 0.1 to 0.2 seconds of the event. So how can subjects report events within 0.2 seconds even though it seems to take 0.5 seconds for the cortex to generate activity that can be experienced? The simplest explanation is that the reaction occurs automatically within 0.2 seconds and then the conscious experience of this reaction occurs 0.3 seconds later. This gives a total 0.5 seconds delay before conscious experience whilst allowing fast reactions.

Libet et al extended their experiments by stimulating a "relay nucleus" in the thalamus that intercepts signals from the senses before they reach the somatosensory cortex. It was found that when this nucleus was stimulated for 0.5 seconds the subjects reported that the stimulus occurred 0.2 seconds after it had begun. When the nucleus was stimulated for less than 0.5 seconds the subjects did not report any sensation. This supports the concept of a 0.5 second delay whilst the cortex puts a stimulus in context before it is experienced.

These experiments show that our experience is an output of cortical processing rather than the processing itself. If our conscious experience is non-cortical then this raises the possibility that the non-conscious cerebral cortex can perform actions without conscious control. Of course, the cortex does this all the time when we are indulging in skilled or routine behaviour. The ability of the non-conscious cortex is quite remarkable; for instance car drivers sometimes discover that they have driven for several miles without conscious experience of driving, even at the level of having no recollection of the route.

Although it might be accepted that much of our everyday behaviour is automatic is there any behaviour that is definitely initiated by conscious experience? This is probably a pointless question because consciousness is about observation, not action; however, despite this there have been several experiments that have attempted to determine the relationship between consciousness and action.

In 1964 Kornhuber and Deecke performed a series of experiments that measured the electrical activity from the scalp (EEG) during voluntary actions. They averaged many EEG's from subjects who were about to move a finger and discovered that there is an increase in scalp potential before the movement takes place. The increase in potential can start as long as 2 seconds or so before the movement and is known as the "readiness potential" (Bereitschaftspotential). The readiness potential is strange because it seems to contradict our conscious experience; we do not decide to move a hand and then wait 2 seconds before the hand moves. It seems that the non-conscious brain may be taking things into its own hands.

Libet et al (1983) extended the readiness potential experiments by asking subjects to observe a Wundt clock whilst flexing a finger. The Wundt clock had a spot of light that moved around a circle every 2.56 seconds and allowed the subjects to obtain timings that were related to their mental experiences. When the subjects flexed a finger it was found that the readiness potential occurred about 0.5 seconds before the finger moved and the subjects reported they were going to move the finger about 0.2 seconds before the movement. This suggested that a subject's cerebral cortex was preparing for the movement about 0.3 seconds before the subject was conscious of this. Libet's experiments have been reproduced elsewhere (see Keller &

Heckhausen 1990). (It is important to note that the subjects in Libet's experiment were asked to wait until they felt the urge to move the finger.) These results are consistent with the idea of the cortex as a modelling system that constructs a consistent model of events to pass on to whatever mediates conscious experience.

Perception, Imagination, Memory and Dreams

Functional Magnetic Resonance Imaging (fMRI) has shown that similar areas of brain are used during perception involving the senses as during imagination (Tong 2003, Kosslyn and Thompson 2003). The phenomenal substrate of the mental images that occur in both modes of brain activity has not yet been found.

Ganis et al (2004) used fairly complex perceptual and imagination tasks that activated large areas of the brain, they found an overlap between the brain areas activated during perception and imagery. The principle areas that were different in the two tasks were found in the primary sensory areas of the visual cortex. Other areas in the visual cortex and activity in the rest of the brain showed a remarkable degree of overlap. The authors suggested that the differences in the activity of primary visual cortex may have been due to differences between the perceptual and imaginary stimuli such as speed of onset etc. The hippocampus was not activated.

It is intriguing that, contrary to object imagery, spatial imagery such as predicting when a cross on a screen would fall on an imaginary letter actually seems to inhibit activity in sensory visual cortex (Aleman et al). Both fMRI and blocking with transcranial magnetic stimulation (TMS) showed that the posterior parietal cortex was involved in the spatial imagery.

Imagery involving places and faces activates the place and face areas that are activated during perception (Ishai et al 2000).

The recall and recognition of things also seems to involve very similar brain areas to those used during perception. Wheeler and Buckner (2003) showed that areas involved in perception were also involved in the recall of the perceptual stimuli.

Recall causes activation of areas used in perception but also seems to use areas that may be particularly related to the process of recall iself, such as the left parietal cortex (Konishi et al 2000) (Brodmann's area 40/39). Frontal and parietal regions are involved in the recognition of whether stimuli have been experienced before.

Image generation during sleep seems to differ from that during imagination and recall. In particular it seems to involve a few well defined areas of cortex and considerable activation of the posterior thalamus.

Sleep studies have shown that people dream throughout sleep. However, dreams are more frequent during the REM (rapid eye movement) periods of sleep than the NREM (non-REM) periods. Dreams are reported after 70-95% of awakenings in REM sleep and 5-10% of awakenings in NREM sleep. REM dreams are more visual than NREM dreams which are more 'thoughtlike' (Solms 2000). Thoughtlike events (mentation) are reported after 43% of awakenings from NREM sleep.

Solms (1997) found that patients who had lesions in the parietal-temporo-occipital junction

reported a cessation of visual images in dreams. Solms also found that patients with lesions in the white matter inferior to the frontal horns of the lateral ventricles, in the ventromesial quadrant of the frontal lobes, also reported loss of dreaming. Loss of dreaming is also reported by leucotomised patients with frontal ventromesial damage. Damasio et. al. (1985) and Solms (1997) also reported that some patients with damage to the medial prefrontal cortex, the anterior cingulate cortex, and the basal forebrain became confused about what was real life and what was dreaming (waking dreams occurred).

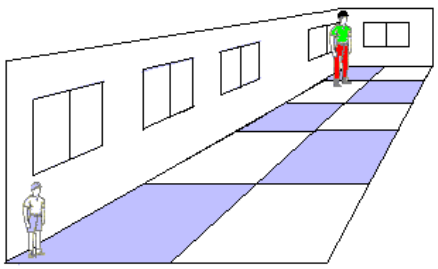
Studies using fMRI show that the sensory occipital lobe (BA 18) and posterior thalamus, especially the lateral geniculate nuclei, are activated in REM sleep, weaker activations of the posterior cingulate, putamen and midbrain were also found (Wehrle et al 2005, Loveblad et al 1999). These findings are consistent with activation of the ponto-geniculo-occipital system (PGO) during REM.

So dreams may be more like primary activations of sensory cortex than imagining or recall. This suggests that dreams have a thalamic origin or are managed via connections from the cortex through the thalamus to the visual cortex.

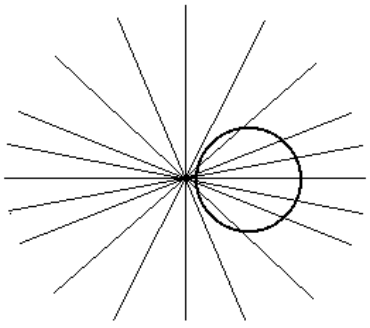
Hallucinations seem to differ from dreams. In Charles Bonnett Syndrome patients can have clear hallucinations. These, like imaginations, seem to involve areas of the visual cortex that deal with processed data, for instance hallucinations of faces activate the "face area" rather than visual cortical area V1 (ffytche et al 1998).

More about Models

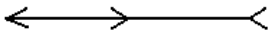
Our dreams are clearly models that form a 'dreamworld' but the idea that perception might be like a dream that is updated by sensation is not so obvious. Experience seems to be an active model of the world (virtual reality) based on sense data rather than a simple mapping of retinal and other sensory data. This is demonstrated by visual illusions such as the Ames Room, Spoke Illusion and Muller Lyer illusions shown below:



The little boy and the man are the same size on the page



The circle is symmetrical

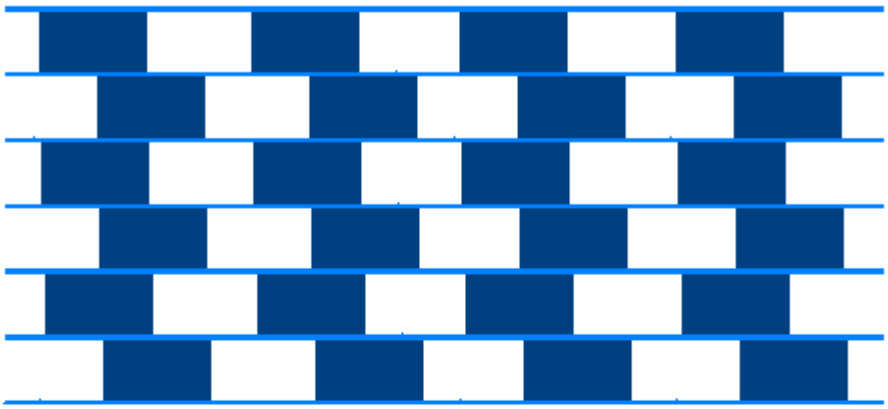


Muller Lyer: The two horizontal lines are the same length

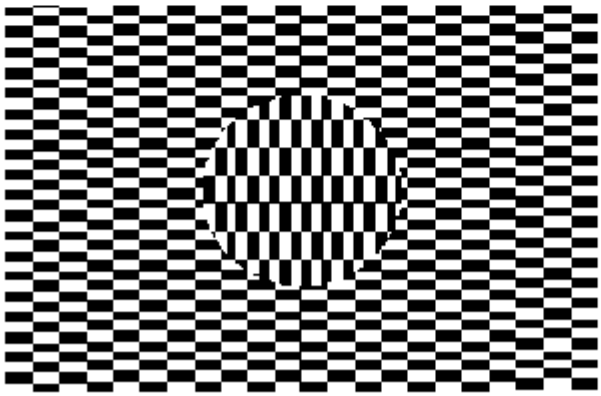
Notice how the circle is distorted without any distortion in the 'spokes', it is as if the circle has been treated as a separate object by the processes in the brain that rearranged it. In all of these illusions the brain has rearranged large areas of the visual field and has managed the input as

a collection of 'objects' that are manipulated separately. Even movement seems to occur in some figures showing that the brain models the position of things:

Cafe Wall Illusion



Ouchi's pattern



Stare at the central disk - does it move?

The creation of a model is also demonstrated by the illusion of movement experienced when we watch the cinema or television. This is due to the cortical modelling that is known as 'short-range apparent motion' rather than flicker fusion or persistence of vision. It is intriguing that, although it has been known for decades that the joining together of static images in our minds is due to modelling activity in the brain the myth that it is due to persistence of vision or flicker fusion is universal. As Anderson and Anderson (1993) noted:

> Indeed, in the past decade, psychoanalytic-Marxist film scholars have retained the model implied by persistence of vision: theirs is a passive viewer, a spectator who is "positioned," unwittingly "sutured" into the text, and victimized by excess ideology.

Our experience of the cinema is like a dream updated by sensation rather than sensation updated by interpretation. In fact the most compelling evidence for the modelling power of the brain is the existence of dreams; our dreams are often models of worlds that do not exist and involve little or no sensory input yet can involve effects as powerful as any television drama.

Short range apparent motion occurs when the interval between presentations of an object is brief (c. 50-100 msecs). Motion modelling in response to longer intervals is known as long range apparent motion. There is evidence that the modelling in short range apparent motion is enhanced if the moving patterns are similar to moving human forms (such as patterns of dots outlining a person)(Thornton et al 1998). The accuracy of predicting movement can actually improve if the interval between presentations is increased when human forms are used.

Motion modelling can also be seen in visual illusions such as the *Waterfall Illusion* (motion aftereffect). The waterfall illusion is commonly seen after viewing a sequence of scrolling credits on the television; when the credits stop rolling it appears as if they briefly move in the opposite direction. Tootel et al (1995) have used fMRI to show that this is correlated with activity in the motion modelling area of visual cortex (area MT/V5). The waterfall illusion is also associated with an intriguing aftereffect known as **storage of the motion aftereffect**. Normal motion aftereffects last for up to about ten seconds after the stimulus, however, if the subjects close their eyes for the normal duration of the aftereffect then reopen them they see the illusion for almost the normal duration. Culham et al (1999) used fMRI to show that activity in area MT/V5 was low during the period when the eyes were closed then increased dramatically when the eyes were opened. This is strongly suggestive of a modelling mechanism outside MT/V5 that has adapted to motion and then models stationary data with movement in the wrong direction.

Visual area MT/V5 is also involved in the separation of moving visual scenes into *sprites* or objects that move together as a whole within a scene (Muckli et al 2002).

The way that mental models may be the basis of ordinary reasoning was outlined by Johnson-Laird (1980), based on earlier work by Kenneth Craik.

Studies of 'change blindness' and 'inattentional blindness', where subjects fail to spot outrageous changes in their environment, also demonstrate that we experience a model and suggest that the brain must analyse an object to incorporate it fully into the model (See for instance Rensink (2000), Simons & Rensink (2005)).

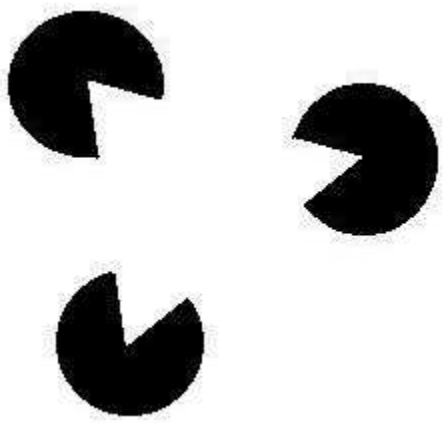
Blindsight

Blindsight studies illuminate the relationship between the cerebral cortex and our experience. When the visual cortex is removed subjects become almost totally blind. If the visual cortex on one side is removed subjects become relatively blind in the contra-lateral hemifield. One of the most revealing studies of blindsight is Marcel's 1998 paper: " Blindsight and shape perception: deficit of visual consciousness or visual function?".

