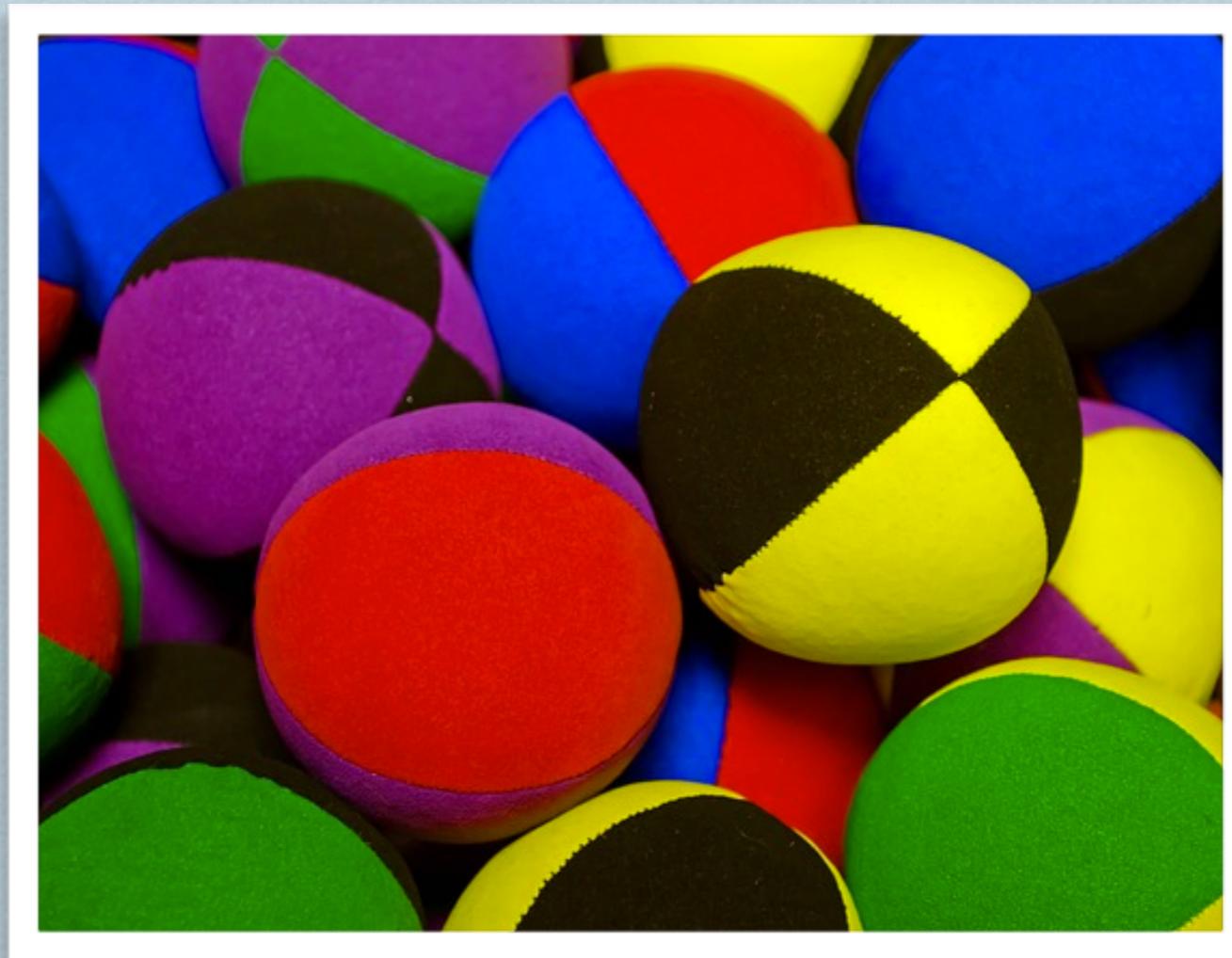
