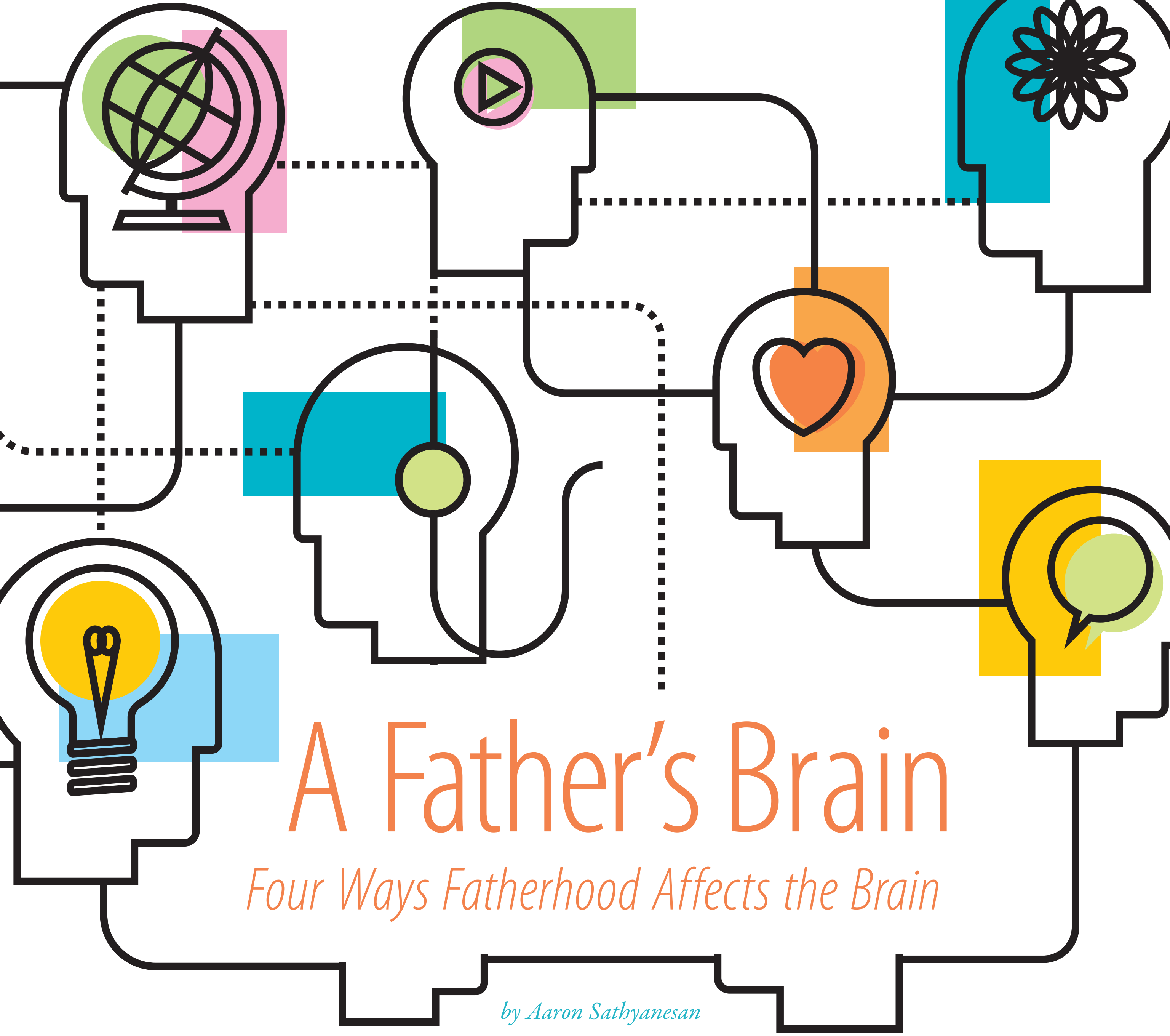

A Father's Brain

Four Ways Fatherhood Affects the Brain

by Aaron Sathyanesan

One of the TV shows that my wife and I enjoyed watching last year was Marvel's *Luke Cage*. Apart from its incisive commentary on systemic racial injustice, an important theme running throughout the show is the importance of fathers. In one of the episodes, following a particularly brutal shootout in Harlem (where the story is set) Luke Cage (Mike Colter) says something that really stuck with me: In Harlem "everyone has a gun, but no one has a father."

Over the decades, psychologists have gathered quite a lot of data on fatherhood and the role it plays in the lives of children. For example, there is data from social and developmental psychology which tells us that parental rejection affects children more when it stems from fathers.[1] This rejection can have negative consequences when these children become adults and begin developing intimate relationships. On the other hand, studies suggest that engaged fatherhood results in reduced behavioral and psychological problems in boys and girls respectively.[2]

But all this is mostly ooey-gooey psychology, not hard biology (no offense to psychologists reading this!).

In all seriousness though, what does the hard science of biology tell us about human fatherhood?

Not much actually. This isn't too surprising considering that generally speaking, far more is physically required from mothers than fathers in the child-bearing and child-rearing process. During pregnancy, the mother's brain experiences the activation of the neuroendocrine system. This system is basically a set of complex groups of brain cells making and responding to pregnancy hormones, all working in concert to aid fetal development

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and prepare the mother for childbirth.[3] These networks continue to exert physiological changes in the mother's body beyond pregnancy. The existence of such a vast mechanism has led to the mother-child bond being far more extensively investigated than the father-child bond.

But more and more, researchers studying the brain are realizing that there is more to fatherhood than meets the eye—quite literally. Powerful tools such as fMRI (a type of MRI that allows us to see brain activity) help us observe and study physical changes in the brain associated with fatherhood. Additionally, since brains in different species share common features, studying animal "models" has vast potential to discover changes in the brain associated with paternity in humans as well.

