Early Brain Development

Neural Structure

The brain processes information by forming networks of nerve cells called neurons. Neurons communicate with one another using electrical and chemical signals.

Early Brain Development

Human life begins with a sperm and egg, each carrying 26 chromosomes. These gametes (sex cells) fuse in a process called fertilisation to produce a single cell (a zygote or fertilised egg with 46 chromosomes). The cell divides into two cells via mitosis to produce two genetically identical cells. Mitosis continues and the 2 cells become 4, 4 become 8, 8 become 16 and so forth. At 3 weeks brain development really begins in an embryo as the spinal column/cord and head begin to form. The rudimentary heart is beginning to beat, at 4 weeks the head is more definite and the umbilical cord through which oxygen, nutrients and waste will move is more evident. The embryo is 4mm in size.

By 8 weeks, the human fetus has a sense of touch and is exploring the umbilical cord and uterine wall.

By 13 weeks, the human fetus has a sense of taste and prefers sweet over bitter.

By 17 weeks, the human fetus has a sense of hearing and after birth will recognise songs played during gestation.

By 25 weeks, the human fetus has eyes that close for sleep and open and move freely during periods of wakefulness.

During early developmental stages, the nervous system is derived from stem cells which transform into neurons (nerve cells). True neurons form around day 42 and all major nervous system structures are in place by 56 days. The brain is complete by halfway through pregnancy meaning the unborn child can move and hear sounds.

Neural Structures

The brain is a network of neurons with about 90 billion in total. The brain processes information by forming networks of nerve cells called neurons. Neurons communicate with one another using electrical and chemical signals.. A neuron consists of a cell body, the branch-like structures of multiple dendrites and an axon which may have numerous axon terminals, and the axon and its terminal branches relay outgoing signals to other neurons. One neuron has many connections with other neurons - it is part of a network of neurons.

Brain Stem

Early Brain Development (cont)

The brain stem is the part of the brain which connects to the spinal cord.

Motor & sensory functions - carries motor and sensory nerves to the brain from the rest of the body via spinal cord.

Automatic functions - Controls many basic life functions such as heartbeat, breathing, sleeping and eating. Many of these functions are controlled by the automatic nervous system. It is automatic, meaning we do not have to consciously direct our heart to beat or stomach to digest food.

At birth the brain stem is the most developed part of the brain, whilst the rest of the brain continues to develop throughout infancy however the brain stem is important in directing basic, automatic behaviours and needs to be well developed for survival.

Cerebellum

Cerebellum means 'little brain'. It is located near the top of the spinal cord. It plays a very important role in the co-ordination of movement, eg. your balance. It also co-ordinates sensory information with motor activity - called sensorimotor. And finally, the cerebellum also has some input into other functions such as language and emotions.

Thalamus

The thalamus is located deep within the brain. In fact there are two of them - one in the left half and one in the right half (each half of the brain is known as a hemisphere). You can only see the thalamus if you cut the brain in half, it is the size and shape of a walnut.

The thalamus acts like a hub of information - receiving signals from other areas of the brain and sending signals on, for example:

The thalamus recieves sensory signals from the retina in the eye and sends the signals on to the visual area where visual information is processed.

The thalamus also co-ordinates motor signals, sending information from the motor area to the body.

Cortex

This is the principal part of the brain, also called the cerebral cortex. The cortex is divided in two hemispheres, each hemisphere has more or less the same structure.

The word cortex means 'bark'. The cerebral cortex is the outer covering of the brain, which is like a tea cosy covering the other structures, the cortex is only 3mm thick and only found in mammals.

Early Brain Development (cont)

All our thinking and processing goes on in this layer of the brain, it is very thin however it is very folded.

Thinking, or cognition, mainly takes place in the frontal cortex, the part of the brain behind your forehead.

Sensory processing takes place in various places such as the visual area at the back of the brain and the auditory area (hearing) at both sides of the brain.

