Subtler Forms of Reinforcement - Cognitive Emotions

The learning which is concerned only with whether to respond to a stimulus or to refrain from responding seems relatively straightforward. Desirable input to internal or boundary senses, if there is wiring which turns it into feedback about the effects of the response which preceded it, can strengthen the connection which triggers the response. (Just how that happens we'll come to later). Undesirable effects can bring inhibitory connections into operation and suppress the response. Learning about environments which tend to coincide with a satisfactory internal condition and are worth approaching can be supposed to work along the same lines.

However, it's clear that not all learning depends on this sort of feedback, for sometimes there are no immediate rewards or discouragements in the shape of physical effects on the organism. Some learning, most notably that involved in constructing the cognitive map, produces longer term benefits. The animal which explores its territory doesn't necessarily benefit from its discoveries at the time of exploring. In fact encounters with immediate rewards seem to distract from the business of exploration. Similarly, when young animals play they discover their own physical powers, and they learn something about the world they play in, but they don't gain any immediate material profit.

Activities like exploration and play must have some other form of motivation. Indeed, we know from subjective experience that exploring a new terrain can be enjoyable for its own sake, and play is, by definition, done 'for fun'. The reinforcements which power this sort of learning are clearly not simple reports from peripheral and internal senses, but something much more difficult to pin down. Just what is 'fun' in scientific terms?

Mysterious they may be, but these non-physical forms of reinforcement shouldn't surprise us. The neuronal machinery involved in creating the conscious experience, and in the process building sensory or motor schemata, constitutes a major investment, and one that is metabolically expensive to maintain. It couldn't have survived the pressures of natural selection if it didn't incorporate a device to ensure that its possessors made the further investment of effort which is necessary if the benefits are to be reaped.

Donald Hebb noted the importance of this form of reward and went so far as to define pleasure as *fundamentally a directed growth of development in cerebral organisation. It is thus a transient state of affairs in which a conflict is being reduced, an incipient disorganization being dissipated, or a new synthesis in as-sembly action being achieved.* In other words a new schema is being created, or an established one extended or modified.

We derive reinforcement, indeed, not only from spending energy on play, and on creating cognitive maps, but also from the less conspicuous efforts of mere everyday perception. For us humans the conscious sensation of seeing or hearing functions as the reward for the unconscious work that goes into creating it. We like to put our advanced sensory powers to work - to have something to look at, and something to listen to. We get painfully bored when there is nothing to activate our senses. Indeed, sensory deprivation experiments show that in the total absence of sensory input we tend to start suffering from hallucinations, as if our perceptual systems couldn't bear to be unemployed. It seems there is a built-in drive to make the fullest possible use of our sensory apparatus. Back in 1947 Robert Woodworth wrote: *perception is always driven by a direct inherent motive which might be called the will to perceive. Whatever ulterior motives may be present from time to time, this direct perceptual motive is always present in any use of the senses ..... to see, to hear - to see clearly, to hear distinctly - to make out what it is one is seeing or hearing - moment by moment, such concrete immediate motives dominate the life of relation with the environment.*

The urge to achieve the best possible perception is present from a very young age, as objective experiment has demonstrated. Infants from one to three months old were shown a fuzzy motion picture, and provided with a dummy, or pacifier, which was connected to the projector in such a way that their sucking affected the focus. They readily developed sucking strategies that achieved a sharp picture. No doubt it's for the same reinforcement - the reward to be obtained from turning a fuzzy experience into a clearer one - that infants learn to control the focus of their own eyes.

We can deduce that all species which possess the neuronal apparatus for conscious sensation have the same urge to put it to use effectively, derive positive reinforcement from doing so, and suffer negative effects if they don't get the opportunity to give proper employment to whatever schema-building abilities they have. It's long been remarked that many caged animals look as if they suffer acutely from boredom. The impression received solid backing when it was shown that laboratory monkeys would learn to perform quite demanding tasks when the reward was simply the opening of a shutter, allowing them to look out of their cages at scientists and laboratory technicians going about their business. (It's to be hoped that laboratory animals are now routinely provided with diverting per-ceptual fare - both for their sake and because animals suffering from depression are unlikely to provide useful evidence on any subject other than depression.)