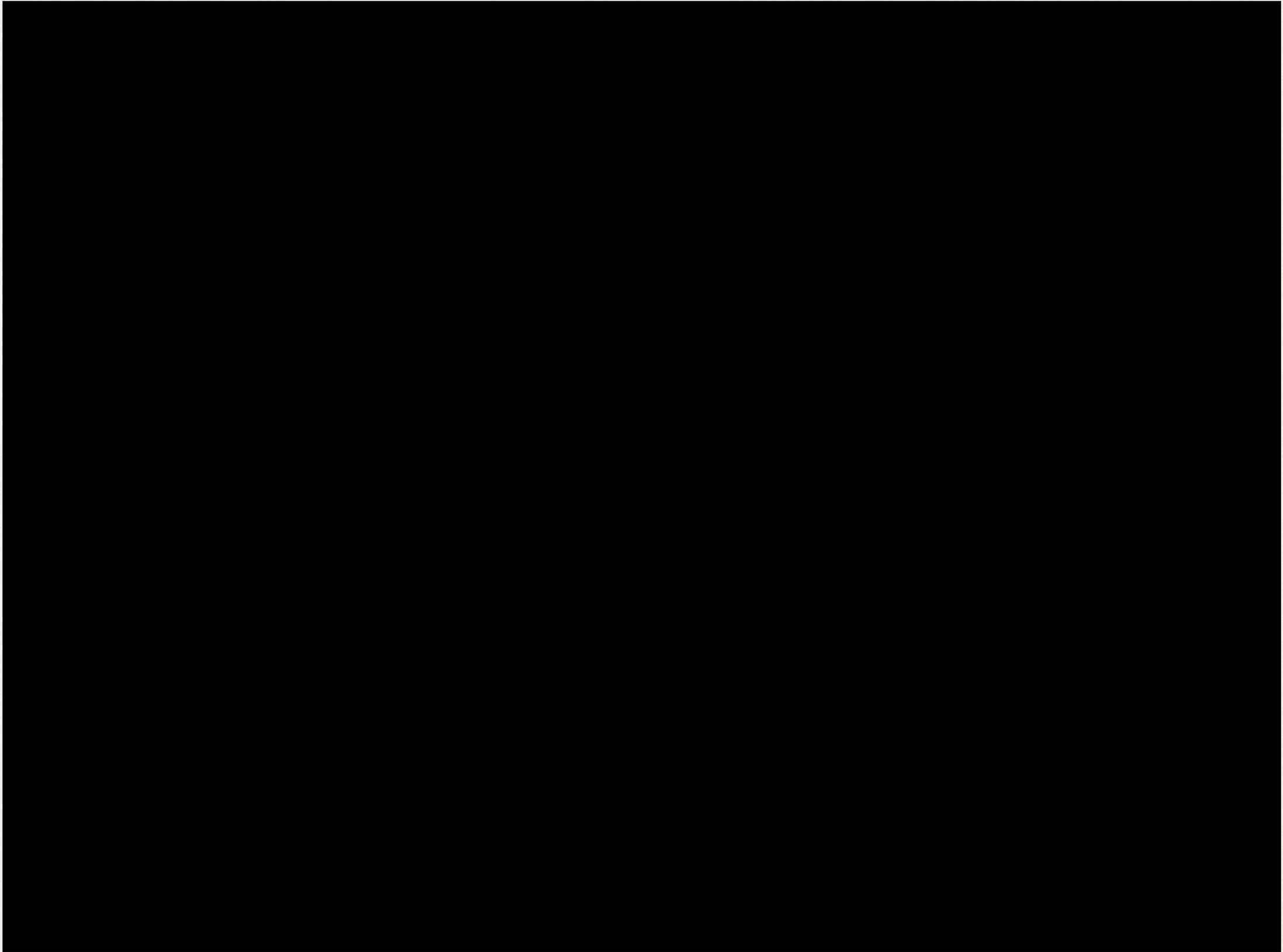