It is useful when considering blindsight to contemplate for a while the appearance of the world with both eyes closed and then with one eye closed. When both eyes are closed our experience is of a darkish space radiating out from our heads, with one eye closed we tend to ignore the darkish areas that cannot be seen even though they are still present. Marcel notes

that patients who have a right blind field still have an underlying visual field on the right side and that this can even contain conscious visual experience. This sounds a bit like the darkish space that we all experience if deprived of visual input on one side. As Marcel says: "A question that naturally arises is whether the loss is a 'total' loss of visual consciousness in the blind field. It is often assumed to be so, especially by those who discuss blindsight without carefully reading the literature or working with the subjects. One can immediately respond negatively to the question.."

The consciousness of the completion of Kanizsa figures in blindsight patients is particularly indicative of the preservation of the field even though the content was largely missing. A Kanizsa figure is shown below:

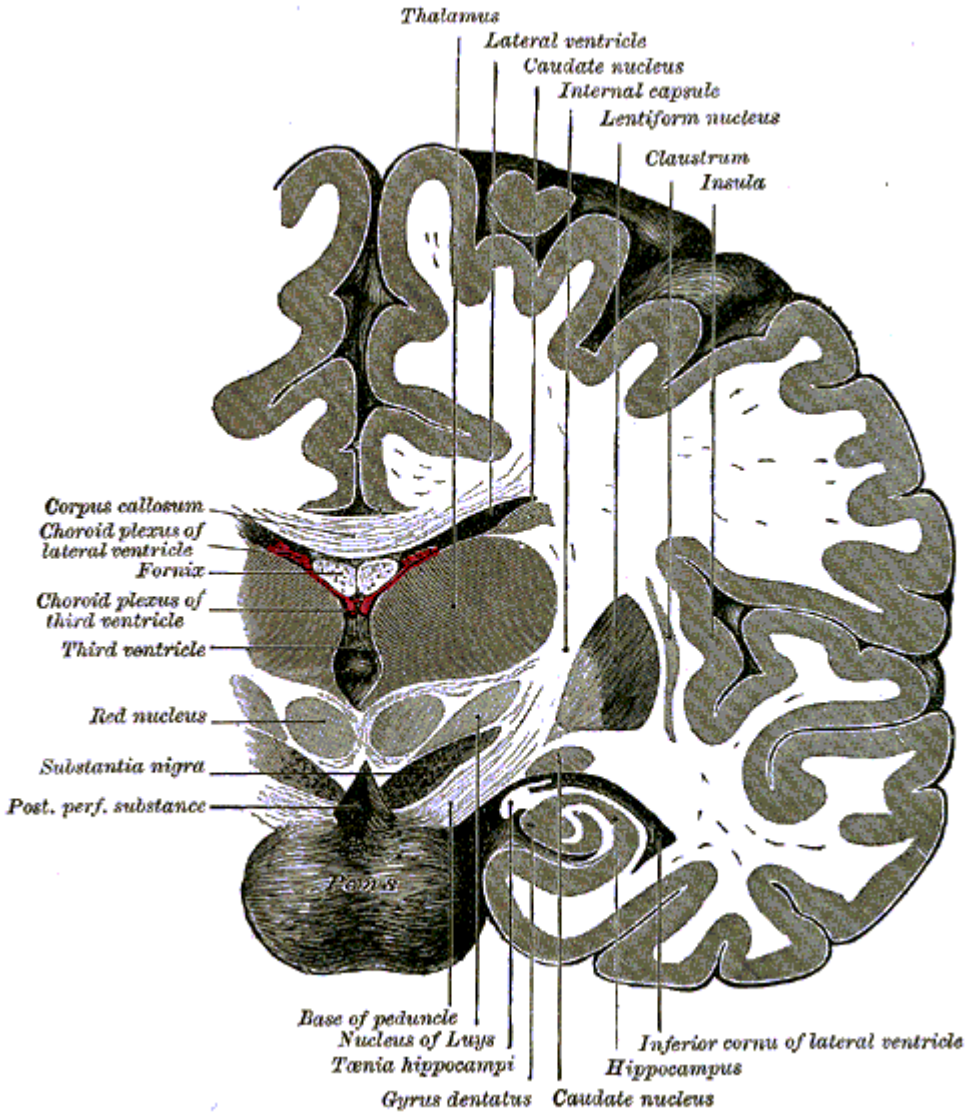


Blindsight patients can see the triangle completed in the blind field.

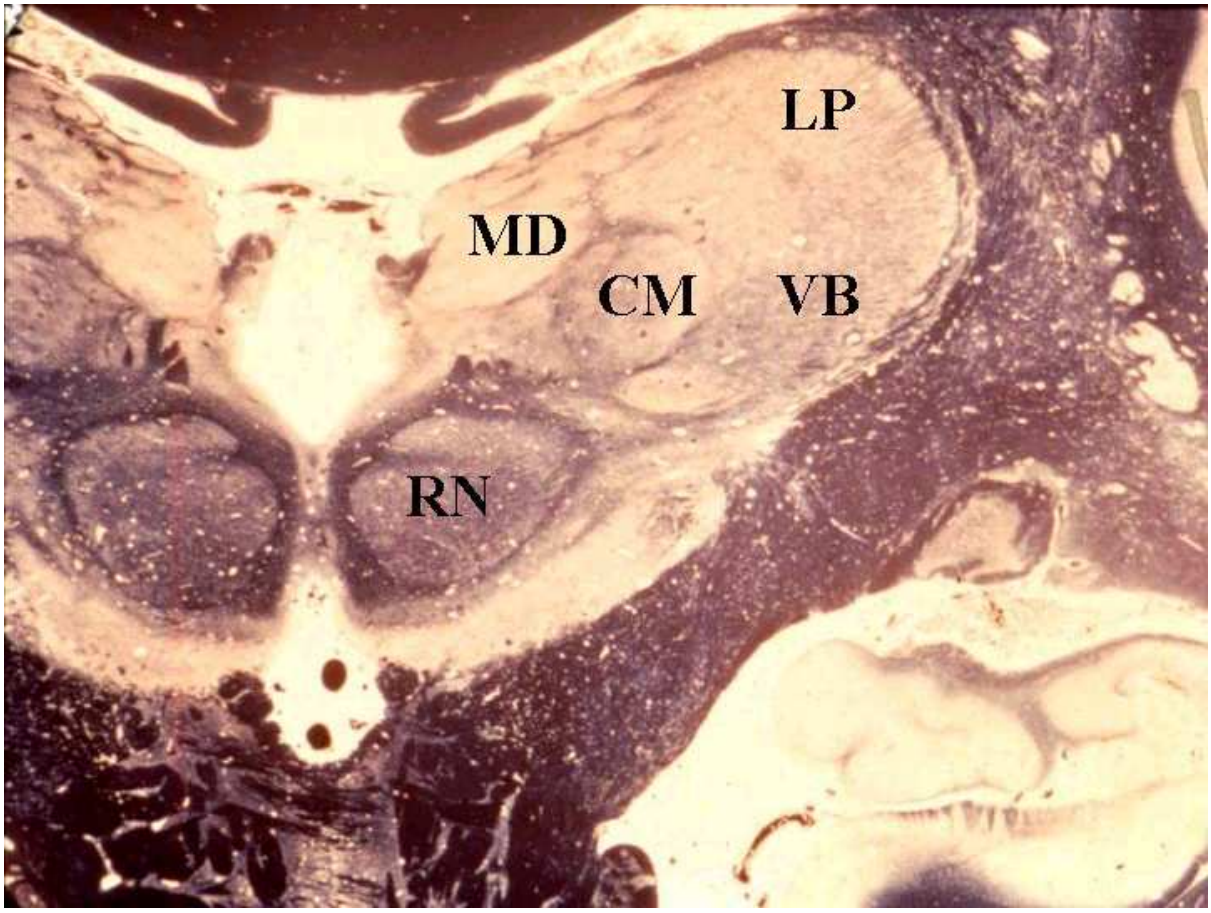
If we put Marcel's observations together with cortical anatomy and function it seems that the space of our experience is located outside of the cerebral cortex. The cortex generates much of visual and other content but it does not generate the space. A reasonable hypothesis is that the field of brain activity that is the space of our conscious experience is located in the sub-cortical brain. This space is loaded with the output of the cortex.

The Role of the Thalamus

The thalamus is connected to the entire bottom layer of the cerebral cortex. It is the nexus of the various cortical processors as well as a recipient of independent input from most of the rest of the brain.



The thalamus is subdivided into numerous small and medium sized nuclei that between them receive inputs from every process in the nervous system (the white fibres in the illustration above largely penetrate the thalamus). The thalamic nuclei are interconnected which means that any of them could, potentially host activity from anywhere in the body or brain. Although the founders of neurology such as Hughlings Jackson and Penfield & Jasper located conscious experience in the diencephalon, including the thalamus, this is no longer the conventional wisdom. The small size of the thalamic nuclei means that they cannot support the processes that are assumed to compose access consciousness, however, even some of the smallest thalamic nuclei host millions of synapses so size would not be an obstacle if the thalamus contains the substrate of phenomenal consciousness. Indeed, the diencephalon and the thalamus in particular can be shown to be excellent candidates for a possible location of phenomenal experience.



The Intralaminar Nuclei of the thalamus. The white space above and to the left of RN is the third ventricle. MD=mediodorsal nucleus. CM=Centromedian nucleus, RN=red nucleus (not part of thalamus) The black areas are stained white fibres. Picture from: http://www.neurophys.wisc.edu/ University of Wisconsin and Michigan State Comparative Mammalian Brain Collections. Preparation of image has been funded by the National Science Foundation, as well as by the National Institutes of Health. May only be used with these acknowledgements.

If the thalamus contains a location for conscious experience then lesions should abolish this experience. Unlike the cerebral hemispheres, lesions of the thalamus do indeed seem to abolish consciousness. The area that is most sensitive to lesions contains the Intralaminar Nuclei, especially the Parafascicular and Centromedian Nuclei. If these are damaged bilaterally patients suffer death, coma, akinetic mutism, hypersomnia, dementia and other equally serious impairments of consciousness that depend upon the size and placement of the

lesions (Bogen 1995, Schiff & Plum 1999). In cases of fatal familial insomnia, in which patients exhibit many of these symptoms, there is marked neuron loss in the Intralaminar Nuclei (Budka 1998). The symptoms of bilateral damage to the ILN are often so severe that it is possible that the patients cease to be conscious and are being coordinated by automatic cortical processes.

Laureys et al (2002) investigated recovery from 'persistent vegetative state' (wakefulness without awareness). They found that overall cortical metabolism remained almost constant during recovery but that the metabolism in the prefrontal and association cortices became correlated with thalamic ILN and precuneus activity. Again confirming that thalamo-cortico-thalamic activity is required for consciousness and that cortical activity by itself is not conscious. Yamamoto et al (2005) investigated persistent vegetative state and found that deep brain stimulation (25Hz) of the centromedian-parafascicular complex (19 cases) or mesencephalic reticular formation (2 cases) resulted in 8 of the patients emerging from persistent vegetative state.

As Bogen(1995) demonstrates, the ILN receive inputs, either directly or indirectly, from every part of the CNS but what do they do?

Interest in the thalamus has recently been revived by the theories of Newman & Baars (1993), Baars, Newman, & Taylor1998) and Crick & Koch (1990). In Baars, Newman and Taylors' (1998) theory it is suggested that "The brain stem-thalamocortical axis supports the state, but not the detailed contents of consciousness, which are produced by cortex". They also propose that the "nucleus reticularis thalami" (Thalamic Reticular Nucleus, TRN), which is a thin sheet of neurons that covers the thalamus, is involved in a selective attention system. This concept is reinforced by the way that point stimulation of the TRN causes focal activity in the overlying cortex (MacDonald et al 1998) and the way the TRN is organised topographically (ie: has activity that is like an electrical image of receptor fields).

The thalamus is ideally placed for integrating brain activity, if tiny parts of the thalamus are removed consciousness is abolished and the thalamus is involved in attention and the global integration of cortical activity. Any impartial judge might pronounce that the site of conscious experience has been found, possibly in the ILN of the thalamus, but no one can say how it works.

General Anaesthesia and the Thalamus

General anaesthesia should result in a profound depression of activity in the ILN if these are indeed the sites of the conscious state. White & Alkire (2003) administered halothane or isoflurane to volunteers and used positron emission tomography (PET) to monitor brain activity. They found severe depression of activity in the thalamus. The depression appeared to be higher in the non-specific nuclei than in the relay nuclei of the thalamus. In other words the anaesthesia is neither turning off the cortex nor turning off the input to the cortex but it is turning off an important part of the thalamus. Fiset et al (1999) have also demonstrated a similar pattern of medial thalamic inactivity and cortical activity in propofol anaesthesia. Suppression of cortical activity is not the cause of unconsciousness; for instance, the anaesthetic agent chloralose leads to increased neural activity in the cortex relative to conscious patients (Cariani 2000).

The function of consciousness

When we walk our conscious experience does not contain data about the control of the spinal, cerebellar and vestibular reflexes that keep us on an even keel. When we reach out for a cup our conscious experience only contains data related to the need for the cup, not data about the elaborate control system that enables the action. When we talk the words just come into mind, we do not painstakingly control the syntax and vocal chords. When our attention shifts the conscious experience containing the shift happens after the attention has shifted. This passive nature of experience recurs throughout the neuroscience of consciousness from the "readiness potential" to the "auditory continuity illusion". So what does conscious observation do? The medical evidence of the lack of consciousness in some forms of delirium, mutism, PVS etc. suggest that the role of conscious observation is to stabilise the brain so that it acts as a coordinated whole. Conscious observation is an orderly arrangement of events, a stable groundform that reflects the environment and composes the stage for action. It could be speculated that if quantum events were prominent in brain function then such a groundform would be essential but even a classical brain might require a stabilising form that could be continuously compared with the world beyond the body.