Subjective experience also suggests that there's positive reinforcement to be obtained from the possession of schemata once they're created. The lack of schemata, meanwhile, can produce aversive emotions. Not knowing where one is, or how to get to where one wishes to be, is at the very least annoying, and sometimes quite unsettling. Similarly, registering a sensory pattern that can't be related to a schema can be disturbing if it seems like something that might have significant implications and one doesn't know what they are.

In short, there is both an urge to put the elaborate machinery that creates conscious sensory experience to work, and two sorts of reward to be gained from having done so - the experience itself and the knowledge gained. The ability to derive these reinforcements from conscious sensory experience must have been crucial to the evolution of a brain that could produce it.

Familiarity and unfamiliarity

The ability to build a sensory model of the world carries an important corollary. When some patterns of sensory input can be matched to a schema those that can't must be classified as unknown, with unknown significance. In contrast, the unknown is something that simply doesn't exist in the context of hardwired responses to genetically determined stimuli. An animal makes a response when one of the predetermined stimulus patterns is registered - perhaps performing an actual action, perhaps just becoming alert and extra-ready for further sensory input - and that's it. Other, irrelevant events may excite a few sensory receptors but make no further impression. The situation is the same where some of the hardwired responses can be modified by conditioned learning, so that they're inhibited by some variations on the basic stimulus pattern and strengthened by others. The sensory machinery registers only relevant bits of data, and anything else simply slips past, leaving the animal unaffected by what it doesn't know.

When the sensory apparatus grows elaborate enough to register large amounts of data, and the data has to be extensively analysed to work out which combinations signify something important, the situation changes. It becomes necessary to distinguish between the familiar and the unfamiliar because the unfamiliar is worth studying, to see what implications it may carry.

The sensations of familiarity and unfamiliarity are such a primary element in our conscious lives that they receive little notice. Familiar stimulus patterns usually don't get much attention, and so neither, as a general rule, does the sense of familiarity. We stop to think about it only when something seems familiar that, as far as conscious memory serves, ought not to. Then we talk about a sense of *déja vu*. Unfamiliarity receives a little more thought because the wholly new is always likely to trigger attention. Occasionally there's a conscious internal debate about whether something is familiar or not, whether it's perhaps an echo from the distant past or merely something with a partial and irrelevant resemblance to a known stimulus pattern. But mostly we can make instant categorisations.

Moreover we can sometimes identify the fact that there is a novelty in the environment without knowing quite what it is. We find ourselves intrigued and alerted by a niggling sense of *something's different here*, but it takes time to work out that a friend has a new hairstyle, or that the furniture has been re-arranged. Similarly, that sense of *déja vu* is a feeling that something is familiar although we can't remember why. In other words a sense of familiarity can be experienced without being accompanied by conscious recognition. It seems, therefore, that the sensations of familiarity and unfamiliarity are created by unconscious processes. The business of matching current sensory input to sensory schemata is an activity which runs constantly in waking life, and automatically.

Presumably the feeling of familiarity is produced when the neuronal impulses resulting from a pattern of sensory inputs readily find their way into a clearcut circuit, and unfamiliarity is the effect when a new circuit has to be created. The two sensations can be seen as reports on the state of the schema-creating systems of the neocortex, just as conscious physical sensations function as reports on the state of the body. Hunger, thirst, tiredness, indicate that more food or water or sleep is desirable. Unfamiliarity indicates that more data is needed. And generally it mobilises attention, so that more data can be gathered. Familiarity and unfamiliarity are perhaps the most basic sensations of a cognitive life. They're the most essential of what we might call the cognitive emotions.

Lacking an established schema to which to relate current input means not knowing what sort of significance for the self may be implied, and not knowing what sort of response might be required. Since the unknown may be dangerous it's best treated with caution until more information is collected. Where there's an appropriate schema there's a record of what sort of consequences for the self, if any, have accompanied similar stimulus patterns in the past, and a means of making predictions about current probabilities. Even a danger is less frightening when it's understood than when it's a mystery. So on the whole the unknown is tinged with insecurity and therefore a little bit aversive, and the familiar is reassuring. On the other hand, the unknown may turn out on investigation to contain all sorts of desirable things, and at the very least the insecurity of strangeness can be banished. So venturing to explore it is attractive too, and perhaps exciting. Thus familiarity and unfamiliarity, like other sorts of feedback, function as reinforcements which can be either positive or negative according to circumstances. Just as food is rewarding when we are empty and aversive when we are already overfed, so the familiar is comforting and desirable when we are tired, ill, or frightened, and the unfamiliar is worrying. On the other hand, when we are full of energy, and especially when we are young and healthy, the unfamiliar beckons.