Motor processing is controlled by the motor area also at the sides of the brain, near the top. The motor area directs movement.

The sensory and motor areas of the cortex are functioning in the womb - the developing baby starts to learn sensorimotor coordination. At birth the cortex is still fairly primitive and goes on developing throughout our lives.

Brain Development After Birth

At birth, the brain already has about all the neurons it will ever have. It will double in size in the first year and by age 3 reach 80% of adult size in volume. Synapses form rapidly. At age 2/3 the infant brain has twice as many synapses as an adult brain, throughout childhood and adolescence, pruning occurs and synapses are lost. This allows the brain to become more attuned to its environment. Changes in the brain occur until about your mid 20s. The brain exhibits plasticity throughout life.

Both nature and nurture influence brain development. Early stages are heavily influenced by nature as the brain is constructed and organises itself to receive information from the environment. As information from the senses (nurture) is passed to the brain it stimulates neural activity and begins to establish neural networks and synaptic connections. At this point you can begin to see how nurture influences the brain. Neural networks and synaptic connections are established through repeated use and exposure, the opposite is also true; they are lost if not utilised (pruning).

Year One

- Recognition of faces and discriminate facial expressions (happy or sad)

- Cerebellum triples in size due to rapid development of motor skills

- Visual areas of the cortex develop to allow binocular vision

- Around 3 months the hippocampus shows growth relating to memory

- Language circuits in the frontal and temporal lobes become consolidated and are influenced by what an infant hears

Early Brain Development (cont)

- Throughout the first year, an infant learns to discriminate between languages and becomes wired to their native tongue.

Year Two

- The language areas of the brain develop further coinciding with an increase in language abilities

- Vocabulary quadruples between the first and second birthday

- Higher level cognitive abilities develop - self awareness becomes evident (recognition of reflection)

Year Three

- Synaptic density in the prefrontal cortex reaches maximum density - 200% of an adult

- Networks and synapses are strengthened as cognitive abilities develop and improve

Nurture has an enormous influence on brain development, particularly in the early stages of life. It is during this phase of our development that parents, caregivers and communities can have a huge impact on a person's chances of achievement and happiness. Clearly, children require a stimulating environment, with opportunities to play in creative and challenging ways. If this is not the case, children are deprived of stimulation in these formative years and it can potentially harm their intellectual development. However, the brain is adaptable and it is possible that periods of deprivation can be overcome.

Evidence of this includes...

- Eastern European children taken from orphanages (deprivation due to lack of stimulation) and adopted by British families in the 80s

- Once adopted, physical and mental health improved dramatically

- Physical development was rapid: however mental development was slower - when they compared with their peers

- These children will be monitored throughout their lives to assess the long term consequences of the experience they encountered in orphanages

Nature & Nurture

One of the biggest questions in psychology. Are we born or made?

Nature - refers to things you have inherited, which are present from the moment that the first cell is formed

Nurture - refers to any other influence such as the kind of home we grew up in, what we eat and experiences we may have had.

Things that effect the growing brain include...

Smoking

Early Brain Development (cont)

It is fairly well known that mothers who smoke give birth to smaller babies. Smoking affects the size of the brain as well as the body due to nicotine slowing brain growth. Nicotine also causes narrowing of blood vessels, reducing blood flow and nutrition from placenta.

Infection

It is also fairly well known that pregnant mothers should avoid contact with anyone with rubella. One of the effects of rubella being brain damage, especially hearing loss if illness is developed within first 20 weeks of pregnancy. Although this is biological, it still counts as nurture as it is the baby's environment which has caused the effect.

Alcohol

Heavy drinking during pregnancy leads to FAS, linked to problems such as having a smaller head and an underdeveloped brain, with central nervous system damage.

Spina Bifida

Folic acid deficiency - leads to the baby's neural tube (tissue from which brain and spinal cord develop)being unable to close properly. This leads to malformations of the brain and spinal cord, folic acid is found in green leafy vegetables, broccoli, beans, citrus fruits and liver. Diet therefore can effect development of the brain.