Plasticity of the Brain



**What does juggling have to do with brain plasticity?
Find out on slide number 9.**

A living example of the brain's plasticity...



You can also view this video at: **Discovery Channel: Brain Plasticity**
<http://www.youtube.com/watch?v=TSu9HGnlMVo&feature=related>

Plasticity is the ability of the brain's neural structure or function to be changed by experience throughout the lifespan.

- This means that the brain is **adaptive**.
- It changes as a result of experience and learning.
- New connections are created between neurons as we learn and experience the world.



That's one reason why it is important for children to experience rich environments with stimulation, interaction and varied sensory experiences.

Plasticity - explanation and variations

- ❖ The brain can reorganise and reassign its neural connections and pathways based on which parts of it are used often, or used little.
- ❖ Some areas of the brain, such as the **sensory and motor cortices**, have a higher level of plasticity than others.



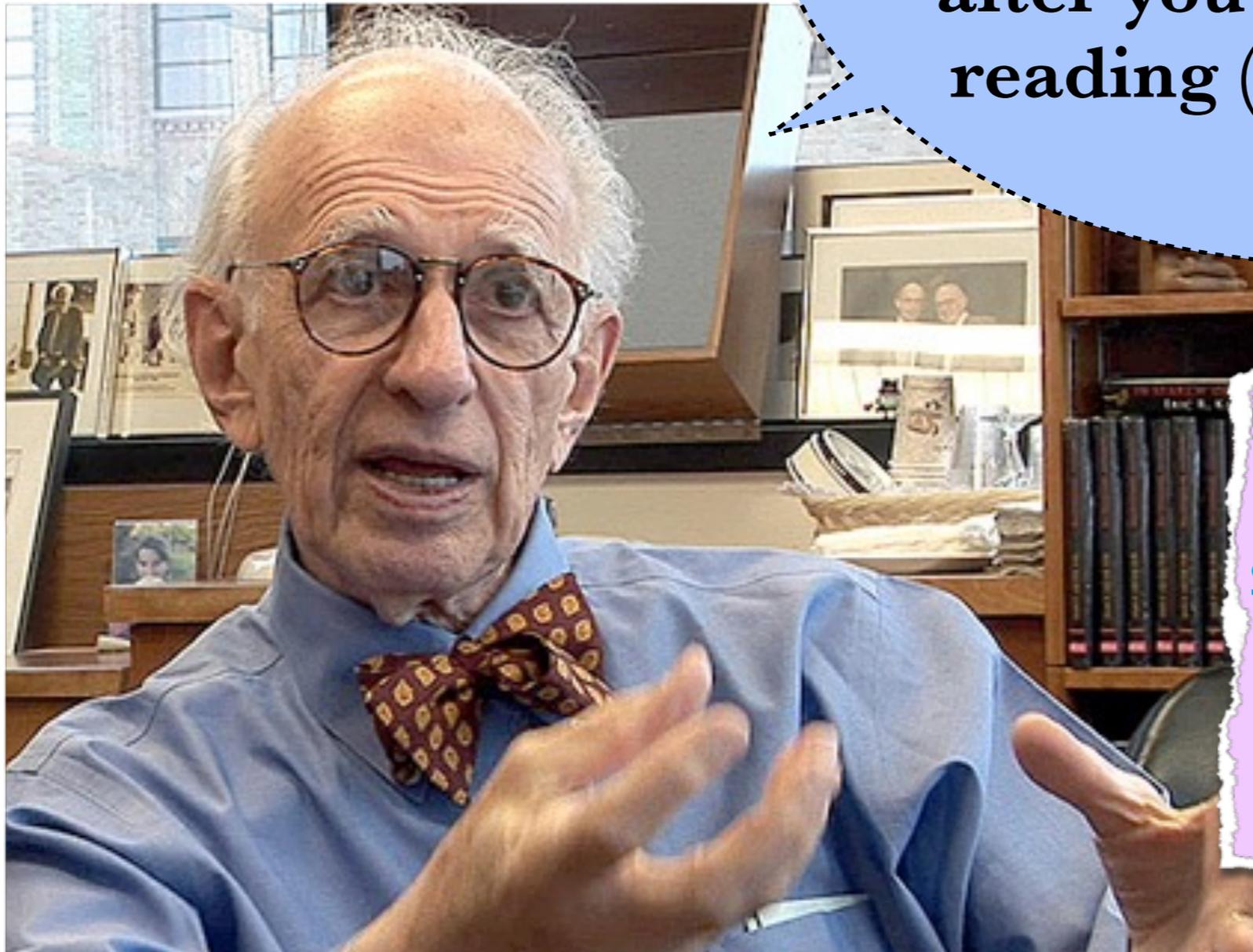
- ❖ A young child's brain is more plastic than that of an adult, particularly at specific times in development when it seems that the brain is more responsive to certain types of experiences.