However, the attractions of the unfamiliar are limited. We like things that extend our existing schemata, or can be related to them in a meaningful way. We don't like things for which we possess no relevant schemata whatsoever, so that we have no guide-lines about what to expect from them. If there's a suggestion of possible danger about such a novelty it's particularly frightening. (The great thing about horror films is that they offer novel sources of terror within the safe and understood context of the cinema or television screen.) Even when something offers no sort of threat an inability to make sense of it can still produce an edgy reaction, or at least a mild distaste. Mathematicians pore over equations with delight while those to whom the figures are mere gibberish turn away from them. Cricket or soccer scores are fascinating to fans but not to the uninitiated. New knowledge needs to be fitted into an established framework.

This taste for novelty, but not too much novelty, is particularly marked in infants. They enjoy encountering variations on familiar themes, which can be related to something already known, and they turn away from the wholly strange, looking upset. There's pleasure in extending an existing schema, but confronting the totally unclassifiable is aversive.

Cognitive emotions and territorial behaviour

Territoriality is obviously closely linked to the evolution of cognitive mapping ability. If an animal is going to stick to the patch of land it knows, defending it against competitors, and if that patch is larger than it can survey at one time by means of its distance senses, then it needs a means of identifying what it regards as its territory. And of course an animal capable of mapping its patch of environment, and learning where useful things are to be found, will benefit from staying on the ground it knows. The ability to construct a cognitive map makes territoriality both possible and desirable.

If we may judge by appearances the creation of the map and the territory is motivated by cognitive emotions. A young animal which must leave the area in which it was born to set up its own home, being healthy and full of energy, sets out with a cocky, purposeful look, as if it finds reward in the adventure of exploring wholly new ground. Once it has established its domain it's likely to leave only reluctantly, if pushed out by a rival, or if the food supplies become inadequate, or something else occurs to make the territory unsuitable. We may suppose that it's motivated by a sense of the advantage of remaining in the known and predictable environment. In some species the male has to range over a more extended area at breeding time to find a mate. But otherwise, once settled, the animal can usually give up exploration and substitute the less demanding business of checking over the territory regularly and noting the effects of the seasons and any other change. (No doubt such species, like us, do not consciously have to look for change but are hit by a '?' feeling when something in the environment doesn't match up to the stored schema.)

The initial exploratory behaviour, meanwhile, must be helpfully shaped by the principle that new information is attractive only if it can be comfortably added on to existing schemata. An aversion for the wholly strange should function to preserve an exploring animal from venturing into habitats to which it’s not suited. When a young adult establishes its own territory it’s likely to choose the same sort of terrain as that in which it grew up, the sort in which it knows the rules and knows what to expect. Only under pressure will it venture into a different kind of landscape. The forest-born creature explores readily in the forest but is super-cautious about venturing out into the open plain, we can guess, and this is generally not so much because it knows that the open plain is dangerous for it as because the possible dangers are unknown.

The territorial animal's map could probably be drawn in contours of familiarity: the densest colouring in the heartland, where rest and sleep are taken and the young are born; a slightly lighter shade covering much of the rest, with perhaps yet lighter patches here and there, representing areas of territory that are not investigated very often because they don't have much to offer; a still paler area beyond the borders, known only by means of distance senses, or through occasional forays taken when the neighbour isn't looking; and beyond that the bleak white of *terra incognita*.

All this implies that building a cognitive map involves a certain minimum of sensory consciousness. What would it be like to belong to a species that used consciousness only for cognitive mapping, with perhaps only one type of reward-site marked on its map? Probably the map would be pretty blurred by our standards, with just a few salient landmarks. We might imagine its possessor moving around its territory with a fuzzy consciousness focussed wholly on reaching the goal, and on the purpose for which it is travelling, and perhaps experiencing something a little like confusion and alarm if it gets lost. Just as its sensory model of the world is very hazy compared to ours, so, we may suppose, are the feelings which relate to the map. They can afford to be, since the animal doesn't have any other conscious feelings from which they might need to be distinguished, or which might distract its attention. Just as we blink, or digest our food, or produce antibodies against invading bacteria, without having to make any conscious decisions, so this animal performs nearly all of its activities without giving them conscious attention or having any conscious feedback about the results.