Stress

Mother's stress during pregnancy may increase the risk of brain malfunction in baby due to release of hormones such as adrenaline (affects blood pressure) and cortisol

Syphilis

A bacterial disease that can be passed from mother to foetus. Early in the pregnancy, the development of the CNS may be affected; can cause baby to have meningitis or excessive fluid on the brain which can cause mental retardation.

Toxoplasmosis

An infection caused by a parasite found in undercooked meat and cat faeces. The pregnant mother won't show any symptoms but the infection can be passed from mother to child. Children may develop learning disabilities, movement problems, mental retardation and vision loss.

Voices

Babies appear to recognise their mother's voice immediately after birth (suck on a special device more if a tape of their mother's voice is played than of a tape of someone else). This shows that the brain is changing before birth in response to external stimuli.

Early Brain Development (cont)

The interaction between nature and nurture

At one time psychologists talked about whether our characteristics and abilities were due to nature or nurture. Nowadays nobody thinks in terms of one or the other - they both operate at the same time. So your brain is the product of your genes but from the minute the first cell was fertilised, the environment has had an effect on your development.

Genes (nature) provide a blueprint for the brain, but the environment & experience (nurture) influence construction and eventual outcome.

Piaget (Introduction)

One of the first people to investigate early development was Piaget, a Swiss born Biologist who dedicated a great deal of time to how children develop and learn. He came to the conclusion that children think differently than adults.

He enshrined his ideas in an idea known as 'cognitive development'; referring to the way a person's knowledge, thinking and intelligence changes as they get older. In psychology the term cognitive is used to refer to mental processes, especially thinking.

Assimilation

New information or experiences that can be fitted into the child's existing schema or understanding of the world. A child sees a kitten and is able to fit this into the same schema as the schema for cat.

Accommodation

New information or experiences cannot be fitted into the child's current understanding so they either have to alter existing schemas or create a new schema; eg. a kitten would not fit under the schema for car, so a new schema needs to be constructed, bringing about a structural change.

A schema is a mental structure containing all the information we have about one aspect of the world.

Equilibrium and Disequilibrium

If a new experience does not match existing schemas, then a state of disequilibrium is produced. The child needs to accommodate to restore the balance. According to Piaget, disequilibrium is essential for learning.

Evaluation

One strength is that Piaget's theory has led to an enormous amount of research to test his ideas.

Piaget (Introduction) (cont)

Scientific theories depend on research evidence to demonstrate whether the theory is right or wrong. Piaget's ideas have led to a large amount of research studies, such as Donaldson's 'naughty teddy study' and Hughes 'policeman doll theory'. These studies didn't fully support Piaget but they help us adjust aspects of his theory.

The test ability of his theory is a good thing because if we can test his ideas, we can be more certain if the theory is correct or whether it needs some refining.

Another strength is how Piaget's ideas have influenced classroom teaching across the world. He proposed the children should be allowed to explore the world around them and develop their ideas to produce highly complex schemas. He proposed that children should not be taught in rows of desks, they should be given work that challenged them and allowed them to try and work out a solution - this became known as activity orientated learning. It allowed children to become engaged in tasks that allowed them to construct their own understanding of the curriculum.

One weakness is that Piaget's research involved middle-class European children.

Piaget developed his theory from research studies he conducted where he lived in Switzerland. The children were from European academic families. In other cultures and social classes, greater value may be placed on, for example, a more basic level of concrete operations (i.e) making things rather than thinking about abstract ideas.

Therefore his theory may not be universally applicable

Piaget Cognitive Development Theory

Piaget's theory of cognitive development suggests that children move through four different stages of mental development; these stages being:

Sensorimotor Stage (birth to 2 years)

Preoperational Stage (ages 2 to 7)

Concrete Operational Stage (ages 7 to 11)

Formal operational stage (ages 12 and up)

The Stages

Through his observations of his own children, Piaget developed a stage theory of intellectual development that included four distinct stages:

Sensorimotor Stage

Major characteristics and developmental changes:

Piaget Cognitive Development Theory (cont)

- The infant knows the world through their movements (motor) and sensations (senses).