- ❖ New neural networks reflect new learning and the formation of new memories.
- ❖ As new memories are formed, the strengthened neural connections underlying them mean that whenever activated, the neurons involved will be able to communicate more efficiently.
- ❖ The more a particular neural pathway is activated, the easier it is for information to travel through the circuit.

❖ This is called **long-term potentiation**: the lasting strengthening of synaptic connections of neurons resulting in their enhanced functioning.

Eric Kandel

If you remember anything of this book (or topic, lecture, etc.), it will be because your brain is slightly different after you have finished reading (or hearing) it.



When you learn something, your brain changes. That's plasticity.

Effects of mental stimulation and deprivation...

- Autopsies have shown that the brains of university graduates have 40% more synaptic connections than those of high-school dropouts (Hockenbury and Hockenbury, 2006)
- The risk of cognitive decline in old age has been found to be reduced by doing mentally stimulating tasks, including social interaction and extensive reading.
- Studies with sets of identical twins have shown that the twin who was not mentally active or who had a lower level of education was more likely to develop Alzheimer's Disease.

Two kinds of plasticity

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graph TD; A[Two kinds of plasticity] --> B[Developmental plasticity]; A --> C[Adaptive plasticity];
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Developmental plasticity occurs as brain development proceeds according to its normal maturational blueprint or plan.

Adaptive plasticity is evident when the brain recovers from trauma due to brain injury and also when changes in brain structure enable adjustment to experience.

Developmental plasticity refers to changes in the brain's neural structure in response to experience during the brain's growth and development.

Our **genes** control the overall architecture of the brain, but **experience** guides, sustains and maintains the details.



When we learn a skill, this learning is incorporated by the brain into its structure. In one study, the grey matter in the mid-temporal lobes of people who learned to juggle increased by 3-4%.

Q: When does synaptogenesis occur most rapidly?

A: Within the first few years of life

Q: What determines which connections will be retained and which ones will be pruned?

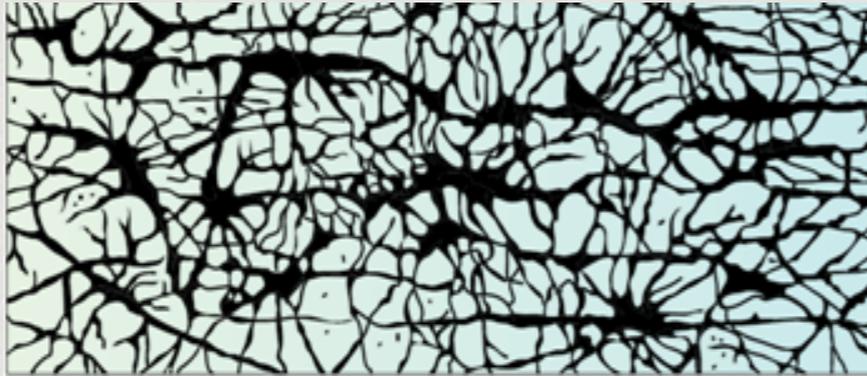
A: Use: the connections that are frequently used are retained and those that are not are pruned. The entire process occurs as if the rule 'use it or lose it' is being followed.