In contrast, our range of conscious feedback is extensive, and our place schemata are correspondingly complex. They are hung about with all sorts of feelings which reflect the values each place has for us, and the experiences we have had there. The place where a proposal of marriage was made and accepted has a special magic - or possibly a special pain or a rueful regret, depending on how things turned out. The feelings attached to a supermarket, for me at least, are a muddled compound of the hopeful promise of good eating, the boredom of regular shopping, and the frustration when they've changed all the sectors around again and I can't find what I want.

More generally, we learn to judge landscapes and cityscapes for their potential, usually without thinking about it, and they acquire an emotive flavour from the assessments. Does the new place offer interest or boredom? Is there a possibility that danger may threaten, so that it's important to stay alert, or is it safe to relax? Is there shelter from the elements if it's needed, and are food and drink available, or are there prospects of discomfort? Are there other people around, and if so do they seem to be friendly? A blend of all these elements colours the record of the place that’s established in memory.

A sense of physical comfort or discomfort, and perhaps particularly of temperature, often seems to play an important part. Was one regularly hot and sweaty there, or cold and shivering, or drenched with rain, or braced against a gale - or was it deliciously comfortable? Canny writers know that the most effective descriptions of places colour them with these subjective qualities. Landscapes are bleak and forbidding, or calm and fruitful. Skies are lowering or smiling. Townscapes are awe-inspiring or tawdry, bustling with life or eerily silent. The feel of sweat dripping and humid air pressing on the skin is evoked, or the tingle caused by cold. And the best descriptions convey not only the emotive flavour of a scene, but also the smells - more evocative than any visual description.

The instinct for attaching an emotional assessment to a place has often been expressed by awarding distinctive sites their own deity. Mountain, stream, grove and forest have been conceived of as being inhabited each by its own spirit, powerful or minor according to the nature of its domain, to which visitors were well-advised to pay respect. The idea must have been a useful one, encouraging people to give proper attention to the nature of the terrain. For instance, thinking of a mountain-god as a powerful figure, readily angered, should convey to the inexperienced that mountains can be particularly dangerous places.

A scientific account of fun

Play is exploration applied to subjects other than geography. It's the experimentation by means of which a juvenile animal investigates its own physical potential, simultaneously discovering what can and can't be done with the components of the landscape around it. Whereas exploration enables an animal to plan where to fulfill its needs, play provides the knowledge that allows it to plan how.

If young animals are studied closely it's clear that the rewards of play come from the development of new skills and the discovery of new features of the world about them. New motor patterns are practised until they can be performed without thought, and then appear less frequently. Objects are thoroughly investigated by whatever means the species possesses, and then put aside. The theories formed as a result of the investigations may be checked again by further experiment, on future occasions. But once the knowledge is secure attention will be turned to other subjects, or to new variations and extensions of the established skills. In other words, the fun comes from forming schemata about what the self can do, and about the objects that things can be done to or with.

Making connections between simultaneous experiences in different sensory channels is clearly part of this. The feel of the arm making a hitting motion, the sight of the hand striking the toy and the feel of the impact all become connected to the noise that results; and the sight of the hand missing the toy can be related to the absence of the usual noise.

Where larger brains provide the means of building a greater variety of schemata more abstract discoveries can also provide fun. Psychologists of the sixties and seventies, studying learning in human infants, began to realise that their subjects often looked as if they were as interested in working out the rules according to which rewards materialised as in obtaining the rewards. They seemed to be trying out strategies, and as the experiment progressed showed expressions of concentration, surprise, pleasure or disappointment. It looked as if the experiments devised by the psychologists were treated by their young subjects as if they too were carrying out experiments, with similar motivation.

Sometimes the apes involved in learning experiments give the same impression. A psychologist told a story of realising during a research session with a chimpanzee that it might have to be curtailed because he hadn't provided a large enough supply of the grapes he was using as rewards. But when the grapes ran out the chimpanzee continued performing the tests, and started returning a grape to the experimenter after each was completed.

Jerome Kagan, pondering the significance of the smile in infants, observed that it often seemed to occur *when the infant matches stimulus to schema - when he has an 'aha' reaction; when he makes a cognitive discovery*. For instance, when a regular representaton of a human face is presented to a very young infant *there is a short period during which the stimulus is assimilated to the schema and then after several seconds, a smile may occur. At eight months the face is recognised immediately but* *there is less likely to be a smile*. Now, however, a smile may be elicited by a picture of a distorted face. This and other experiments led Kagan to conclude that stimulus patterns which require *an active process of recognition* are a source of pleasure. But there's no such reward from input that's too easily assimilable, or too difficult.