- Children learn about the world through basic actions such as sucking, grasping, looking and listening

- Infants learn that things continue to exist even though they cannot be seen (object permanence)

- They are separate beings from the people and objects around them

- They realise their actions can cause things to happen in the world around them

Preoperational Stage

- Children begin to think symbolically and learn to use words and pictures to represent objects

- Children at this age tend to be egocentric and struggle to see things from the perspective of others

- While they are getting better with language and thinking, they still tend to think about things in very concrete terms. dominated by a world view they can sense; however, they are starting to develop internal representations (schemas) of the world due to language development (starting to think about the world)

Concrete Operational Stage

- During this stage, children begin to think logically about concrete events - things they experience through their senses, although they still struggle to deal with abstract ideas and concepts and to imagine objects or situations they cannot see. An example would be to tell them that Ben is taller than Tom but shorter than John and asking them to place the boys in order of height. They cannot do this as they cannot visually internalise.

- They become decentered (less egocentric) and can see the world through the eyes of others.

- They begin to understand the concept of conversation; that the amount of liquid in a short, wide cup is equal to that of a tall, skinny, glass for example.

- Their thinking becomes more logical and organised but still very concrete.

- Children begin using inductive logic or reasoning (Piaget called these operations) from specific information to a general principle.

Something that is 'concrete' can be experienced through your senses, such as touch or vision.

Piaget Cognitive Development Theory (cont)

Something that is abstract exists in your mind but doesn't have a physical or concrete existence.

Formal Operational Stage

- At this stage, the adolescent or young adult begins to think abstractly and reason about hypothetical problems.

- Abstract thought emerges

- Teens begin to think more about moral, philosophical, ethical, social and political issues that require theoretical and abstract thinking.

- Begin to use deductive logic, or reasoning from a general principle to specific information, critical think skills develop

- Around 30-40% of the population are believed to never make it to this stage

Abstract Thinking

The ability to think about objects, principles and ideas that are not physically present; related to symbolic thinking, which uses substitution of a symbol for an object or idea.

Everyday behaviours that constitute abstract thinking include:

- Using metaphors and analogies

- Understanding relationships between verbal and non-verbal ideas

- Spatial reasoning, sudh as critical thinking, scientific methods and other approaches to reasoning through problems

Evaulation

Underestimated children's abilities - A weakness with Piaget's theory. Other research has found that younger children can show conservation and a reduction in egocentrism. This suggests that certain types of thinking develop earlier than he proposed.

Overestimated children's abilities - A weakness with Piaget's theory. He argued that 11 year old children should be capable of abstract reasoning when other research (eg. Wason's card task) found this to be untrue. This shows that not all children's thinking is advanced as he suggested.

Basic idea is correct - a strength with Piaget's theory; showing children's thinking changes with age. Although research has suggested that changes in thinking occur earlier, the fact remains they still occur, thus showing the basic principle of the theory is valid.

Application of Piaget's Ideas to Education

Readiness

According to Piaget, each stage of cognitive development appears through the natural process of ageing. Therefore in his view, you could not teach a child to do certain activities before they are biologically ready. E.g. Trying to teach a pre-operational child to perform abstract mathematical calculations would be a waste of time.

For real learning to take place, activities should be at the appropriate level for a child's age. If a child is not mature enough, they would only acquire skills superficially. In order to truly understand and become competent, it is important to wait until the child is ready.

Learning By Discovery & The Teacher's Role

Piaget also believed that, in order for true understanding to develop, a child must discover concepts for themselves rather than rote-learning material that is given to them. It is important that children play an active role in their education.