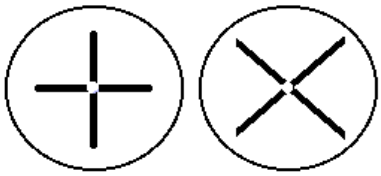
Rivalries, Synchronisation and Workspaces

Binocular Rivalry, Pattern Rivalry and Binocular Fusion

Sir Charles Wheatstone (1838) was the first scientist to systematically investigate binocular rivalry. Binocular rivalry occurs when different images are presented to the left and right eyes. The subject sees successively one image, a combined image and then the other image. The swapping of images can take a second or more. Binocular rivalry is of interest in consciousness research because the parts of the brain that contain the dominant image should also be those parts that are contributing to conscious experience. Binocular rivalry involves at least two components; the first switches from one image to a merged image and then to the other image and the second permits the view to be part of conscious experience.

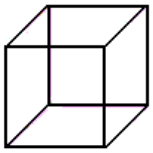
Bistable Percepts

Binocular Rivalry



In binocular rivalry experiments different images are presented to each eye. It is possible to get a feel for what this is like by looking at the circles above and crossing the eyes slightly so that the plus and cross overlie each other.

Pattern Rivalry



Necker Cube

Rubin face-vase

The switching of one image for another may involve selecting one of the images as the percept or selecting one of the eyes. Blake et al (1979) performed an experiment in which subjects could change the image at a given eye by pressing a button. When a particular image became dominant they pressed a button to change the image at the eye receiving the dominant image for the non-dominant image. They found that the subjects immediately experienced the second image as the dominant image. This suggests that binocular rivalry is selecting between eyes rather than images. Lehky in 1988 proposed that the switching may be occurring as a result of feedback between visual cortical area V1 and the Lateral Geniculate Nucleus (a thalamic relay - see Carandini et al 2002) and Blake in 1989 also proposed that the switching occurred at the level of area V1. (Visual cortical area V1 receives visual input direct from the LGN.)

Tong (2001) has argued that, in humans, the switching of images in binocular rivalry may occur at the earliest levels in the visual cortex. In particular, Tong and Engel (2001) used an elegant technique measuring the activity in the visual cortex that represents the blind spot of the eye to show that almost complete switching to the dominant image occurs at the level of visual cortical area V1. In support of this idea of switching at the level of V1 or even before the cortex, Kreimann et al (2001, 2002) used direct electrode recordings in human cortex and found that the activity of most neurons changed with the percept. Other experiments have not shown a single locus in the brain where the suppressed sensory information gets switched out

(Blake & Logothetis 2002, Leopold & Logothetis 1996, Gail et al., 2004).

Functional MRI has also shown cortical activity outside of sensory visual cortex related to both images in binocular rivalry. Lumer et al (1998) found that only the fronto-parietal areas of cortex switched with the percept, Fang & He (2005) found that activity relating to both suppressed and unsuppressed images were present in the dorsal stream of the visual system. Wunderlich et al (2005) and Haynes et al (2005) have both found suppression at the level of the lateral geniculate nucleus using fMRI in humans.

Pasley et al (2004) have shown that, even during suppression, fearful faces can produce activity in the amygdala (see Pessoa (2005) for a review).

Rivalry alternations seem to be the result of widespread activity changes that cover large parts of the brain, including but not necessarily originating at the earliest sensory stages of visual processing. Most investigators have found that, once switching has occurred, there are areas of the brain that contain activity that is solely related to the percept but this varies from most of the cortex to largely more frontal regions depending upon the study. The most likely explanation for binocular rivalry is that the switching occurs at the level of the LGN as a result of feedback from the cortex.

Pattern Rivalry is also of interest in consciousness research for the same reasons as binocular rivalry. In pattern rivalry a figure may have two or more forms that replace each other. Typical examples of such figures are the Necker cube and Rubin's face-vase. The similarity of the time course of the switching between percepts in binocular rivalry and pattern rivalry has led many authors to suggest that these involve the same mechanism. Logothetis et al (1996) used novel dichoptic stimuli (different images to each eyes) to produce a form of rivalry that seems to involve switching at levels in the cerebral cortex that are more distal to the sensory stimulus than V1. Leopold and Logothetis (1999), on the basis of their work with monkeys, state that "..many neurons throughout the visual system, both monocular and binocular, continue to respond to a stimulus even when it is perceptually suppressed.". Kleinschmidt et al (1998) investigated pattern rivalry with MRI and found activity in higher order visual areas during change of dominant pattern. Pettigrew (2001) also describes effects on rivalry due to thought and mood that may require involvement of large areas of cortex in the switching operation and stresses the way that V1 represents different visual fields in different hemispheres of the brain so that inter-hemispheric switching must also be considered.

It seems likely that the change of dominant pattern or percept is associated with higher level cortical activity but once the dominant percept is established many of the visually responsive neurons in the cortex are switched over to the new percept. This might account for the similarities in timing of binocular and pattern rivalry and the disparate results found by the various groups of authors. In the words of Kleinschmidt et al (1998):

"The transient activity fluctuations we found suggest that perceptual metastability elicited by ambiguous stimuli is associated with rapid redistributions of neural activity between separate specialized cortical and subcortical structures."

Which permits both the idea of selecting particular eyes or percepts, perhaps by feedback that switches a thalamic relay on the basis of cortical processing of patterns. Once the cortex has switched the thalamic relay most of the neurons in V1 would become exposed to the

dominant percept but there would still be a few neurons in the cortical visual system receiving data from the non dominant image.

The investigations of binocular and pattern rivalry provide evidence that conscious visual experience is probably distal to V1 (ie: cortex or thalamus).

Perceptual rivalry may be part of complex decision making rather than being simply a switch to blank out unwelcome input. It is clear from the Rubin face-vase that pattern rivalry is linked to recognition and would involve a complex delineation of forms within cortical processing. This would suggest that many areas of cortex should be involved before a particular percept is made dominant. Pettigrew (2001) argues that rivalry is the result of a complex phenomenon rather than being simply a switching event. Pettigrew's discovery that laughter abolishes rivalry also points to a complex cortical system for switching percepts. Pettigrew proposes that complex cortical processes control rivalry and that the actual switching of percepts is performed sub-cortically in the Ventral Tegmental Area. He concludes his review of the problem by noting that "Rivalry may thus reflect fundamental aspects of perceptual decision making.." Pettigrew (2001).

Another effect, known as "binocular fusion", provides further compelling evidence for the non-conscious nature of the cerebral cortex. In binocular fusion images from both eyes are fused together to create a single image in experience. Moutoussis and Zeki (2002) used a form of binocular fusion in which images of faces were flashed at 100ms intervals to both eyes simultaneously. When both eyes received images of the same colour the subject could see the faces but when one eye received a green image on a red background and the other a red image on a green background the subjects reported seeing a uniform yellow field that contained no faces.

fMRI scans of the subject's brains showed that when both eyes were exposed to images of the same colour the part of the brain that deals with faces was active and when each eye received images of different colours the same areas of brain showed activity. In other words the cortex contained strong activity related to faces whether or not faces were experienced. Moutoussis and Zeki found a similar effect when they used images of houses instead of images of faces. The authors concluded that: "The present study further suggests that there are no separate processing and perceptual areas but rather that the same cortical regions are involved in both the processing and, when certain levels of activation are reached and probably in combination with the activation of other areas as well, the generation of a conscious visual percept".

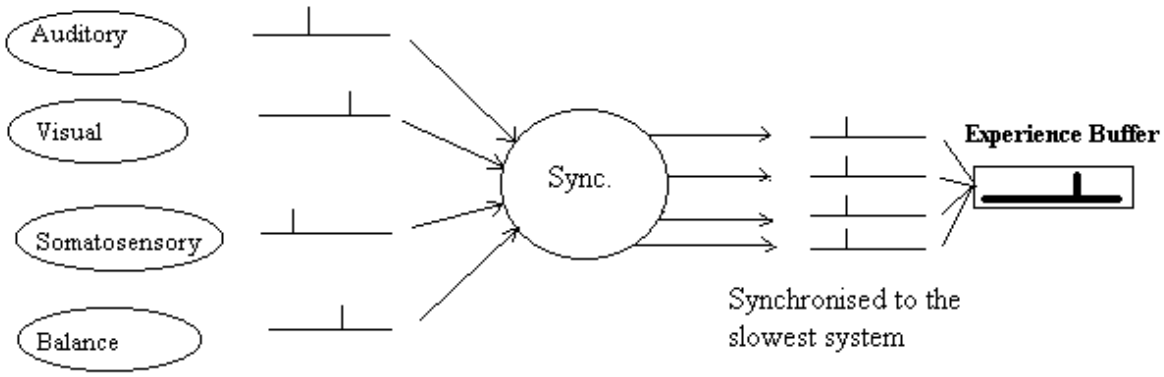
This conclusion does not seem to be supported by the data. There is no evidence that any area of cortex contains the percept itself. The experiment shows that the cortex contains data relating to both red and green faces which suggests that the cortex is not the site of the conscious percept. The percept is most likely distal to the cortex in the thalamus.

It is interesting that Fries et al (1997) found that neurons that were activated by the dominant image in binocular rivalry fired synchronously whereas those that were activated by the non-dominant image did not. Thalamocorticothalamic oscillations are the most likely source for synchronising neurons over whole areas of cortex, again suggesting that the conscious percept is located in the thalamus rather than the cortex.

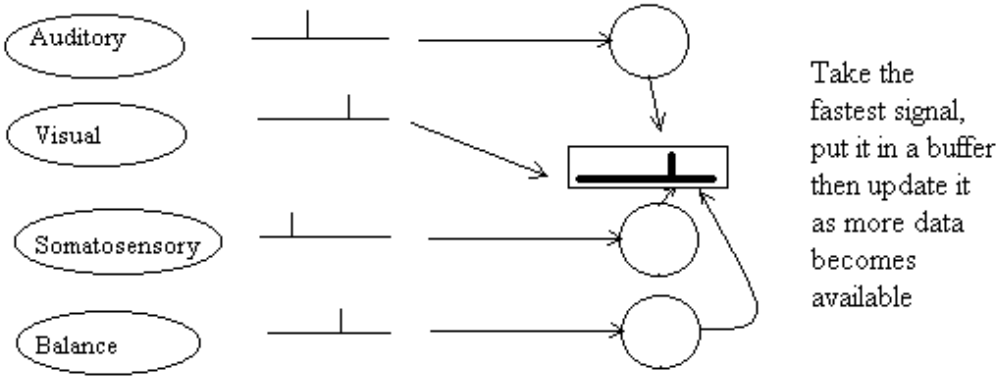
Synchronisation of Neural Processes

Our experience seems to contain entities with their attributes attached to them at the correct places in space and time. When a dog barks we see its jaws open at the same time as the bark and both jaws and bark are at the same location. We take this for granted but the brain must be engaging in some complex processing to achieve this synchronised and appropriately positioned set of objects and events. The illustration below shows the two basic processes that might be used to synchronise events between the different specialised processors in the cerebral cortex and brain in general.

Synchronising Multiple Processes - Experiencing a Stimulus



Option 1: Wait till all data has arrived then integrate it.



Option 2: Take the fastest then update it

These options are not exclusive: a mixture of 1 & 2 might occur.

In the first option a complete model of sensation, dream etc. may be created and then allowed to become part of conscious experience. In the second model events are released into experience as fast as possible but are synchronous when recalled, having been synchronised in a storage buffer. There is a third option in which there is no synchronisation of events so that the output from different processors would occur at different times.

The 'experience buffer' would be a volume of brain in which a succession of events could be recorded. The buffer might either be updated in steps, the previous content being discarded, or continuously updated with the oldest content being lost continuously.

In the first option events from different processes would always appear to be simultaneous unless the experience buffer were updated as a series of steps in which case any changes at around the moment of updating might appear in successive buffers. For instance, if change of position were processed before change in colour a circle on a screen that changed from green to red at the start of a motion might seem to be briefly green during the motion and then turn red.

In the second model events from different processors might appear asynchronous at the moment of experience but synchronous when recalled.

Colour vision and motion vision are processed in different parts of the visual cortex and in distinct parts of visual cortical areas V1 and V2. They are different processes and hence ideal for studying the synchronisation of cortical activity. Moutoussis and Zeki (1997) presented subjects with moving coloured squares on a computer screen that changed from red to green or vice versa as they changed direction of movement. It was found that subjects seemed to perceive changes in colour some 70-80 msecs before they perceived a change in the direction of motion of the squares. Further work by Arnold et al (2001) and Arnold and Clifford (2001) have confirmed that colour changes seem to be perceived before motion. Arnold and Clifford (2001) also found a quantitative relationship between the colour/motion asynchrony and the direction of change of motion, complete reversals of direction giving rise to the greatest asynchrony between the detection of colour and motion changes.

Moutoussis and Zeki (1997) conclude by stating that the asynchrony of neural processes shows that "..the perception of each attribute is solely the result of the activity in the specialised system involved in its processing..". It seems more likely that the experiments simply show that slow neural processes are not synchronised before they become percepts (the third option above). The experiments are excellent evidence for the concept of the cortex as a set of specialised processors that deliver their output asynchronously to some other place where the output becomes a percept.

These experiments on colour and motion suggest that there is no synchronisation between the processes that deal with these two aspects of vision. Another set of experiments by Clifford et al (2003) supports this idea of processing being asynchronous. They asked subjects to perform a variety of judgements of when visual events occurred and found that the degree of synchrony of one visual event with another depends on the type of judgement. Different judgements probably use processors in different areas of cortex and the output from these arrives asynchronously at the part of the brain that supports the percept.

When the percept is formed there must be feedback to the cortical processes that create its content. Otherwise it would not be possible to report about the percept and the cortex would be unable to direct processing to the percept in preference to other, non-conscious cortical data.