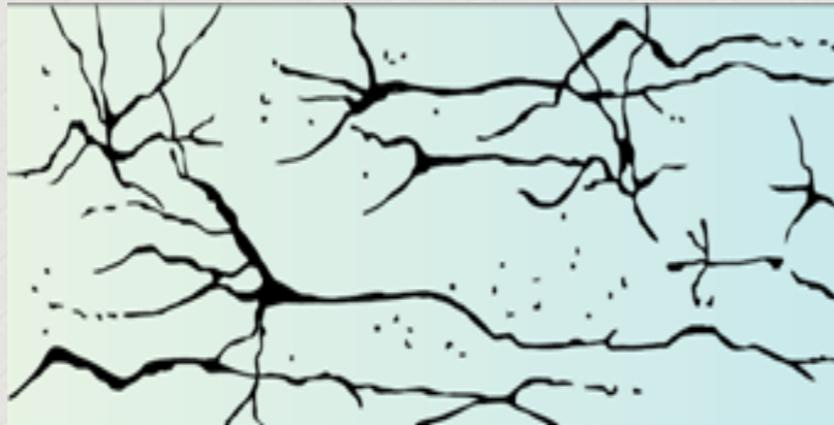


- *Babies are born with all 86 billion nerve cells.*
- *Each cell at birth synapses with around 2500 other neurons.*
- *By late childhood the number of connections increases to around 15,000 per neuron.*
- *By adulthood this number decreases to around 8,000 as unused connections are destroyed.*
- *Children's brains show greater plasticity than adults', which might explain why children learn languages faster than adults.*