At every age, in fact, we like something that is a little bit novel, but not too novel to make sense of. Setting up new neuronal connections somehow results in a reinforcing feedback. This feedback must play a large role in the smile-evoking capacity of jokes, which usually give a novel twist to a wellknown idea. Jokes too might be said to involve *an active process of recognition*. So, indeed, does looking at pictures, reading books, watching theatre or films. To entertain there must be novelty, or a degree of complexity such that there is always something new to discover; but total incomprehensibility repels.

Do humans ever quite grow up?

The light-hearted business of play is usually confined to juvenile animals, still living under the protection of mother and provisioned by her in one way or another. When maturity arrives play is generally replaced by the more serious, adult satisfactions to be obtained from exploration. Geographical exploration can't usefully start earlier, for the neuronal wiring that is essential to mapping must first mature. What helps to keep the youngster from trying it, though, must be the urge to stay close to the reassuring familiarity of mother, or the den. The mapmaking facility is ready for use by the time the animal has grown to adult size, has discovered and developed its own physical abilities and investigated the more interesting aspects of the world around it, and is feeling capable and confident. Now pleasure can be derived from putting this knowledge to work. And in adulthood the demands of maintaining a territory, finding food, finding a mate and producing young, generally combine to use up all the available energy. If there is any energy to spare the best policy may be to conserve it, in case it's required for a sudden emergency.

In some species play may continue into adulthood, however. When play is observed in adult animals it's usually in a social species, and the benefit is assumed to be that social bonds are thereby strengthened. In other words when individuals derive pleasure from their interactions the group functions better as a co-operative unit. Large-brained species are also more likely to indulge in adult play than smaller-brained ones. This probably reflects a correlation between brain size and the reinforcement to be derived from play, but the picture is confused by the fact that large brains make their possessors more efficient at acquiring food, so there's more likely to be time and energy to spare. Captive apes and monkeys spend more time in play (provided they are kept in suitable social groups and in large and adequately furnished enclosures) than do wild animals, and more time in experimentation with whatever objects are available. Spared the dangers of the wild and needing to spend no energy on finding food and water (maintained, in other words, in much the same protected and leisured conditions that characterise childhood), they have plenty of leisure to fill. We humans are just the same, of course. We play when there's time and energy left over from doing the things that seem more essential to survival; and even in adulthood there is often time to spare.

Some of it may be devoted to sport and games. But many of the more serious activities undertaken in adulthood can qualify as sophisticated forms of play, for they're obviously similarly motivated by the reinforcement we gain from the development and maintenance of schemata. Our devotion to this sort of reinforcement is probably the most defining characteristic of *Homo sapiens.* It's what drives artists, scientists and inventors, philosophers, lawmakers and the creators of religions. It's responsible, too, for the fact that some people put much energy into decorating their homes, while others go in for elaborate cooking, or devote considerable attention to dressing stylishly.

In fact humans often seem to obtain a higher degree of reward from the pursuit of new ideas than from more vital and long-established forms of reinforcement, cheerfully postponing the latter to pursue creative activity. Children don't want to come in for tea until they've finished their game. Teenagers are capable of using their lunch money to go to a film, or to buy a lipstick with which to create a new face. The artist may be willing to starve in a garret, the scientist not only fails to look for a more profitable career but stays up all night to watch experiments, and the explorer is even prepared to risk his life. The intellectual reward can take precedence over mere matters of food, drink or sleep, at least until the need for sustenance or sleep becomes really pressing. It's in the neuronal mechanisms which produce this avid pursuit of new schemata that the essential key to the evolution of reason must lie.

There's reward in the commissioning of a new neuronal circuit, whether it embodies a piece of wholly original thinking or an idea that has been conveyed from outside, having been born in another brain (which luckily means that artists, scientists and other creators don't always have to starve in a garret). Establishing a significant new schema provides a great buzz. A good story, or a scientific theory that makes several previously disparate facts hang together, or a painter with a new and distinctive vision, or anything else that expands the mind and the understanding, can be a source of delight.