Although slow processes (20 milliseconds to 1 second) do not seem to be synchronised there is some evidence for very rapid synchronisation. Andrews et al (1996) revisited a problem raised by the famous physiologist Charles Sherrington. Sherrington considered the

phenomenon of 'flicker fusion' in which a flickering light appears to be a continuous steady light if it flashes on and off at frequencies of about 45 Hz or higher. He reasoned that if the images from both eyes are brought together to form a single image then the frequency at which a flickering light appears to be steady should depend on whether one or two eyes are used. Flicker fusion should occur if each eye receives alternate flashes at only half the normal flicker fusion frequency. The flicker should disappear if the left eye receives flashes at 23 pulses per second and the right eye receives alternate flashes at 23 pulses per second. When Sherrington performed the experiment he found that this was not the case, using approximate figures, each eye required 46 pulses per second for fusion to occur. Sherrington proposed that the flicker fusion in alternate binocular presentation was occurring "psychically", outside of normal physiological processes.

Andrews et al duplicated Sherrington's result but investigated it further. They found that when lights were flashed in each eye alternately at low frequences (2 Hz) the experience was the same as a light being flashed in both eyes at this rate. At frequencies of four Hz and higher the subjects began to report that the lights being flashed alternately in both eyes seemed to flicker at the same rate as lights being flashed in both eyes at half the frequency. It seemed as if a flash in one eye followed by a flash in the other eye was being perceived as a single flash or "conflated" as the authors put it. The authors explained this effect by suggesting that the brain activity corresponding to the flashes was sampled for a short period and any number of flashes occurring during this period became perceived as a single flash. The maximum rate of sampling would be about 45 Hz. This idea is similar to option (1) above, where the buffer is filled and emptied 40 - 50 times a second.

An experience buffer that is refreshed at 40-50 times a second might also explain the results obtained with colour and motion asynchrony because synchronisation between processes may well happen too quickly to affect processes that occur at very slow rates. Singer and Gray (1995), Singer (2001) have proposed that synchronisation between neurones at about 45Hz is the discriminator between those neurones with activity that contributes to conscious experience and activity in other neurones. A rapid refresh rate in a sychronising buffer agrees with the results found by Fries et al (1997) in which visual cortical neurones that represent a percept underwent synchronous oscillations in the gamma frequency range (39-63 Hz). Tononi et al (1998) have also found synchronisation of neural activity in neurones that represent the percept.

The gamma frequency oscillations are intrinsic to the cortex but are triggered by the thalamus and are part of the 'arousal system'. Readers should be wary of the term 'arousal system' because it evokes the idea of something waking up a conscious cortex. The cortex can be fully active during sleep and even during pathological unconsciousness such as persistent vegetative state so it is possible that the arousal centres themselves or nearby structures actually host phenomenal consciousness.

EEG and synchronisation

If electrodes are placed on the scalp varying electrical potentials of a few tens of microvolts can be recorded between the electrodes. Recordings of potentials from electrodes on the scalp are known as electroencephalograms (EEGs).

The potentials recorded in the EEG are due to postsynaptic potentials in nerve cells. The EEG

is insensitive to the activity of single cells and occurs as a result of relatively slow, **synchronised**, changes in large areas of cells. The differences in potential between two scalp electrodes are largely due to depolarisation and hyperpolarisation of the dendritic trees of cortical pyramidal cells. The folding of the cortex (gyri) is problematical for recording and interpreting EEGs because opposing layers of cortex can cancel any net potentials.

The EEG shows rhythmic activity. This is conventionally divided into the following frequency bands:

Delta waves 0-4 Hz

Theta waves 4-8 Hz

Alpha waves 8-12 Hz

Beta waves >10 Hz

Gamma waves (also called fast beta) 25-100 Hz

EEGs also contain short bursts of activity called spindles and very fast oscillations (VFOs). Spindles last for 1-2 seconds and contain rhythmic activity at 7-14 Hz. They are associated with the onset of sleep. The VFOs consist of short bursts at frequencies of over 80 Hz.

When the eyes are closed the amplitude of activity from most pairs of electrodes is increased compared with when the eyes are open. When subjects are awake the EEG consists mainly of alpha and beta activity with considerable low amplitude gamma when the eyes are open. In stage 1 sleep the EEG consists of theta waves, in stage 2 sleep of varied activity and spindles, in stage 4 sleep of delta and during REM sleep of beta and theta activity. In epileptic seizures there tends to be high amplitude activity with pronounced synchronisation between many pairs of electrodes.

The rhythmic electrical activity is due to cortical feeback loops, cortico-cortical synchronisation, thalamic pacemakers and thalamo-cortical synchronisation. VFOs have been attributed to the activity of electrical connections between cells (dendro-dendritic gap junctions) (Traub (2003)).

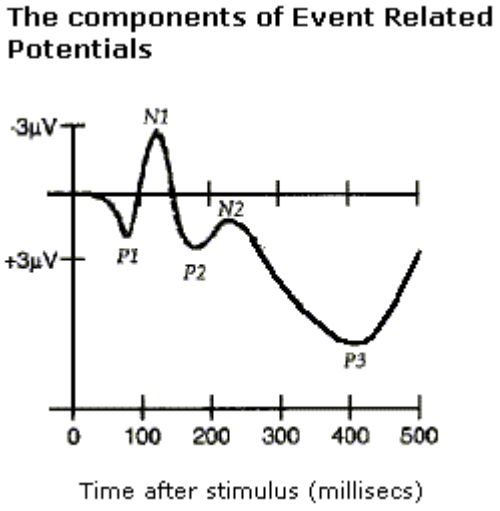
The gamma activity, centred on a frequency of 40 Hz appears to be related to activity in cortical interneurons that form electrical connections between their dendrites (Tamas et al 2000). These oscillations can be triggered by high frequency stimulation of the posterior intralaminar nuclei of the thalamus (Barth and MacDonald 1996, Sukov and Barth 2001) and as a result of activation of the reticular system (Munk et al 1996). This suggests that stimulation of cortex by thalamic sensory relays triggers gamma band activity in the cortex. A shift from gamma to beta waves can occur in human event related potentials after about 0.2 secs (Pantev 1995, Traub et al 1999).

The alpha activity is related to thalamic pacemakers, perhaps as a result of intrinsic oscillatory activity in thalamic sensory relays (see Roy & Prichep 2005 for a brief review). Theta activity, which occurs during some cognitive tasks and mental arithmetic involves a loop from the cortex to the non-specific thalamic nuclei. Delta activity seems to be endogenous to cortex when input is suppressed during sleep. Beta activity is due to cortico-cortical interactions, often after a brief period of gamma activation. It should be noted that

gamma and beta activity can be expressed as impulses in cortico-thalamic pathways and that when cortical and thalamic activity is correlated there is a conscious state. In other words gamma or beta waves in the cortex are not correlates of consciousness on their own - see for instance Laureys et al (2002).

Event related potentials

After a sudden event there are a characteristic set of changes in EEG activity known as **event related potentials** or ERPs. The time course of the ERP is shown in the diagram below.



ERPs occur in response to novel stimuli and are also produced by brief transcranial magnetic stimulation (TMS)(Iramina et al 2002). The slow component is known as the P3 or P300 phase of the ERP. It is due to activation of areas of the brain that are relatively remote from the primary sensory areas of brain.

Nieuwenhuis et al (2005) have reviewed the origin of the P300 ERP: "To summarize, convergent evidence suggests that P3-like activity can be recorded in several, widely separated brain areas. These include some medial temporal and subcortical structures (e.g., the hippocampal formation, amygdala, and thalamus), but these structures are unlikely to contribute directly to the scalp-recorded P3.". According to Nieuwenhuis et al (2005) the recorded P300 may be due to temporo-parietal and prefrontal cortical activity. Linden (2005) has also concluded that widespread, but specific, cortical activation is correlated with the recorded P300 ERP.

The generator of the P300 is still obscure. Nieuwenhuis et al (2005) consider that the Locus coeruleus, a nucleus in the pons that regulates task related attention and part of the sleep-wake cycle, may be responsible. In line with this, Mashour et al (2005) have discovered that TMS induced P300 activity is reduced in unconscious states.

Whether the P300 is related to Libet's 0.5 second delay is still obscure but the discovery that the P300 occurs in association with subliminal stimuli (stimuli that do not enter awareness)(Bernat et al 2001) suggests that it is associated with non-conscious cortical processing. Williams et al (2004), in an investigation of subliminal and supraliminal fear perception, found that "conscious fear perception was distinguished by a more prominent N4, peaking around 400 msec"; the N4 component follows the P300 component in the succession of phases of the ERP. Williams et al considered that the earlier phases in the ERP are probably related to non-conscious processing. In contrast Vogel et al (1998) found that suppression of the P300 was associated with suppression of awareness.

Global Workspace Theory

Global Workspace Theory is the idea that somewhere in the brain there is a facility that integrates the processes that occur in the various separate areas of the brain. The theory was first proposed by Descartes as the *sensus communis*, the common sense, but the modern form of the theory dispenses with the idea of a point soul looking at the brain. In modern Global Workspace theory it is proposed that an area of brain receives input from most of the cerebral cortex and provides integrative output that can solve problems across sensory and pre-motor modalities.

Modern Global Workspace Theory has been championed by Baars (1983, 1988).

There is increasing evidence for a Global Workspace or Global Workspaces in the brain. Much of this evidence comes from fMRI, single unit and magnetoencephalography studies in which it is shown that non-conscious or subliminal processing mainly occupies primary, sensory cortex whereas conscious processing occupies large areas of cerbral cortex.

In binocular rivalry the stimulus that is consciously perceived is responsible for relatively intense activation of large areas of brain whereas the non-conscious stimulus is often suppressed (see above and Sheinberg & Logothetis (1997), Tononi et al (1998)). The suppression is likely to occur in the Lateral Geniculate Nuclei which suggests a role for the Thalamic Reticular Nuclei, which modulate LGN activity, in the control of the percept.

Masking and visual awareness

Word masking has also been used to investigate the idea of a Global Workspace. When a word is presented on its own for a few tens of milliseconds it remains readable but if it is immediately succeeded by, or accompanied by, another word it becomes indistinct or invisible. This effect is known as "word masking". Vogel et al (1998) have investigated a version of word masking known as the "attentional blink". They found that when stimuli became invisible the P3 component of the Event Related Potential, which peaks at around 300-500 millisecs after a stimulus, was completely suppressed. The P3 component of the ERP has been related to the lodging of data in working memory and also to gamma band activity in the EEG. This strongly suggests the involvement of a cortico-thalamic loop in the "attentional blink". The delay of 0.3 to 0.5 secs is typical of the time required for conscious

awareness (see above).

Word masking in conjunction with fMRI and Event Related Potential (ERP) recordings has been used by Dehaene et al (2001) to expose control by a central mechanism. It was found that masked words activate mainly the visual cortex and ventral stream (inferior temporal lobe) whereas visible words also activated distant parietal, prefrontal and cingulate sites.

Dehaene et al (2003) and found that the dynamics of the loss of visibility of words in an attentional blink experiment could be modelled by a simulated cortico-thalamic loop. In their simulation a distributed cortical process determined which events would receive attention and the system used the thalamic gating systems to exclude those that did not receive attention.

Tse et al (2005) have used purely visual stimuli in masking experiments and concluded that, in the case of purely visual stimuli, the neural correlates of awareness were limited to the occipital cortex:

"We suggest that there are both lower and upper bounds within the visual hierarchy for the processing of visual masking and the maintenance of visual awareness of simple unattended targets; the lower bound is at least as high as the border between V2 and V3, and the upper bound is within the occipital lobe, possibly somewhere downstream of V4."

This discovery would mean that activation of large areas of cortex are unnecessary for awareness.

Attention and the global workspace

Baars (2002) in his review of evidence for the Global Workspace Theory quotes many other experiments that show activation of larger areas of cortex in response to conscious stimuli compared with unconscious or subliminal stimuli.The effect is also seen in change blindness, learning and attention. Newman and Baars (1993) consider that the "workspace" is fairly global in the brain:

"This Neural Global Workspace (NGW) model views conscious processes in terms of a globally integrative brain system. The neural circuitry contributing to this system is not only widely distributed across the neocortex, but includes key corticothalamic and midbrain circuits as well. These cortico-subcortical circuits are hypothesized to be critical to understanding the mechanisms of attentional control that provide an essential basis for the conscious processing of information".

However they focus particularly on the role of the thalamic Reticular Nucleus and cortico-thalamic connectivity in the control of attention.

Other ideas for the location of the Global Workspace are the idea of Singer et al. that gamma synchrony controls access to the content of consciousness and Llinas et al. (1998) that the thalamus is the hub through which communication occurs between areas of cortex.

One of the problems with Global Workspace theory is that it suggests that attention, working memory, cognitive control and consciousness may all be in the same area of the brain. It is likely that the mechanisms of attention, working memory, and cognitive control may involve several, interlinked systems perhaps co-opting the basal ganglia in the process. In view of this Maia and Cleeremans (2005) propose that ".. attention, working memory, cognitive control

and consciousness are not distinct functions implemented by separate brain systems. Attempting to find separate neural correlates for each may therefore be the wrong approach. Instead, we suggest that they should be understood in terms of the dynamics of global competition, with biasing from PFC (prefrontal cortex).". The inclusion by Maia and Cleeremans of consciousness with distributed attention, working memory and cognitive control is reminiscent of Zeki & Bartel's idea of microconsciousness.

It should be noted that, in common with Libet's data, the percept seems to be available to phenomenal consciousness some 0.3 to 0.5 secs after a stimulus; this suggests that whatever determines the content of phenomenal consciousness operates before events become part of phenomenal consciousness. This relegates phenomenal consciousness from being a controller of attention to being the recipient of content that is the subject of attention. This finding is consistent with the philosophical problem of the **apparently** epiphenomenal nature of phenomenal consciousness.

Given the data on the timing of conscious awareness it seems that there may be two "workspaces", an active workspace that models the world, discarding and suppressing data during rivalry, and a passive workspace that receives the final, edited product. The active workspace would correlate with the cortical systems stressed by Dehaene et al and Maia and Cleermans although, given the results of Tse et al., the workspace would be limited to small zones of cortex. The loading of the passive workspace with the output of the active workspace would correlate with thalamo-cortical activity during component P3 of the ERP in which data is transferred from the cortex to the thalamus. This workspace might constitute the source for reports of the content of phenomenal consciousness.