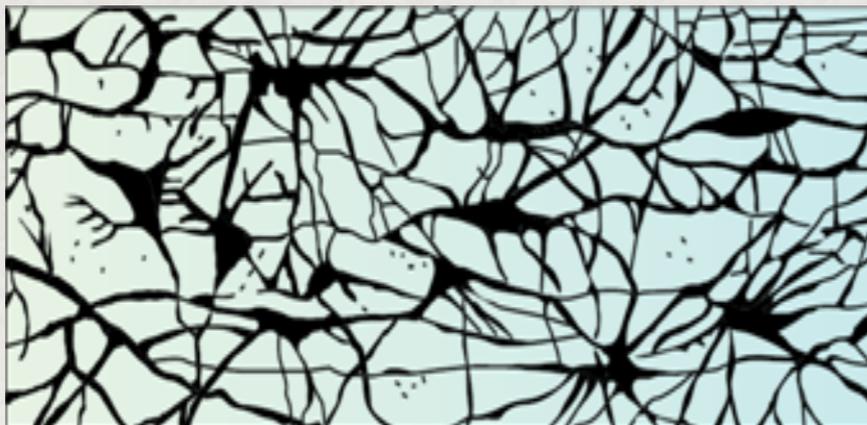
A



B



C

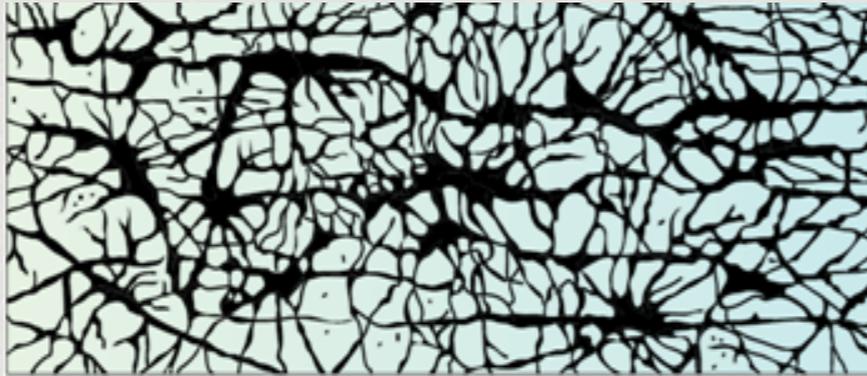


Question

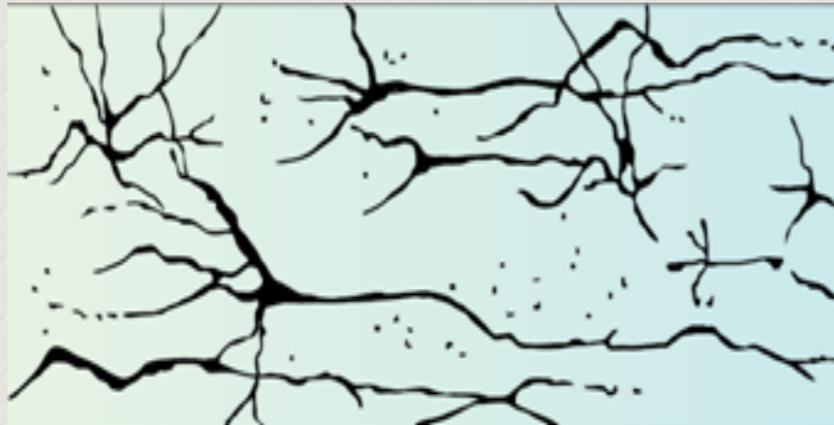
These images depict the neural connections of a baby at birth, a young child of 6 and a teenager of 14.

Which do you think would go with which?

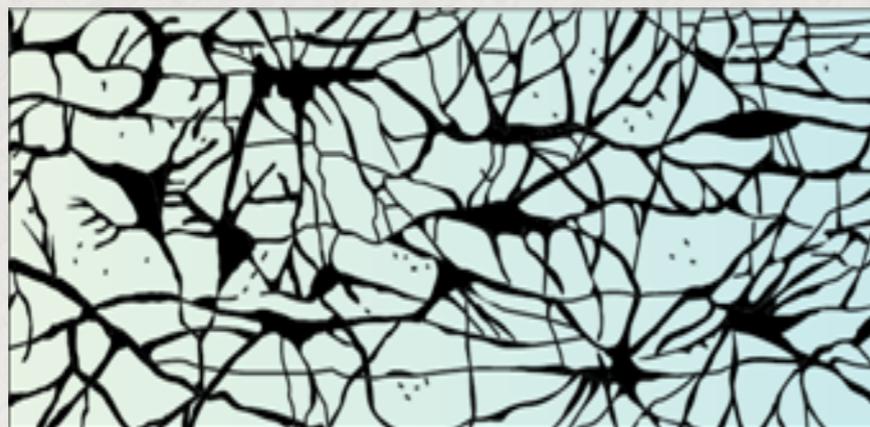
A



B



C



Answer

A represents the brain of a six-year-old.

B represents the brain of a newborn baby.

C represents the brain of a 14-year-old.

Developmental plasticity

A **sensitive (or critical) period** is a specific period of time in development when an organism is more 'sensitive' or responsive to certain environmental stimuli or experiences.



Developmental plasticity

Another language is most easily acquired during a sensitive period in development and is more difficult and time-consuming (and may not be as successful) if undertaken outside the ‘window of opportunity’.



In relation to language learning, psychologists are not in complete agreement about the age limits for the sensitive period. Generally, the sensitive period for our native language is up to the age of about 12 years, with the window gradually closing from about age seven.