The teacher's role is to create an environment which will stimulate children to ask questions. The teacher should plan activities so that a learner is challenged to accommodate current schemas to cope with new information, thus assimilation and accommodation will take place and a child's thinking will develop.

Individual Learning

Piaget's theory claims that all children go through the same developmental stages in the same order; however, they do so at different rates. Because of this, teacher's must make a special effort to arrange classroom activities for individuals and groups of children rather for the entirety of a class group.

Application to Stages

Sensorimotor Stage - Provide a rich stimulating environment with opportunities to experiment with sensory experiments and learn motor co-ordination. For example, allowing a child to play with toys that squeak when squeezed.

Other activities: Giving child rattling and squeaking toys, play 'clapping' games, play 'peek-a-boo' & use sand, water and other materials that can be shaped.

Pre-operational Stage - Games that involve role play and dressing up may reduce egocentricity. Hands on activities with, for example, Plasticine, allow children to experiment with quantities (discovery learning). Focus should not be on written work but experimentation

Application of Piaget's Ideas to Education (cont)

Other activities: Playing dressing up games, encouraging child to play a character, asking child to cut letters out of magazines to make words.

Concrete Operational Stage - Children should be given concrete materials to manipulate, for example, an abacus to develop numerical skills. Cooking is a useful activity because it involves practical work and involves following a logical sequence of instructions

Other activities: Following a recipe to create cupcakes, writing a short story on 'my life as a dog', making a coca cola and mentos rocket

Formal Operational Stage - Scientific activity will help develop an understanding of logic. Discussions in groups enable young people to think about things like what their ideal world would be like (idealistic thinking)

Other activities: Turning data into graphs, charts and diagrams, setting up a classroom debate.

Practical Application

Piaget (together with Barbel Inhedler) did a number of studies to test formal operational thinking. In the pendulum task children were given a length of string and a set of weights. The task was to consider what factor was most important in determining the speed of swing of the pendulum. The children could vary the length of the string, the heaviness of the weight and/or the strength of push.

To solve the problem a child needed to systematically vary each of the three variables. Piaget found that older children did this. They tested one variable at a time to see its effect (such as varying the length of the string). Younger children typically tried out these variations randomly or changed two things and the same time.

Evaluation

One strength of Piaget's theory has been the enormous effect it has had on primary education in the U.K.

The Piowden Report was published in 1967 to review primary education in the U.K and make recommendations on changes which were needed. The report drew extensively on Piaget's theory and recommended new child-centred, active approaches to primary school education in the U.K. Such child-centred education ran counter to the more teacher-centred, rote learning educational practises of the time.

This demonstrates the value of Piaget's theory for education.

Application of Piaget's Ideas to Education (cont)

One weakness is that Piaget's stage-based approach suggests that practice should not improve performance if a child is 'not-ready' - but not all research supports this.

If 'readiness' is important then no amount of practice should enable a child to do something at a younger age. It's like trying to make a fruit ripen before its ready - it kind of works but you end up with something a bit woody and tasteless.

Peter Bryant and Tom Trabasso (1971) showed that pre-operational children could do some logical tasks if they were given practice. The researchers argued that the reason they couldn't do the tasks was because their memory skills needed practice rather than because of their lack of operational (logical) thinking. When pre-operational children practised solving simple comparisons (A > B) and gradually built up to more complex tasks they could cope, showing that practice, not readiness, mattered.

This challenges the notion that education should be centred around Piaget's stages of development because children don't have to be ready.

One weakness is that Piaget's emphasis on discovery learning may not always be the best approach.

A study by Neville Bennett (1976) compared traditional formal methods of teaching with Piaget's more child-centred active approach. More formal methods involve a teacher explaining a task to a whole class and children do lots of exercises to give them repeated practice. Active methods permit children to experiment for themselves to see what works.

Bennett found that children taught using the more formal methods did better in subjects such as reading, maths and English than children taught using a more child-centred active approach.

This suggests that at least some aspects of learning are best taught through direct instruction rather than active learning.

Ego-centrism