Llinas et al (1998) have proposed two parallel cortico-thalamic attentional systems, one of which is related to the thalamic specific nuclei and the other to the thalamic non-specific nuclei, especially the ILN. The non-specific system would be related to consciousness itself.

Bibliography

Defining the States of Consciousness. Tassi, P., Muzet, A. (2001) Neuroscience and Behavioural Reviews 25(2001) 175-191.

Neuroanatomy: "Digital Slice of Life" by Stensaas and Millhouse

http://medlib.med.utah.edu/kw/sol/sss/subj2.html

See also: http://medlib.med.utah.edu/kw/sol/sss/index.html

EEG's: Coles, M.G.H., Rugg, M.D. Event Related Brain Potentials: An Introduction.

http://whalen.psych.udel.edu/667/1.What_is_ERP/ColesRugg1995chpt1.pdf

Visual System: Tong, F. (2002). Primary Visual Cortex and Visual Awareness. Nature Reviews Neuroscience 4, 219 (2003)

http://www.psy.vanderbilt.edu/tonglab/publications/Tong_NRN2003.pdf

Professor Bogen's Consciousness Page

http://www.its.caltech.edu/~jbogen/text/toccons.htm

Demonstrations of Auditory Illusions and Tricks. Yoshitaka Nakajima

http://www.kyushu-id.ac.jp/~ynhome/ENG/Demo/illusions2nd.html

[edit]

References

- Aleman, A., Ramsey, N., Van Honk, J.E., Kessels, R.P.C., Hoogduin, J., Schutter, D.L.G., Postma, A., Kahn, R.S., De Haan, E.H.F. (submitted). Parietal cortex mediates visuospatial imagery: evidence from fMRI and rTMS. http://igitur-archive.library.uu.nl/dissertations/1954455/c10.pdf

- Alkire, M.T., Haier, R.J., Fallon, J.H., and Barker, S.J.(1996). PET imaging of conscious and unconscious verbal memory. Journal of Consciousness Studies, 3 (5-6) 1996 , pp. 448-462 http://www.imprint.co.uk/jcs_3_5-6.html

- Anderson, J. & Anderson, B. (1993). "The Myth of Persistence of Vision Revisited," Journal of Film and Video, Vol. 45, No. 1 (Spring 1993): 3-12. http://www.uca.edu/org/ccsmi/ccsmi/classicwork/Myth%20Revisited.htm

- Andrews, T.J., White, L.E., Binder, D. & Purves, D. (1996). Temporal events in cyclopean vision. Proc. Natl. Acad. Sci. USA Vol. 93, pp. 3689-3692, April 1996. Neurobiology. http://www.dur.ac.uk/tim.andrews/PNAS_93_3689.pdf

- Arnold, D.H., Clifford, C.W.G. (2001) Determinants of asynchronous processing in vision. Proceedings of the Royal Society of London, Series B: Biological Sciences, 269, 579 - 583. http://www.psych.usyd.edu.au/staff/colinc/Reprints/AC02.pdf

- Arnold, D.H., Clifford, C.W.G, Wenderoth, P. (2001). Asynchronous processing in vision: Color leads motion. Current Biology, 11, 596 - 600. http://www.psych.usyd.edu.au/staff/colinc/Reprints/ACW01.pdf

- Baars, B.J. (1983) Conscious contents provide the nervous system with coherent, global information. In Consciousness and Self-Regulation (Vol 3). Davidson, R.J. et al., editors. Plenum Press.

- Baars, B.J. (1988) A Cognitive Theory of Consciousness, Cambridge University Press.

- Baars, B., Newman, J., & Taylor, J. (1998) Neuronal mechanisms of consciousness: A Relational Global Workspace framework., in Hameroff, Stuart and Kaszniak, Al and Laukes, James, Eds. Toward a Science of Consciousness II: The second Tucson discussions and debates., chapter 24, pages 269-278. MIT Press. http://cogprints.ecs.soton.ac.uk/archive/00000946/

- Baars, B.J. (2002) The conscious access hypothesis: origins and recent evidence. Trends in Cognitive Sciences. Vol 6, No 1, 47-52. 2002. http://www.cs.memphis.edu/~wrcm/BaarsTICS2002.pdf

- Barth, D. S. and MacDonald, K. D. (1996) Thalamic modulation of high-frequency oscillating potentials in auditory cortex. Nature. 383, 78-81.
- Bernat E, Shevrin H, Snodgrass M. (2001). Subliminal visual oddball stimuli evoke a P300 component. Clin Neurophysiol. 2001 Jan;112(1):159-71.
- Blake, R., Westendorf, D. and Overton, R. (1979) What is suppressed during binocular rivalry? Perception 9: 223-231.
- Blake, R. and Lee, S.-H. (1999). Rival ideas about binocular rivalry. Vision Research. 39: 1447-1454 http://www.psy.vanderbilt.edu/faculty/blake/PDFs/Lee_Blake_99VR.pdf
- Bogen, J.E. (1995). On the neurophysiology of consciousness: I. An overview. Consciousness and Cognition, 4, 52-62. http://www.its.caltech.edu/~jbogen/text/bogen-95.pdf
- Bogen, J.E. (1995). On the neurophysiology of consciousness: Part II. Constraining the semantic problem. Consciousness and Cognition, 4, 137-158. http://www.its.caltech.edu/~jbogen/text/concog95.htm
- Bregman, A.S. (1990). Auditory scene analysis: The perceptual organization of sound. Cambridge, MA: MIT Press.
- Budka, H. (1998). Fatal Familial Insomnia Around the World. Brain Pathology, 8: 553-570. http://brainpath.medsch.ucla.edu/pdfs/0803pdf/budka.pdf
- Carandini M, Heeger DJ, & Senn W, (2002). A synaptic explanation of suppression in visual cortex, Journal of Neuroscience, 22:10053-10065, 2002. http://www.cns.nyu.edu/~david/ftp/reprints/Carandini-JNeurosci2002.pdf
- Cariani, P. (2000). Anesthesia, Neural Information Processing, And Conscious Awareness. Consciousness And Cognition Vol. 9, No. 3, September 2000 p. 387-395
- Castro-Alamancos, M.A., Connors, B.W. (1997). Thalamo-cortical synapses. Progress in Neurobiology, Vol.51, pp. 581 to 606, 1997 http://neurobio.drexel.edu/castroweb/progneurobio1.pdf
- Christmann, C. & Leuthold, H. (2004). The Quarterly Journal of Experimental Psychology: Section A. Volume 57, Number 2 / February 2004. 357-381.
- Clifford, C.W.G., Arnold, D.H., Pearson, J. (2003). A paradox of temporal perception revealed by a stimulus oscillating in colour and orientation. Vision Research 43 (2003) 2245-2253. http://www.psych.usyd.edu.au/staff/colinc/Reprints/CAP03.pdf
- Crick, F and Koch, C.(1990). Towards a neurobiological theory of consciousness Seminars in the Neurosciences (1990) 2, 263-275
- Crick, F and Koch, C.(1998). Consciousness and Neuroscience. Cerebral Cortex, 8:97-107, 1998 http://www.klab.caltech.edu/~koch/crick-koch-cc-97.html

- Culham, J.C., Dukelow, S.P., Vilis, T., Hassard, F.A., Gati, J.S., Menon, R.S. and Goodale, M.A. (1999). Recovery of fMRI Activation in Motion Area MT Following Storage of the Motion Aftereffect. The Journal of Neurophysiology Vol. 81 No. 1 January 1999, pp. 388-393. http://jn.physiology.org/cgi/content/full/81/1/388

- Deecke, L. (1996) Planning, preparation, execution, and imagery of volitional action, (Introduction / Editorial) in: L. Deecke W. Lang, A. Berthoz (Eds) Mental Representations of Motor Acts. Cognitive Brain Res 3 / Special Issue (2) 59-64. http://cogprints.ecs.soton.ac.uk/archive/00000015/00/COGBRAIN.html

- Dehaene, S., Sergent, C., and Changeux, J. (2003) A neuronal network model linking subjective reports and objective physiological data during conscious perception. PNAS July 8, 2003 vol. 100 no. 14 http://www.unicog.org/publications/DehaeneSergentChangeux_BlinkModel_PNAS2003.pdf

- Dehaene, S. et al. (2001) Cerebral mechanisms of word masking and unconscious repetition priming. Nat. Neurosci, 4, 752-758. http://www.unicog.org/publications/Dehaene_MaskedWords_NatureNeuroscience2001.pdf

- Destexhe, A. (2000). Modelling corticothalamic feedback and the gating of the thalamus by the cerebral cortex. J. Physiol (Paris), 94 (2000) 391-410. http://cns.iaf.cnrs-gif.fr/files/Brem2000.pdf

- Fang, F. & He, S. (2005).Cortical responses to invisible objects in the human dorsal and ventral pathways. Nat Neurosci. 2005 Oct;8(10):1380-5. Epub 2005 Sep 4.

- Ffytche, D. H., Howard, R. J., Brammer, M. J., David, A., Woodruff, P., & Williams, S. (1998). The anatomy of conscious vision: an fMRI study of visual hallucinations. Nature Neuroscience, 1, 738â€“742.

- Fiset, P., Paus, T., Daloze, T., Plourde, G., Meuret, P., Bonhomme, V., Hajj-Ali, N., Backman, S.B., and Evans, A.C. (1999). Brain Mechanisms of Propofol-Induced Loss of Consciousness in Humans: a Positron Emission Tomographic Study. The Journal of Neuroscience, July 1, 1999, 19(13):5506-5513. http://www.jneurosci.org/cgi/content/full/19/13/5506

- Fu, C.H.Y., Morgan, K., Suckling, J., Williams, S.C.R., Andrew, C., Vythelingum, G.N., McGuire, P.K. (2002). A Functional Magnetic Resonance Imaging Study of Overt Letter Verbal Fluency Using a Clustered Acquisition Sequence: Greater Anterior Cingulate Activation with Increased Task Demand. NeuroImage 17, 871-879 (2002) http://www-bmu.psychiatry.cam.ac.uk/PUBLICATION_STORE/fu02fun.pdf

- Ganis, G., Thomson, W.L. and Kosslyn, S.M. (2004). Brain areas underlying visual mental imagery and visual perception: an fMRI study. Cognitive Brain Research 20 (2004) 226â€“241 http://www.wjh.harvard.edu/~kwn/Kosslyn_pdfs/2004Ganis_CogBrainRes20_BrainAreas.pdf

- Hultin, L. (1997). On Neuromagnetic Assessment of the Contingent Negative Variation. http://www2.lib.chalmers.se/cth/diss/doc/9697/HultinLeif.html

- Fries, P.. Roelfsema, P.R., Engel, A.K., KÃ¶nig, P. and Singer, W. (1997). Synchronization of oscillatory responses in visual cortex correlates with perception in interocular rivalry. Proc. Natl. Acad. Sci. USA, Vol. 94, pp. 12699-12704, November 1997. http://www.pnas.org/cgi/content/full/94/23/12699

- Fuentealba, P., Crochet, S., Timofeev, I., Bazhenov, M., Sejnowski, T.J. and Steriade, M. (2004). European Journal of Neuroscience 20(1):111-119. http://www.theses.ulaval.ca/2004/22126/ch03.html

- Goaillard, J. & Vincent, P. (2002). Serotonin suppresses the slow afterhyperpolarization in rat intralaminar and midline thalamic neurones by activating 5-HT7 receptors. Journal of Physiology (2002), 541.2, pp. 453-465 http://jp.physoc.org/cgi/content/full/541/2/453

- Haynes, J., Deichmann, R. and Rees, G. (2005). Eye-specific effects of binocular rivalry in the human lateral geniculate nucleus. Nature 438, 496-499 (24 November 2005)

- Hughes S.W., Blethyn K.L. , Cope D.W. , & Crunelli V. (2003). Properties and origin of spikelets in thalamocortical neurones in vitro. Neuroscience. 2002;110(3):395-401

- Iramina, K., Maeno, T., Kowatari, Y. and Ueno, S.. (2002). Effects of Transcranial Magnetic Stimulation on EEG Activity .IEEE TRANSACTIONS ON MAGNETICS, VOL. 38, NO. 5, SEPTEMBER 2002

- Ishai, A., Ungerleider, L.G., Haxby, J.V.. (2000) Distributed neural systems for the generation of visual images. Neuron 28, 979-990.

- Johnson-Laird, P. N. (1980). Mental models in cognitive science. Cognitive Science, 4, 71-115. http://cognitrn.psych.indiana.edu/rgoldsto/cogsci/classics.html

- Keller, J. & Heckhausen, H. (1990). Readiness potentials preceding spontaneous motor acts: voluntary vs. involuntary control. Electroencephalography and Clinical Neuropsycholgy, 76, 351-361.

- King, C.C. (1991). Fractal and Chaotic Dynamics in Nervous Systems. Progress in Neurobiology, 36, pp. 279-308, 1991. http://citeseer.nj.nec.com/king91fractal.html

- Klein, S. (2002). Libet's Timing of Mental Events: Commentary on the Commentaries. Consciousness and Cognition. 11, 326-333. http://cornea.berkeley.edu/pubs/ccog_2002_0580-Klein-Commentary_on_the_commentaries.pdf

- Kleinschmidt, A., Bichel, C. Zeki, S. and Frackowiak, R.S.J. (1998). Human brain activity during spontaneously reversing perception of ambiguous figures. Proc R Soc Lond B Biol Sci. 1998 Dec 22;265(1413):2427-33

- Konishi, S., Wheeler, M.E., Donaldson, D.I., Buckner, R.L.. (2000) Neural correlates

of episodic retrieval success. NeuroImage: 12: 276-286.

- Kornhuber HH, Deecke L: HirnpotentialÃ¤nderungen beim Menschen vor und nach WillkÃ¼rbewegungen, dargestellt mit Magnetbandspeicherung und RÃ¼ckwÃ¤rtsanalyse. PflÃ¼gers Arch. ges. Physiol. 281 (1964) 52.

