

Brain and behavioural plasticity in the developing brain: Neuroscience and public policy

An interview with Dr Bryan Kolb

Why care about the brain?

Because you are your brain. Anything that changes your brain, changes who you will be. Your brain is not just produced by your genes; it's sculpted by a lifetime of experiences. Experience alters brain activity, which changes gene expression. Any behavioural changes you see reflect alterations in the brain. The opposite is also true: behaviour can change the brain. When we first learn a new motor skill, it seems impossible until practice – repetition – changes the brain.

What is the most important time in brain development?

The brain remains 'plastic' throughout life, but trajectories are set during the prenatal period and early childhood. Brain development is very rapid in the womb and continues at an accelerated rate in the first two to three years in particular. Although the sculpting of the brain actively continues for the next 20 years or more, early life experiences will affect your responses throughout life. Many health and behavioural disorders are related to how the brain developed in its earliest period. If we want to change developmental trajectories for children, early interventions can make a huge difference.

What environments help brain development?

The developing cortex is altered by many pre- and postnatal events, including sensory and motor experience, parent-child relationships, play, stress, hormones and psychoactive drugs.

Healthy, engaged parents are the best brain supports a child can have. There is a connection between touch, the skin and brain development. Tactile stimulation by caregivers, and even expectant mothers rubbing their abdomens, aids brain development. The caregiver's behaviour is transferred to the child epigenetically and affects the lifelong health of the infant via later stress reactivity. The trajectory is set very early on.

In experiments on rats, we found that the adult offspring of pregnant rats kept in complex environments had more complex brains than the control group. The adult offspring of males placed in complex environments before they mated, also had more complex brains. You can account for the difference in outcomes because sperm are regularly reproduced whereas the women's eggs are set at birth.

The offspring of female rats that are stressed during pregnancy have smaller brains, larger adrenal glands, and an

altered orbital frontal cortex. Play behaviour is grossly abnormal and there are cognitive impairments in adulthood.

In healthy males with healthy lifestyles, the offspring's brain is larger and has more connections, enhancing cognitive and motor behaviour. We also see this in humans. There is pretty compelling information now that if your father was an alcoholic, even if you never met him, your brain is different from someone whose father was not.

How does play impact brain development?

The speed at which the matured social brain comes on line is biased by early experiences. For some people, it never comes because of high stress or other factors in early childhood. Play behaviour profoundly changes the social brain. Play mimics adult behaviour and helps establish social rules. The brains of animals that grow up with adults only are different than those exposed to many playmates. Peer relationships are critical.

What about other social behaviours?

Outcomes such as talking or toilet training are not possible until the brain is ready. Some behaviours take a long time to mature. As late as the mid-teens, children have a difficult time deciphering emotion; they're not bad at recognizing happy things but don't do well with sad or disgusting things. This partly relates to the relative immaturity of the brain and also to the differences between boys and girls.

What brain development differences are there between the sexes?

There are big differences in gray volume that reflect the number of neurons in brain cells, with boys reaching their peak approximately two years after girls. This means that environments and experiences will have different effects in girls than in boys.

Hormones have huge influences on the brain, resulting in different sizes in different areas of the brain between the sexes. This should affect behaviour and, in fact, it does. But the effect of hormones is affected by the experience you have during each phase of life – from embryo through to adulthood. Males, for example, are more affected by prenatal experiences because of the presence of testosterone.

There is a huge difference in language ability. Young girls begin talking much sooner than boys, and this is reflected in girls having much more complex cells in the language areas of the brain. Males use more brain to talk because their cells

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are not as large. There are many more sexual differences in early development, but discrepancies in language development alone suggest that preschool environments and expectations should adapt to these differences.

Can parents boost their children's IQ?

Cognitive function is also influenced by early experience. We know that more educated people have more complex language centres. But language is found everywhere in the brain and is related to talking, understanding, reading, writing, thinking and emotion. When children are read to, the experience does different things to different parts of the brain. We don't know yet what types of early experiences give us the biggest effect on brain capacity or IQ, but we know that early reading does have an impact.

Has the link between early experience and adult experience been documented?

The Adverse Childhood Experience study, headed by Vincent Felitti, analyzes the relationship between multiple categories of childhood trauma (adverse childhood experiences) and health and behavioural outcomes later in life. The presence of family violence, sexual abuse, drug or alcohol abuse, growing up in a family where someone is in jail, or where a parent suffers from chronic depression or other mental illness, has the effect of turning gold into lead in terms of the future prospects of children.

The presence of any one of these circumstances compromises adult health. The presence of two or more increases the likelihood of being addicted to drugs or attempting suicide by 50 times.

As early as the second decade of life, adverse early childhood experiences are linked to school failure, teen pregnancy and criminality. By the third and fourth decade, obesity, elevated blood pressure and depression are prevalent. Coronary artery disease and diabetes arise by the fifth and sixth decade. In the seventh decade of life, memory loss and premature aging are factors.

Brain injury is another kind of trauma. The earlier the injury occurs, the more profound the impact.

What about psychiatric disorders?

We should see disorders as developmental, beginning very early in childhood. Once we head down the road, the influence of that experience becomes greater and greater. With schizophrenia, you often don't see symptoms until late adolescence or even later, but if you go back and look at a film of an adult schizophrenic at two years of age, you can see there were unusual behaviours even then.

What impacts do drugs have on brain development?

Drugs given prenatally, as well as in early development and adolescence, can alter later response to sensory experiences, learning and memory. The developing cortex is altered by psychoactive drugs as well as by 'heavy' drugs, and most of us were exposed to some drugs in utero – nicotine, caffeine, antidepressants, etc.

All drugs leave a footprint on the brain. Something about them changes the brain structure. The likelihood of becoming an addict depends on prenatal and early childhood experiences. Tactile stimulation has a reducing effect, whereas pre- and postnatal stress heighten the likelihood of addictions.

How do we translate the science of the brain into public policy?

Life success, whether health or socioeconomic status, is profoundly affected by brain development. Managing the factors that affect brain development is similar to an insurance policy that is only available early in life. We need to recognize this and get others to recognize it. What we know about brain development needs to be reflected in health and education policies in particular, but it also holds lessons for the treatment of adolescents in the justice system, immigration rules that can separate parents from their children, housing and community development, etc – together, these create the environments in which the developmental trajectories of children are established.