The importance of the sensitive (or critical) period

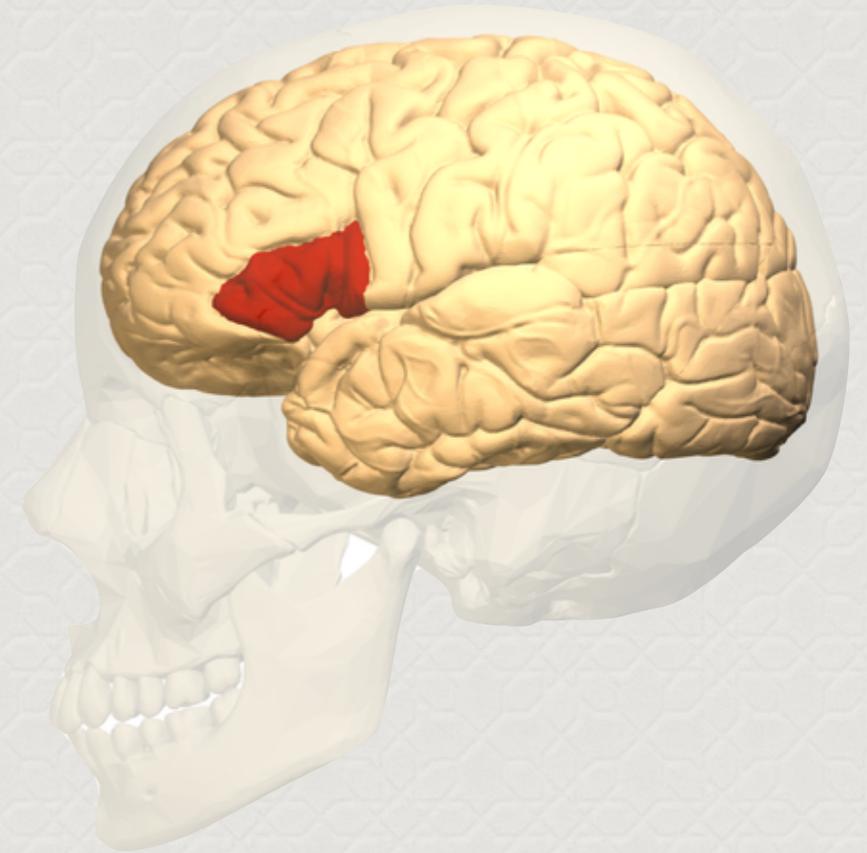
- Language acquisition is believed to have a sensitive period (some think between birth and 12 years).
- Genie, a deprived girl who for the first 12 years of her life lived without language in a kind of solitary confinement, was never able to develop normal language. It is however difficult to be certain which factors influenced this outcome.



Genie

The importance of the sensitive (or critical) period

- A child who learns two languages simultaneously in childhood uses Broca's Area for both and is usually able to be completely fluent in both languages.
- Those who learn the second language after puberty may develop a separate area for that language, adjacent to but not overlapping with the area used for the native language. This is like a second Broca's area.
- Usually this kind of language acquisition is not as natural and fluent as the language acquired as a child.



The importance of the sensitive (or critical) period



This child developed a haemangioma on her right eye as a young baby.

The importance of the sensitive (or critical) period



Doctors warned that if this growth obscured her vision in the first year or two of life, there might never be sight in that eye. The eye itself would have been intact but the time when the brain makes connections with that eye's input would have passed.

The importance of the sensitive (or critical) period



- Lack of stimulation during this sensitive period can lead to a long-term deficit.
- For instance, a closed eye from birth leads to later blindness in that eye, even when the eye eventually opens.

A happy ending...



This child was lucky. Her haemangioma never did obscure her vision and she is now a fully sighted child.



Note: A clear line cannot be drawn between the two types of plasticity.

- Both types of plasticity are influenced by **experience**.
- As Jodie's recovery after her radical surgery shows, the maturing brain of a child has the capacity to adapt to and therefore recover from trauma more effectively than the mature brain of an adult.

Adaptive plasticity can take place at any time in the lifespan. However, it is typically quicker and more substantial and extensive in the earlier years, particularly in infancy and early childhood.