- Kosslyn, S.M., Thompson, W.L. (2003). When is early visual cortex activated during visual mental imagery? Psychol. Bull. 129 (2003)723-746.

- Kreiman, G., Koch, C. and Fried, I. (2000). Imagery neurons in the human brain. Nature (2000) 408: 357-361 http://www.cns.caltech.edu/~gabriel/publications/imagination1.html

- Kreiman, G., Fried, I., & Koch, C. (2001). Single neuron responses in humans during binocular rivalry and flash suppression. Journal of Vision, 1(3), 131a, http://journalofvision.org/1/3/131

- Kreiman, G., Fried, I. And Koch, C. (2002) Single Neuron responses in the human brain during flash suppression. Proceedings of the National Academy of Science USA, 99:8378-8383 http://www.ai.mit.edu/projects/cbcl/publications/ps/kreimanetal_flash-suppression.pdf

- Laureys, S. et al. (2002). Brain function in the vegetative state. Acta neurol. belg., 2002, 102, 177-185 http://www.jsmf.org/meetings/2003/nov/LaureysANB2002.pdf

- Lee. S, and Blake, R. (2002). V1 activity is reduced during binocular rivalry. Journal of Vision (2002) 2, 618-626 http://journalofvision.org/2/9/4/article.pdf

- Leopold, D.A. and Logothetis, N.K. (1999). Multistable phenomena: changing views in perception. Trends in Cognitive Sciences. 3: 254-264. http://www.kyb.tuebingen.mpg.de/publications/pdfs/pdf201.pdf

- Libet, B., Alberts, E.W., Wright, E. W., Jr., Feinstein, B.(1967). Responses of Human Somatosensory Cortex to Stimuli Below Threshold for Conscious Sensation. Science 158, 1597-1600.

- Libet, B., Wright, E. W., Jr., Feinstein, B., and Pearl, D.(1979). Subjective referral of the timing for a conscious sensory experience. Brain, 102, pp. 192-224.

http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?holding=npg&cmd=Retrieve&db=PubMed&list_uids=427530&dopt=Abstract

- Linden, D.E.J. (2005) The P300: Where in the Brain Is It Produced and What Does It Tell Us? The Neuroscientist, Vol. 11, No. 6, 563-576 (2005) http://nro.sagepub.com/cgi/reprint/11/6/563.pdf

- Llinas, R., Ribary, U., Contreras, D. & Pedroarena, C. (1998). The neuronal basis for consciousness. Philos. Trans. R. Soc. London Ser. B.353, 1841-1849 http://big.cs.uiuc.edu/anncbt-papers/fall05/Llinas.the-neuronal-basis-of-consciousness.pdf

- Logothetis, N.K., Leopold, D.A. and Sheinberg, D.L. (1996). What is Rivalling During Binocular Rivalry. Nature, 380:621-624. http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v380/n6575/abs/380621a0.html

- Loveblad, KO. et al. (1999). Silent functional magnetic resonance imaging demonstrates focal activation in rapid eye movement sleep. Neurology 1999;53:2193Z

- Lumer, E.D., Friston, K.J. & Rees, G. (1998) Neural correlates of perceptual rivalry in the human brain. Science. 280(5371):1930-4.

- Macdonald, K.D., Fifkova, E., Jones, M.S. and Barth, D.S. (1998) Focal Stimulation of the Thalamic Reticular Nucleus Induces Focal Gamma Waves in Cortex. The Journal of Neurophysiology Vol. 79 No. 1 January 1998, pp. 474-477 http://jn.physiology.org/cgi/content/full/79/1/474

- Maia, T.V. & Cleeremans, A. (2005). Consciousness: converging insights from connectionist modeling and neuroscience. TRENDS in Cognitive Sciences Vol.9 No.8 August 2005 http://srsc.ulb.ac.be/axcWWW/papers/pdf/05-TICS.pdf

- Marcel AJ. (1998). Blindsight and shape perception: deficit of visual consciousness or visual function? Brain 1998, 121, 1565-1588. http://brain.oupjournals.org/cgi/reprint/121/8/1565.pdf

- Marois, R., Yi, D-J., & Chun, M.M. (2004). The Neural Fate of Consciously Perceived and Missed Events in the Attentional Blink. Neuron, 41, 3: 465-472.

- Mashour, G.A., Tononi, G. and Massimini, M. (2005). Cognitive Unbinding in Sleep and Anesthesia. Science 16 December 2005: 1768-1769.

- Moutoussis, K. and Zeki, S. (1997). A direct demonstration of perceptual asynchrony in vision. Proceedings of the Royal Society of London, Series B: Biological Sciences, 264, 393 - 399. http://juno.ingentaselect.com/vl=6492085/cl=26/nw=1/rpsv/cgi-bin/cgi?body=linker&ini=nlm&reqidx=issn=0962-8452vl=264is=1380yr=1997mn=Marpg=393

- Moutoussis, K. and Zeki, S. (2002). Responses of Spectrally Selective Cells in Macaque Area V2 to Wavelengths and Colors. J Neurophysiol 87: 2104-2112, 2002. http://jn.physiology.org/cgi/content/full/87/4/2104

- Moutoussis, K. and Zeki, S. (2002). The relationship between cortical activation and perception investigated with invisible stimuli. Proc. Nat. Acad. Sci. USA, 99(14):9527-9532. http://www.pnas.org/cgi/content/full/99/14/9527

- Muckli, L., Singer, W., Zanella, F.E. and Goebel, R. (2002) Integration of multiple motion vectors over space: an fMRI study of transparent motion perception. Neuroimage. 2002 Aug;16(4):843-56.

- Munhall, K.G. (2001). Functional Imaging During Speech Production. Acta Psychologica 107 (2001) 95-117. http://pavlov.psyc.queensu.ca/~munhallk/07_acta_version.pdf

- Munk MHJ, Roelfsema PR, KÃ¶nig P, Engel AK, and Singer W. (1996). Role of reticular activation in the modulation of intracortical synchronization Science. 272, 271-274.

- Newman, J. & Baars, B.J. (1993) A neural attentional model for access to consciousness: A Global Workspace perspective. Concepts in Neuroscience, 4:2, 255-290 http://cogprints.ecs.soton.ac.uk/archive/00000073/

- Nieuwenhuis S, Aston-Jones G & Cohen JD (2005). Decision making, the P3, and the locus coeruleus-norepinephrine system. Psychological Bulletin, 131(4), 510-532. http://www.csbmb.princeton.edu/conte/pdfs/project5/Proj5Pub06.pdf

- Pantev C (1995) Evoked and induced gamma-band activity of the human cortex. Brain Topogr 7:321-330

- Pasley BN, Mayes LC, Schultz RT (2004) Subcortical discrimination of unperceived objects during binocular rivalry. Neuron 2004, 42:163-172.

- Pessoa, L. (2005) To what extent are emotional visual stimuli processed without attention and awareness? Current Opinion in Neurobiology 2005, 15:188-196 http://www.brown.edu/Research/LCE/publications_files/Pessoa_CONB_2005.pdf

- Pettigrew, J.D. (2001) Searching for the Switch: Neural Bases for Perceptual Rivalry Alternations. Brain and Mind 2: 85-118, 2001. http://www.uq.edu.au/nuq/jack/searchswitch.pdf

- Raymond, J. E, Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? Journal of Experimental Psychology. Human Perception and Performance, 18 (3), 849-60.

- Rees, G., Kreiman, G., & Koch, C. (2002) Neural Correlates of Consciousness in Humans. Nature Reviews Neuroscience 3, 261 -270 (2002) http://www.nature.com/cgi-taf/DynaPage.taf?file=/nrn/journal/v3/n4/abs/nrn783_fs.html&dynoptions=doi10698422948

- Rensink, RA. (2000). When Good Observers Go Bad: Change Blindness, Inattentional Blindness, and Visual Experience. PSYCHE, 6(09), August 2000. http://psyche.cs.monash.edu.au/v6/psyche-6-09-rensink.html

- Roy, J.E. & Prichep, L.S. (2005) The Anesthetic Cascade: A Theory of How Anesthesia Suppresses Consciousness Anesthesiology: Volume 102(2) February 2005 pp 447-471 http://www.anesthesiology.org/pt/re/anes/fulltext.00000542-200502000-00030.htm

- Schiff, N.D., & Plum F. 1999. The Neurology of Impaired Consciousness: Global Disorders and Implied Models. [Target article]. Association for the Scientific Study of Consciousness. http://www.phil.vt.edu/assc/niko.html

- Schiff ND, Plum F. (2000) The Role of Arousal and "Gating" Systems in the Neurology of Impaired Consciousness. Journal of Neurophysiology. 17(5):438-452. (

http://www.uni-tuebingen.de/cog/lehre/ss2003/seminar_bewusstsein/epapers/SchiffPlum00.pdf

- Sheinberg, D.L. and Logothetis, N.K. (1997). The role of temporal cortical areas in perceptual organization. Proc. Natl. Acad. Sci. USA 94, 3408-3413. http://www.pnas.org/cgi/content/full/94/7/3408

- Simons, D.J. & Rensink, RA. (2005). Change blindness: Past, present, and future. Trends in Cognitive Sciences, Vol.9, pp16-20, No.1 January 2005. http://www.psych.ubc.ca/~rensink/publications/download/S&R-TICS-05a.pdf

- Singer, W. & Gray, C.W. (1995). Visual feature integration and the temporal correlation hypothesis. Annu. Rev. Neurosci., 18, pp. 555-86, 1995.

- Singer, W. (2001). Consciousness and the Binding Problem. Annals of the New York Academy of Sciences 929:123-146 (2001)

- Solms, Mark (2000) DREAMING AND REM SLEEP ARE CONTROLLED BY DIFFERENT BRAIN MECHANISMS, Behavioral and Brain Sciences 23 (6): 793. http://www.bbsonline.org/Preprints/OldArchive/bbs.solms.html

- Sukov, W. & Barth, D.S. (2001). Cellular Mechanisms of Thalamically Evoked Gamma Oscillations in Auditory Cortex. J Neurophysiol 85: 1235-1245, 2001; http://jn.physiology.org/cgi/content/full/85/3/1235

- Takeuchi, T., Miyasita, A., Inugami, M. & Yamamoto, Y. (2001). Intrinsic dreams are not produced without REM sleep mechanisms: evidence through elicitation of sleep onset REM periods. Journal of Sleep Research Volume 10 Issue 1 Page 43 - March 2001 http://www.blackwell-synergy.com/links/doi/10.1046/j.1365-2869.2001.00237.x/full/

- TamÃ¡s, G., Buh, E.H., LÃ¶rincz, A., and Somogyi, P. (2000). Proximally targeted GABAergic synapses and gap junctions synchronize cortical interneurons. Nature Neuroscience volume 3 no 4 april 2000. http://mrcanu.pharm.ox.ac.uk/pdfs/TamasNatureNeurosci2000.pdf

- Tanaka, Y. & Sagi, D. (1998). A perceptual memory for low contrast visual signals. Proc. Natl. Acad. Sci. USA Vol 95:12729-12733. http://www.weizmann.ac.il/~masagi/TS98b.pdf

- Tong, F. (2001). Competing Theories of Binocular Rivalry: A Possible Resolution. Brain and Mind 2: 55-83, 2001 http://www.princeton.edu/~ftong/Tong_Brain&Mind2001.pdf

- Tong, F. (2002). Primary Visual Cortex and Visual Awareness. Nature Reviews Neuroscience 4, 219 (2003) http://www.princeton.edu/~ftong/Tong_NRN2003.pdf

- Tootell, R.B., Reppas, J.B., Dale, A.M., Look, R.B., Sereno, M.I., Malach, R., Brady, T.J. and Rosen, B.R. (1995) Visual motion aftereffect in human cortical area MT revealed by functional magnetic resonance imaging. Nature. 1995 May 11;375(6527):139-41.

- Tononi, G., Srinivasan, R., Russell, P.D. & Edelman, G.M. (1998). Investigating neural correlates of conscious perception by frequency-tagged neuromagnetic responses . Proc. Natl. Acad. Sci. USA. Vol. 95, Issue 6, 3198-3203, March 17, 1998 http://www.pnas.org/cgi/content/full/95/6/3198

- Thornton, I.M., Pinto, J. and Shiffrar, M. (1998). THE VISUAL PERCEPTION OF HUMAN LOCOMOTION. COGNITIVE NEUROPSYCHOLOGY, 1998, 15 (6/7/8), 535-552. http://psychology.rutgers.edu/~mag/TPS98.pdf

- Traub, D.R., Whittington, M.A., Buhl, E.H., Jefferys, J.G.R., & Faulkner, H.J. (1999). On the Mechanism of the Frequency Shift in Neuronal Oscillations Induced in Rat Hippocampal Slices by Tetanic Stimulation. The Journal of Neuroscience, February 1, 1999, 19(3):1088-1105 http://www.jneurosci.org/cgi/content/full/19/3/1088

- Traub, R.D. (2003). Fast Oscillations and Epilepsy. Epilepsy Curr. 2003 May; 3(3): 77-79. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=321178

- Tse, P.U., Susana Martinez-Conde, S., Schlegel, A.A. and Macknik, S.L. (2005). Visibility, visual awareness, and visual masking of simple unattended targets are confined to areas in the occipital cortex beyond human V1/V2. Proc. Natl. Acad. Sci. USA November 22, 2005 vol. 102 no. 47. 17178-17183. http://www.pnas.org/cgi/content/full/102/47/17178

- Vogel, E.K., Luck, S.J. & Shapiro, K.L. (1998) Electrophysiological Evidence for a Postperceptual Locus of Suppression During the Attentional Blink. Journal of Experimental Psychology: Human Perception and Performance 1998, Vol. 24. No. 6,1656-1674 http://www.psychology.uiowa.edu/faculty/Luck/lucklab/pdfs/Vogel_1998_JEPHPP.pdf

- Wehrle, R., Czisch, M., Kaufmann, C., Wetter, T.C., Holsboer, F., Auer, D.P., and Pollmacher, T. (2005). Rapid eye movement-related brain activation in human sleep: a functional magnetic resonance imaging study. NeuroReport 16:853-857 http://www.univie.ac.at/mcogneu/lit/wehrle.pdf

- White, NS., Alkire, MT. (2003). Impaired thalamocortical connectivity in humans during general-anesthetic-induced unconsciousness. NeuroImage. Volume 19, Issue 2 , June 2003, Pages 402-411. http://smallurl.com/?i=2597 (http://www.sciencedirect.com/science/article/B6WNP-48GP5CG-5/1/cedb33dc0bec4301d1960c7c27cea70f)

- Wheeler, M.E., Buckner, R.L.. (2003) Functional dissociation among components of remembering: control, perceived oldness, and content. J. Neurosci. 23, 3869-3880.