The ability to obtain reward from acquiring another individual's ideas must have been important in the evolution of large brains. It would increase the probability that when someone invented a new tool or a new technique the idea would be passed on to their offspring. If beneficial ideas died with their inventors there would be little selective pressure to promote the survival of the genes that make for inventiveness. The idea itself, meanwhile, stands a better chance of lasting survival if others not only imitate it but gain an intellectual pleasure from it, as well as the physical reinforcement obtained by its application. Once the ability to reap pleasure from a new schema was firmly in place ideas which didn't lead to immediate physical rewards could also be appreciated. In a society in which cultural transmission was well developed large and inventive brains will have begun to produce seriously valuable dividends.

The capacity for cognitive pleasure varies from individual to individual, of course, and is influenced by both genes and nurture. An animal whose juvenile period coincides with a time of severe food shortage or constant danger, so that it lacks the opportunity for play, won't discover the joys of that sort of learning. The same goes for a human infant raised in an environment that is lacking in stimulation, or one whose curiosity is constantly discouraged. Conversely, the more a juvenile experiences of the pleasures of investigation and experimentation the more likely he or she is to pursue them in later life.

But the underlying strength of the urge to explore and investigate is determined by the genes, and some of the genetic variations that make for exceptionally curious individuals have been unveiled. Since curiosity is a trait which leads to risk-taking, and since the fellow members of a group can benefit from the discoveries of the few, populations should tend to thrive best if there is a fair degree of variation here. A downside of the trait is that when individuals with a strong need for cognitive reinforcements don't get the chance to learn how to satisfy that need in ways that are useful to society they are likely to look for other means of obtaining excitement.

Humans have extra opportunities to become hooked on the pleasures of creating new schemata thanks to the efficient means of conveying schemata from one brain to another provided by language. The possibilities have been expanded further with mathematical language, and devices such as diagrams. The possibility of transferring ideas easily means that the individual encounters far more schemata than they could possibly create on their own. Such frequent encounters (as long as they are not too demanding and therefore aversive) must tend to intensify the addiction to establishing new neuronal circuits.

It's worth remembering, though, that today's world of constant change and innovation is not typical of the cultural environments to which humans were exposed even in the comparatively recent past, let alone in more distant times. Large brains and a taste for new ideas must have been around a long time before they altered human society to such a degree that new ideas could spread quickly and widely, and thereby interbreed easily with other new ideas. Among ancient hunter-gatherer groups the invention of a new tool, perhaps even a new story, must have been a rare event. Or perhaps one invention sometimes sparked a few more, and there were bursts of creativity followed by long pauses. The arch-aeological record shows that there can have been no ongoing tradition of looking for new ways of doing things. The imitation that sustains culture is its strongest element, and the normal situation has been that the vast majority of people assume things will go on the way they apparently always have done. Despite the possibilities opened up by large brains, leisure and playfulness, only the occasional genius introduced something new. In small societies with restricted horizons the very idea of pursuing novelty would have been novel. We can be pretty certain of this because it's the attitude more likely to promote survival. The old ways of doing things have been tried and tested, and only occasionally cease to work, while innovation often involves risks.

However, it's clear that the human brain, in an encouraging environment, is capable of creating schemata in enormous numbers. Humans also seem to be alone among species in being capable of becoming dedicated to an idea to the extent of sacrificing physical wellbeing.

Recapitulation

The evolution of cognitive brains, brains that create conscious experience out of sensory input and in the process build schemata about the world, must have been accompanied by the evolution of a drive to use that machinery and a capacity to obtain reinforcement from doing so.

The investment in such complex neuronal machinery could not have paid off otherwise.

Where there's conscious sensory experience there's a satisfaction in that experience (sometimes even in exploring painful experience).

There's also reinforcement to be had from the investigatory behaviour that sensory consciousness requires to make it profitable, as well as in the resulting knowledge that makes useful predictions possible.

Conversely, it's unpleasant to be deprived of sensory experience, or to lack the knowledge which would support predictions.

These pleasures and displeasures have been called cognitive emotions. They are what motivate exploration and play.

Other cognitive emotions are familiarity and unfamiliarity, which function as feedback about the relation of current sensory input to the contents of the schemata store.

Cognitive emotions, like physical pleasures, pains and discomforts, are somewhat ambivalent. Whether familiarity and unfamiliarity are pleasurable or otherwise, and whether exploration is attractive, depends on the current state of the organism.

A uniquely highly developed capacity to obtain reinforcement from establishing new neuronal connections and discovering new ideas seems to be the most important distinguishing characteristic of *Homo sapiens.*

Language has played an important part in promoting this trait.