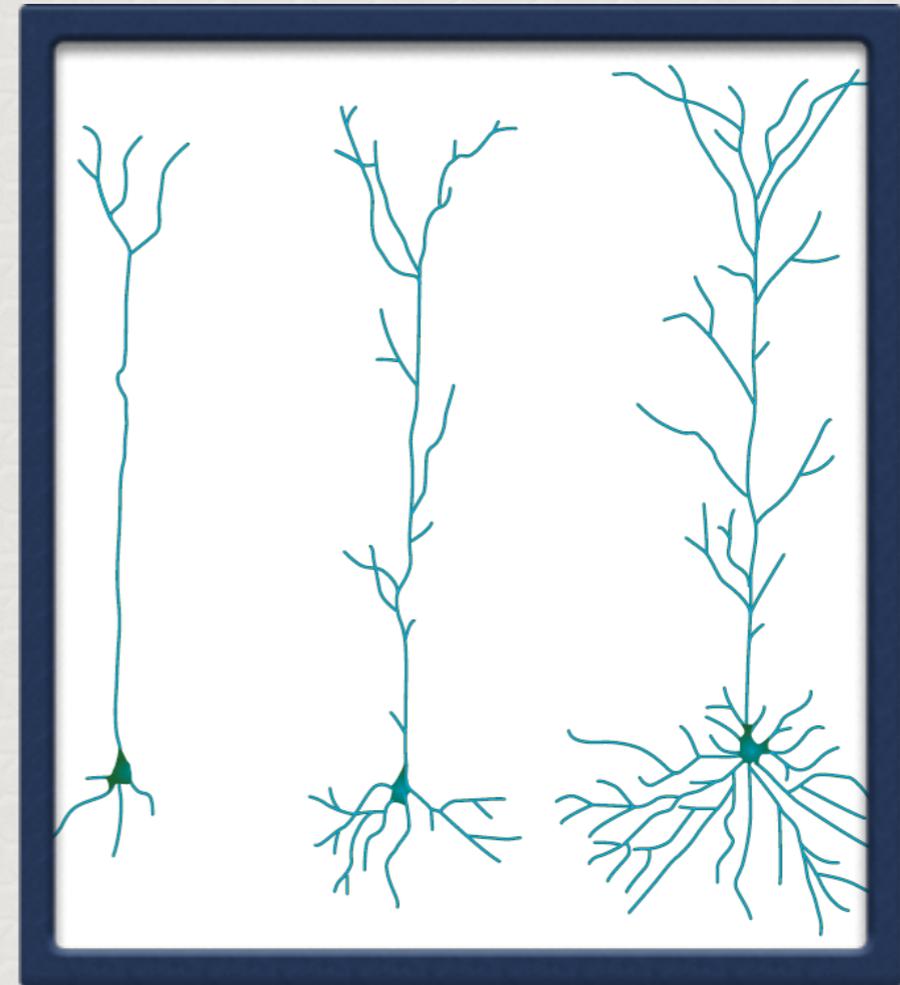


This 7-year-old girl had a hemispherectomy at the age of 3 for Rasmussen syndrome (chronic focal encephalitis). Intractable epilepsy had already led to right-sided hemiplegia and severe regression of language skills. Though the dominant hemisphere was removed, with its language centres and the motor control for the left side of her body, the child is fully bilingual in Turkish and Dutch, while even her hemiplegia has partially recovered and is only noticeable by a slight spasticity of her left arm and leg. She leads an otherwise normal life.

Adaptive Plasticity

Re-routing: an undamaged neuron that has lost a connection with an active neuron may connect with a new active neuron instead.

Sprouting: the growth of new bushier nerve fibres with more branches to make new connections.



Adaptive Plasticity and Experience

Neuro-imaging studies show that in musicians who play string instruments, the area of the **somatosensory cortex** that represents the fingers of the left hand is larger than the area that represents the fingers on the right hand.



Adaptive Plasticity and Experience

When MRI scans of London taxi drivers (who find new routes daily) are compared with London bus drivers (who follow a limited number of set routes daily), they show that the rear part of the hippocampus of taxi drivers, which is involved in spatial navigation and memory, is significantly larger.



Quick Quiz - Match up the terms for each definition/question below:

(a) synaptogenesis | (b) long-term potentiation | (c) motor cortex | (d) sensory cortex

1. The lasting strengthening of synaptic connections of neurons, resulting in their enhanced functioning
2. Two parts of the brain that are believed to have a higher level of plasticity than others
3. The process of forming new synapses

Quick Quiz - Match the terms for each definition/question below:

(a) rerouting | (b) birth | (c) sensitive or critical period

4. Specific period of time in development when an organism is more responsive to certain environmental stimuli or experiences and consequently very swift to learn a particular skill

5. When an undamaged neuron that has lost a connection with an active neuron connects with a new active neuron instead

6. The period of your life when you have the fewest neural connections

Quick Quiz - Match the terms for each definition/question below:

(a) becomes bushier, i.e. sprouts new branches |
(b) experience | (c) dendrite | (d) they are "pruned", i.e. disused synaptic connections disappear

7. The part of a the postsynaptic neuron that receives the neurotransmitter from the synapse

8. This happens to the answer to 7 when it repeatedly receives neurotransmitters

9. This happens to our neural connections between the age of 6 and 14

10. Both types of plasticity are influenced by this factor