- Williams LM, Liddell BJ, Rathjen J, Brown KJ, Shevrin H, Gray JA, Phillips M, Young A & Gordon E (2004). Mapping the time course of nonconscious and conscious perception of fear: An integration of central and peripheral measures. Human Brain Mapping,21, 64 - 74 http://psychmed.iop.kcl.ac.uk/neuroscience-and-emotion/downloads/46.pdf

- Wunderlich, K. Schneider, K.A., & Kastner, S. (2005).Neural correlates of binocular rivalry in the human lateral geniculate nucleus. Nature Neuroscience 8, 1595 - 1602 (2005)

- Yamamoto, T. & Katayama, Y. (2005). Deep brain stimulation therapy for the vegetative state. in Neuropsychol Rehabil. 2005 Jul-Sep ; 15(3-4): 406-13

- Zeki, S., & Bartel, A. (1999). Toward a Theory of Visual Consciousness. Consciousness & Cognition, 8, 225-259.

Behaviourism and Consciousness

References

- Behaviourism. Graham, G. (2002) Stanford Encyclopedia of Philosophy
- Watson, J.B. (1907) Studying the Mind of Animals The World Today, 12, 421-426.
- Watson, J.B. (1913) Psychology as the Behaviorist Views it. Psychological Review, 20, 158-177
- Lektorsky, V.A. (1980)Subject Object Cognition.
- Vygotsky L.S. (1925) â€œConsciousness as a problem in the psychology of behaviorâ€ Undiscovered Vygotsky: Etudes on the pre-history of cultural-historical psychology (European Studies in the History of Science and Ideas. Vol. 8), pp. 251-281
- Gibson, J. J. (1950). The perception of the visual world. Boston: Houghton-Mifflin
- Gibson, J. J.(1979). The ecological approach to visual perception. Boston: Houghton-Mifflin
- Ryle, G. (1949). The concept of mind. Harmondsworth, Middlesex: Penguin.

[edit]

Models of Access Consciousness

There have been numerous attempts to model reflex and access consciousness. These models, being connectionist and information systems based, do not model phenomenal consciousness but are essential steps in understanding global brain function.

[edit]

Neural networks

Neural networks achieve information processing by establishing connections between processing units in a system of processors that have similar characteristics. Neural networks are used for classifying data. The processing units serve the function of both filtering and storing information.

This is a stub and requires expansion

[edit]

Classification of sensory stimuli

The path from transducers to a single neuron that responds to a single complex stimulus.

This is a stub and requires expansion

[edit]

Classification of motor control

From premotor activity to skilled behaviour.

This is a stub and requires expansion

[edit]

Olfaction: classification out of chaos?

This is a stub and requires expansion

[edit]

Quantum information processing

*This is a **stub** and needs expanding*

[edit]

Contemporary Explanations of Consciousness

This section is about the types of theory that have been advanced to explain consciousness. Specific explanations should be entered as separate pages.

Introduction

Explanations of consciousness fall into four broad categories, those that attempt to explain the empirical experience called consciousness with scientific theories, those that seek to find some way in which consciousness could be explained by digital computers or nineteenth century materialism by redefining or eliminating experience and those that regard consciousness as inexplicable or supernatural.

Identity theory of mind

The identity theory of mind, or type physicalism, holds that the mind is identical to the brain. Type physicalists identify qualia and the form of experience with brain activity. They argue that "mind states" have physical causes and physical effects - thus the mind states themselves must be physical; a non-physical "middle step" is superfluous.

Type physicalism has not yet gained widespread support because although brain activity that correlates with experience has been found everywhere in the brain, no set of brain activity that is phenomenal consciousness itself has yet been found - although this is not surprising because neuronal spike activity is unlikely to host phenomenal consciousness - see scientific theories of consciousness.

Functionalism

Functionalism was developed as a theory of the mind-body problem because of objections to identity theory and logical behaviourism. Its core idea is that the mental states can be accounted for without taking into account the underlying physical medium (the neurons), instead attending to higher-level functions such as beliefs, desires, and emotions. It is a theory of behaviour and access consciousness and so from the outset avoids any explanation of phenomenal consciousness, substituting beliefs and judgements (functions) for entities such as qualia.

According to functionalism, the mental states that make up consciousness can essentially be defined as complex interactions between different functional processes. Because these processes are not limited to a particular physical state or physical medium, they can be realized in multiple ways, including, theoretically, within non-biological systems.This affords consciousness the opportunity to exist in non-human minds that are based on algorithmic processors such as digital computers. This is a highly contentious conjecture although non-functionalist physicalists might agree that machines that are not digital computers could possess consciousness through an identity theory of mind - see The problem of machine and digital consciousness.

Functionalism's explanation of consciousness, or the mental, is best understood when considering the analogy made by functionalists between the mind and the modern digital computer. More specifically, the analogy is made to a "machine" capable of computing any

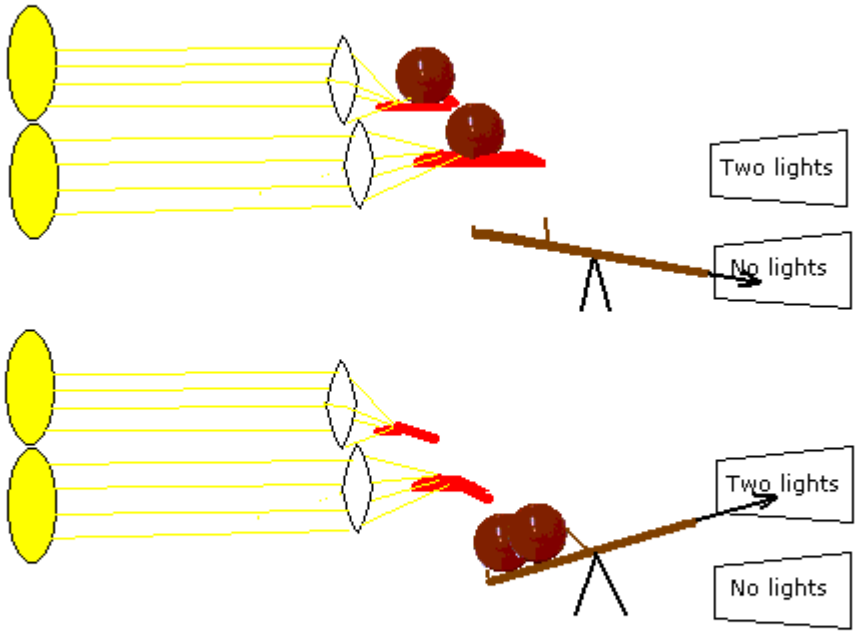
given algorithm (i.e. a Turing machine). This machine would involve:

Data input (the senses in humans), data output (both behaviour and memory), functional states (mental states), the ability to move from one functional state into another, and the definition of functional states with reference to the part they play in the operation of the entire entity - i.e. in reference to the other functional states.

So long as the same process was achieved, the "physical stuff" -- that being computer hardware or biological structure -- could achieve consciousness. This combination of data input, data output, functional states and movement from state to state is shown in the model system in the illustration below.

Functionalism

According to functionalism a stimulus response system is conscious. In the model below the heat from lights melts some wax which allows two falling balls to provide the output "two lights".



Which part of the system observes the event? Would the addition of another lever and another set of balls with a pointer to a sign saying "I am observing the event" truly give rise to observation? Or does the system only make sense because you are a conscious observer with an active imagination?

Many naive proponents of functionalism do not realise that digital computers are conceptually equivalent to very large systems of balls and levers.

This variety of functionalism was developed by Hilary Putnam. One of the major proponents of functionalism is Jerry Fodor.

Further reading:

Block, N. (1996). The Encyclopedia of Philosophy Supplement, Macmillan, 1996 http://www.nyu.edu/gsas/dept/philo/faculty/block/papers/functionalism.pdf

Dualism

Substance dualism

This theory proposes that phenomenal experience occurs in a non-physical place. In Cartesian Dualism the non-physical place is a point-soul that looks out at the brain. In Reid's Natural Dualism the non-physical place is a point-soul that looks out at the world.

Property dualism

Property dualism asserts that when matter is organized in the appropriate way (i.e., organized in the way that living human bodies are organized), mental properties emerge. Property dualism is a branch of emergent materialism. The appeal to emergentism deserves closer attention. Scientific theories often deal with emergent phenomena, for instance an enzyme consists of carbon, hydrogen, nitrogen, manganese and oxygen and from this catalytic action emerges. The theory of enzyme structure and the action of this structure on the substrate explains how this emergence occurs. Notice that the theory of enzymes explains the emergence of catalytic activity; emergence does not explain the theory. In science the statement that some property will 'emerge' means that there will be a theory that accounts for this property. Property dualism, by appealing to emergence, is stating that some theory of consciousness will be possible. In other words it is an explanation that proposes that the explanation is yet to be known.

Intentionalism

[edit]

Higher order thought

This section is a stub and needs expansion

[edit]

Eliminativism

Eliminative materialism is the school of thought that argues for an absolute version of materialism and physicalism with respect to mental entities and mental vocabulary. It principally argues that our common-sense understanding of the mind (described with the pejorative term 'folk psychology' by eliminativists) is not a viable theory on which to base scientific investigation, and therefore no coherent neural basis will be found for many such everyday psychological concepts (such as belief or intention) and that behaviour and experience can only be adequately explained on the biological level.

Eliminative materialists therefore believe that consciousness does not exist except as an epiphenomenon of brain function and some believe that the concept will eventually be eliminated as neuroscience progresses. Similarly, they argue that folk psychological concepts such as belief, desire and intention are illusory and therefore do not have any consistent

neurological substrate.

Proponents of this view often make parallels to previous scientific theories which have been eliminated, such as the four humours theory of medicine, the phlogiston theory of combustion and 'vital force' theory of life. In these cases, science has not produced more detailed versions of these theories, but rejected them as obsolete. Eliminative materialists argue that folk psychology is headed the same way. According to W.V. Quine it will take tens of years before folk psychology will be replaced with real science. Eliminativism is novel however because it uses theory based on nineteenth century materialism to reclassify all observation as theory. This use of theory to eliminate observation is highly unusual and suspect (see Phenomenal consciousness and access consciousness).

Eliminative materialism was first defended by W.V. Quine, Paul Feyerabend, and Richard Rorty. This view is most associated with philosophers Paul and Patricia Churchland, although philosophers such as Daniel Dennett would also consider themselves eliminativists for many aspects of psychology. Philosopher Dale Jacquette has claimed that Occam's Razor is the rationale behind eliminativism and reductionism.

The most common argument against eliminative materialism the argument from qualia, which is deployed in various forms by Thomas Nagel, Frank Jackson, and many others. Perhaps the most powerful argument against eliminativism is that experience itself is many things simultaneously; it is, as Aristotle points out, immediately things in space and hence is not composed of judgements.

Mysterianism

New Mysterianism is a philosophy proposing that certain problems (in particular, consciousness) will never be explained.

Owen Flanagan noted in his 1991 book "Science of the Mind" that some modern thinkers have suggested that consciousness might never be completely explained. Flanagan called them "the new mysterians" after the rock group ? and the Mysterians. The term originated with the Japanese alien-invasion film The Mysterians. The "old mysterians" are thinkers throughout history who have put forward a similar position. They include Leibniz, Dr Johnson, and Thomas Huxley. The latter said, "How is it that anything so remarkable as a state of consciousness comes about as a result of irritating nervous tissue, is just as unaccountable as the appearance of the Djin, when Aladdin rubbed his lamp." [6, p. 229, quote]

Noam Chomsky distinguishes between problems, which seem solvable, at least in principle, through scientific methods, and mysteries which do not, even in principle. He notes that the cognitive capabilities of all organisms are limited by biology, e.g. a mouse will never speak. In the same way, certain problems may be beyond our understanding.

The term New Mysterianism has been extended by some writers to encompass the wider philosophical position that humans don't have the intellectual ability to understand many hard problems, not just the problem of consciousness, at a scientific level. This position is also known as Anti-Constructive Naturalism.

For example, in the mind-body problem, emergent materialism claims that humans aren't

smart enough to determine "the relationship between mind and matter." [4] Strong agnosticism is a religious application of this position.

Colin McGinn is the leading proponent of the New Mysterian position.

Critics argue this philosophy isn't useful and encourages capitulation. One critic noted:

the extreme "Mysterian" position, that there are vital issues forever beyond our reach, is in many ways deeply unsatisfying. [7]

References

[1] McGinn, Colin - The Problem of Consciousness

[2] McGinn, Colin - Problems in Philosophy: the limits of enquiry

[3] McGinn, Colin - The Mysterious Flame

[4] Blackburn, Simon - Think: A compelling introduction to philosophy, chapter two

[5] Flanagan, Owen - The Science of the Mind (1991) 2ed MIT Press, Cambridge

[6] Horgan, John - The Undiscovered Mind (1999), Phoenix, ISBN 0753810980

Idealism and panpsychism

Idealism

[edit]

Panpsychism

If you are here, reading about panpsychism, then it may be because you still have no clue as to what consciousness is. Or, you have read philosophers say ' Without consciousness the Mind-Body problem would be much less interesting, with consciousness it seems hopeless' T. Nagel, ' What it's Like to be a Bat'. You may have reached this section rationally, logically. It follows the previous section, you are reading linearly. Basically you are thinking and acting scientifically/ philosophically. Or, you may have read " Panpsychism " and thought ' strange, flaky, interesting '. You are following your feelings, and close behind are your intuitions. This kind of thinking could be called Magical thought. There is more than one way to be aware of the world. Although a panpsychic might say consciousness is everything, it is not every where the same thing. It has an infinite number of aspects, forms and patterns. We arrive at panpsychism intuitively, by following our feelings. Science and philosophy represent one kind of awareness, one aspect of consciousness.Magical thinking is another aspect of consciousness. " ...intuitions are important and that even if expressed vaguely they can serve as useful pointers to those seeking a more complete account of the mind" David Skrbina, ' Panpsychism in the West ' p.3.

Put 2 Greek god's together and you end up with a term that appears more mythological and intuitive than scientific or philosophical. Pan- Psyche (ism) ! That is the place we begin to

understand what the term means. The literature and art of the Ancient Greeks express the mythical and intuitive perspective. ' Modern theories of panpsychism have their roots in the mythology and spiritualism of the pre-classical world. ' David Skrbina, 'Panpsychism in the West ' p.23 (MIT press). That perspective begins to change with the emergence of science and philosophy or, correctly, science and philosophy emerge when the perspective changes. Greek consciousness changed. (see the section on Homer above) ' They transformed the mythological, pre-historic animist worldview into rational and logical theories of the cosmos' (ibid).

Scientific Theories of Consciousness

Theories of Consciousness

Some recent scientific theories of consciousness are tabulated below. The extent to which they account for the phenomenon of consciousness is shown.

It is remarkable that many of the theories are consistent with one another. As in the tale of the 'blind men and the elephant' some of the theories seem to describe the trunk, some the tail etc. but they all seem to be part of the same elephant! The convergence of the theories is shown in the illustration below:

A Summary of some of the theories of consciousness

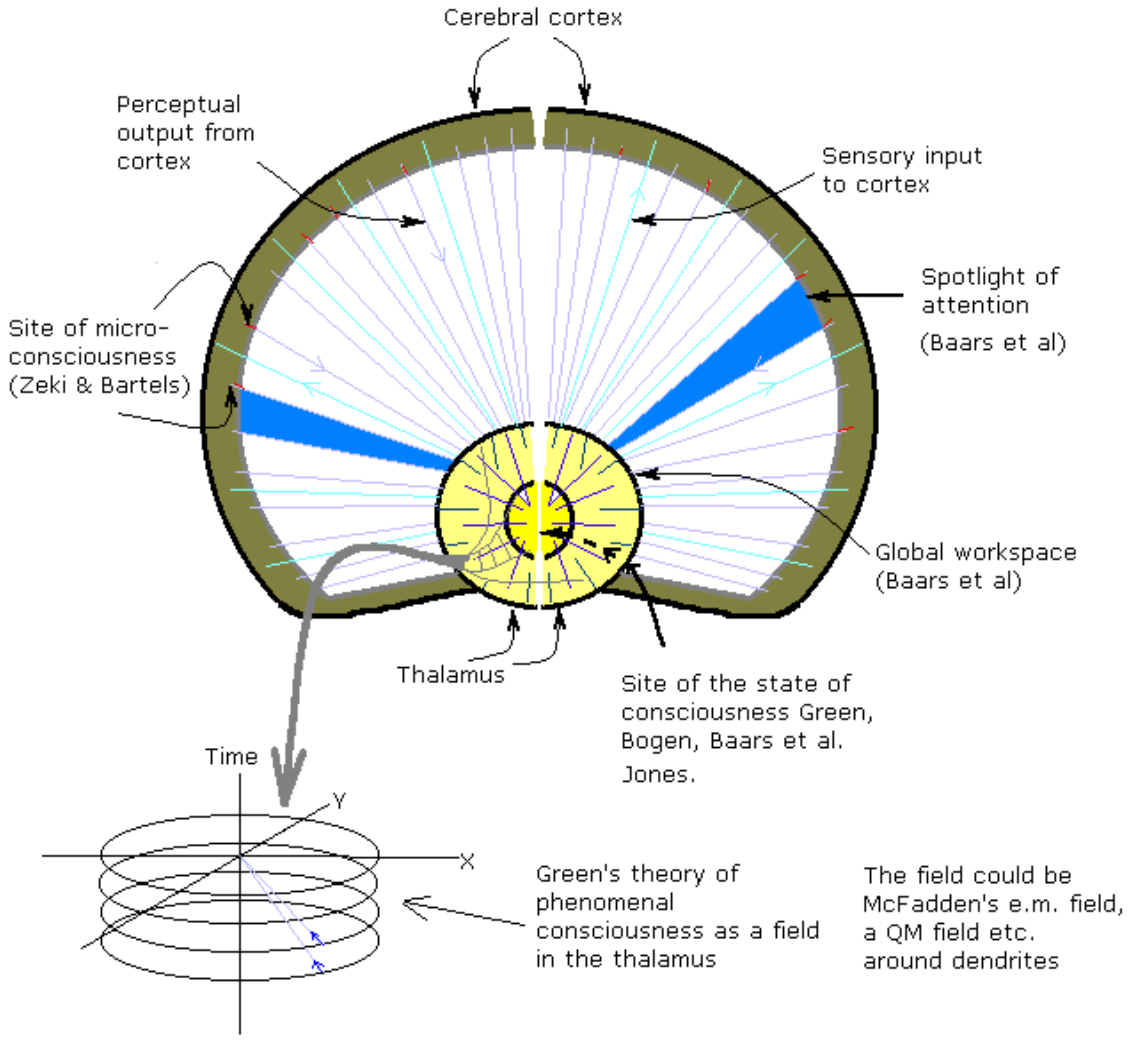


Table of theories

A = Model of observer's view	**D = Explanation of unconscious but active cerebral cortex**	**G = Binding (simultaneo relevant data)**
B = Model of Anaesthetic Action in thalamus	E = Explanation of knowing you know	H = Extended present
C = Explanation of Libet's data	F = Explanation of non-computability	I = Quantum state vector

Name	**Author/Ref**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Microconsciousness	Zeki, S., & Bartel, A. (1999) Toward a Theory of Visual Consciousness. Consciousness & Cognition, 8, 225-259.	N	N	N	N	N	N	Y	N	N
Geometrical Phenomenalism	Green, A. (2003) Geometrical phenomenalism	Y	Y	Y	Y	Y	?	Y	Y	Y
ORCH-R	Hameroff, S & Penrose, R. 1989	N	N	N	N	N	Y	Y	N	Y
Quantum Brain Model	Ricciardi, L. M. and H. Umezawa, 1967. Brain physics and many-body problems, Kibernetik 4, 44-48. http://arXiv.org/abs/q-bio/0309009	N	N	N	N	N	?	Y	N	Y
Many Minds	Donald, M. 1990. Quantum Theory and the Brain. Proc R Soc Lond. A427 43-93. http://xxx.lanl.gov/PS_cache/quant-ph/pdf/9904/9904001.pdf	Y	N	N	N	?	?	Y	Y	Y

A = Model of observer's view	**D = Explanation of unconscious but active cerebral cortex**	**G = Binding (simultaneo relevant data)**
B = Model of Anaesthetic Action in thalamus	E = Explanation of knowing you know	H = Extended present
C = Explanation of Libet's data	F = Explanation of non-computability	I = Quantum state vector

Name	**Author/Ref**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Dual-Time Supercausality	King, C.C. 1989. Physics Essays 2/2 128-151. http://www.math.auckland.ac.nz/~king/Preprints/Transup.htm	N	N	N	N	Y	Y	Y	?	Y
Spin Mediated Consciousness	Hu, H. & Wu, M. 2002. Spin-Mediated Consciousness Theory: An Approach Based On Pan-Protopsychism. http://cogprints.ecs.soton.ac.uk/archive/00002579/	N	N	N	N	N	?	Y	N	Y
Quantum Theory of Consciousness (synaptic cleft)	Walker, E.W. 1998. the *Noetic Journal*, *1*, 100-107, 1998 http://users.erols.com/wcri/CONSCIOUSNESS.html	N	N	N	N	N	N	Y	N	Y

A = Model of observer's view	**D = Explanation of unconscious but active cerebral cortex**	**G = Binding (simultaneo relevant data)**
B = Model of Anaesthetic Action in thalamus	E = Explanation of knowing you know	H = Extended present
C = Explanation of Libet's data	F = Explanation of non-computability	I = Quantum state vector

Name	**Author/Ref**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Global Workspace Theory	Baars, B. 1988. A cognitive theory of consciousness. Cambridge University Press, New York http://www.ceptualinstitute.com/genre/baars/baarsBrain.htm	**Y**	**Y**	**Y**	**Y**	N	N	**Y**	N	N
Topological Geometrodynamics (TGD) Inspired Theory of Consciousness	PitkÃ¤nen, M. 199?. Topological Geometrodynamics http://www.physics.helsinki.fi/~matpitka/mainpage.html	Y	?	N	N	Y	Y	**Y**	Y	**Y**
The Conscious Electromagnetic Field Theory	McFadden, J.J. 2002 http://www.surrey.ac.uk/qe/cemi.htm	Y	?	N	N	N	N	Y	N	?

Name	**Author/Ref**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Real Time Consciousness	Smythies, J. 2003.Journal of Consciousness Studies 10:3 47-56 http://www.imprint.co.uk/pdf/smythies.pdf	Y	N	N	N	Y	?	Y	Y	?
Consciousness as memory	Gerald Edelman's theory Proc Natl Acad Sci U S A. 2003 April 29; 100(9): 5520â€“5524	N	N	N	N	N	N	N	N	N

Other Explanations

Conscousness only

Consciousness-only is the foundation of a buddhist theory known as vijnanavada. Proponents suggest that the sum of experience exists only in our minds. Philosophers recognize this view as subjective idealism. Consciousness-only views can also be found in taoist philosophy, notably Lao Tzu and Chuang Tzu.

Bps model

This brief summary is an illustration of an attempt to model a multidisciplinary biopsychosocial (bps) understanding of self-consciousness seen from the perspective of both scientific methodology and metaphysical logic where the empirical and the inferential provide a seamless blend of the ontological brain with the epistemological mind.

The achievement of self consciousness is the crucial mental state allowing the human species to monitor the equilibrium state of biopsychosocial ongoing contingencies especially when confronting life-threatening circumstances. The inherited proto-semantics and acquired language guide the required recursive co-generation of the appropriate language and thought to meet the contingency. Thus informed, it allows humans to elaborate effective adaptive short and long range responses.

Definition of terms

Bps model uses some unusual definitions of terms. These are explained below.

"Sense-phenomenal awareness" is defined as an unconscious, life-preserving, adaptive reflex response which may occur without qualia. It originates at a sensory receptor, wherever located in the body economy, and ends at an effector organ, glandular or muscular. - Phenomenal consciousness/awareness is a term normally reserved for experience containing qualia in other analyses.

System/network "awareness" is defined in the bps model as that unconscious processing occuring during the integration of the participating neural network modules leading to a stereotyped adaptive response. - normally awareness is defined as knowledge that a conscious state is present.

Sense-phenomenal awareness may become a conscious experience when relevant inferential networks (e.g., memory, emotions, etc.)are subsequently accessed, including inner-language processors. When experiences are recalled the qualia that arise are called "conceptual qualia".

"Access consciousness" is described as being initially an unconscious process that makes it possible for a life-preserving, reflex-driven and 'unconscious' sense-phenomenal state of mind to become conscious by making use of available, pertinent and concurrent mental states to interact with the novel sense-phenomenal input, a potentially life-threatening event.

"Proto-linguistic organ" or 'plo' is described as the first line of defense to guard against life-

threatening stimuli arising from sense-phenomenal inputs (external, visceral or propioceptive). Housed in the amygdaloidal complex, it represents the inherited proto-semantic (primitive 'meanings') database responsible for activating the corresponding unconscious fight/flight adaptive Cannon effector response.

"Proto-semantic" input from plo is described as a required initial participant in the subsequent recursive co-generation of inner language and thought as may be required in the eventual elaboration of "conceptual consciousness".

Higher order consciousness theory

The 'bps' model of 'consciousness' is a high order consciousness theory in which an unconscious, non inferential phenomenal state (established from either online sensory receptor input or offline memory input), when confronting a novel life-threatening event, triggers an initially unconscious access intermediate stage where relevant modular networks are incorporated including Broca's language processor recursively co-generating in the process the 'inner language' narrative state and accompanying thought, a conscious high order mental state, all of which causally precedes (or is simultaneous with) the adaptive response (if any, as we see in dreams).

Notice that bps considers phenomenal states to be non-conscious, this would confuse the ordinary reader who expects the Kantian term "phenomenal" to be equivalent to the term "conscious experience". Only the higher order mental state is regarded as "conscious".

The 'bps' model basically describes two co-existing, ongoing mental states, one non-inferential subconscious 'gut feeling' inner sense (BOP, a variant of Lycan's 1996 HOP) and an initially non-inferential unconscious accessing of narrative pathways leading to (recursive co-generation of 'inner language' and thought is an open option) the eventual production of higher order thought (HOT) whose content is the feeling that oneself is the subject of self-consciousness.

In other words, according to the 'bps' theory, feelings are not part of consciousness until higher order thought occurs, ie, qualia needs a context.

In 'bps' theory not even self-consciousness, of which 'qualia' may arguably be considered a subset of, has revealed its constitutive secrets. This means that bps is a theory of brain processing rather than a theory of the content of consciousness (qualia) or consciousness itself except when it ventures into the postulate that language and self-consciousness are recursively co-generated or co-causal. More controversial is the mediation of the amygdaloid complex (plo) in providing inherited primitive 'meanings' (protosemantic codelets) to initiate Chomskian language processing and thought co-generation, i.e., protosemantics precedes syntax structuring. For a more complete exposition see: http://home.earthlink.net/~dr.ds/neurophilosophyofconsciousnesssummary/id1.html

Further Reading: http://delasierra-sheffer.net/