An important side note I should add here is that although the neuroscience of fatherhood is an exciting area of research, it is still an emerging field, and many studies require replication and independent confirmation by other research groups.

With that disclaimer, here are four significant insights biology offers into the effects of fatherhood on the brain:

1. Fathers experience hormonal changes as well

One of the better-known hormones in the brain is oxytocin. Oxytocin is implicated in the formation of social bonds between the mother and infant in socially monogamous species, including humans.[4] Interestingly, oxytocin has also been suggested to play an important role in father-infant interactions as well. In fact, a study involving 160 first-time parents showed that oxytocin levels in the blood plasma were similar in mothers and fathers during the first six months following childbirth.[5]

One big caveat regarding oxytocin research is that much of it has been done on prairie voles, because they are socially monogamous, like humans. While conclusions on oxytocin's role in the bonding behavior of prairie voles are generally accepted in the neuroscience community, oxytocin's role in human pair-bonding is hotly debated and many times, conclusions in support of the "positive" effects of oxytocin are overblown. Nevertheless, the study cited here, which was one of the first of its kind to look at oxytocin levels in fathers, suggests that at the very minimum, there is circumstantial biochemical evidence to expect oxytocin to affect paternal behavior, especially during early interactions with children.

2. Parenting activates similar areas of fathers' and mothers' brains, but in distinct ways

One of the earliest experiments on how parental brain activity was related to infant stimulus—specifically infant cries—showed that both the mother's and father's brains showed greater activation in the amygdala, which is a brain region critical to the processing of emotional experiences.[6] Many other studies suggest much similarity in the ways that the brains of mothers and fathers are activated in response to hearing their children cry or looking at pictures or movies of their children.[7] However, while pregnancy hormones activate unique pathways in the brain for mothers, fathers tend to show activation in brain pathways based on experience and learning.

While these findings seem interesting, one should be wary in drawing strong conclusions, since many of these studies involve small sample sizes. Larger studies would have to be conducted to definitively conclude differences in brain activation patterns between mothers and fathers.

3. Social interaction with offspring likely changes a father's brain cells

One of the most exciting insights we have gleaned from paternal care research in animal models is that there are actual cellular changes in fathers' brains when they interact with their offspring. This can be clearly seen in two breakthrough studies conducted by independent research groups.

In a pioneering preliminary study involving marmosets, researchers found significant microstructural changes in the neurons of the pre-frontal cortex of infant-carrying marmoset fathers.[8] These neurons displayed more "spines" on their dendrites, structures that are responsible for communicating with other nearby neurons. The prefrontal cortex plays a role in planning, decision-making, and social behavior. Researchers found that these changes were more profound in both first-time and experienced marmoset fathers compared to those adult marmosets that did not father children. Such cellular changes in a non-human primate associated with fatherhood was then unprecedented.

Even more recently, a different group of researchers found that for male mice, new neurons are born when they interact with their pups.[9] In an important experiment for this study, researchers separated the pups from the fathers for a period of time and then reunited them when the pups became adults. The researchers found that the ability to make those new neurons is critical for these fathers to recognize their own pups when they are reunited. These neurons were born in parts of the brain responsible for smell and memory—the olfactory bulb and hippocampus, respectively. It was previously known that mothers could recognize their offspring easily, but that even fathers could do this, and had specialized brain cells responsible for this recognition, was a new finding.

Together, these studies show that neurons change their shape and are even born in response to fatherhood and caring for offspring.

4. Fatherhood up, testosterone down

For a long time, it was thought that the reason that some men do not invest in their children is because fatherhood represents

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a tradeoff between mating and being involved with their children. Recently, a group of researchers tested this idea in an interesting way. They measured the volume of fathers' testicles and compared it to their caregiving. What they found was that caregiving and testicular volume was inversely correlated.[10] In other words, men with larger testicular volume scored lower on caregiving, and vice versa.

Caregiving was also inversely correlated to testosterone levels. In the most important experiment of the study, researchers measured brain responses of fathers while they were in an fMRI machine, as they were shown pictures of their own children. The researchers looked at patterns of activation across the whole brain and found that a specific region in the brain called the ventral tegmental area (VTA) showed an inverse correlation with testicular sizes of the subjects. The VTA is a part of the "reward system" of the brain and has also been observed in rats to be activated during parental behavior. This would make sense, because parental investment comes at a heavy cost to the parent, so the brain "rewards" good parenting by turning on this region. In summary, this study showed evidence that a more involved fatherhood comes at the price of decreased testosterone levels.

What all these studies show is that fatherhood (as distinct from motherhood) is clearly very important, not just for children, but also for the fathers themselves. In a father's brain, there are distinct regions and pathways dedicated to parenting. They are activated in ways that are similar to those of mothers' brains, but are also different in some respects.

Often, Christian leaders idealize the more stereotypically "masculine" behaviors associated with testosterone (drive for dominance and competitiveness, for example). The oft-heard message for fathers is that more "manliness" is where fathers find satisfaction, and that this is what children need from their fathers. But evidence from neuroscience suggests a more nuanced understanding of fatherhood, one that is more complicated and sometimes quite different from what is commonly preached from the pulpit. We should all strive to make men realize that although there may be no one-size-fits-all formula for fatherhood, they have God-given potential, embedded even in their own brains, to be better, more involved, more nurturing fathers in the lives of their children. This is the kind of fathering we should encourage men to pursue.

Aaron Sathyanesan is a developmental neuroscientist by profession. He has authored multiple research papers in neuroscience journals. He also enjoys writing on topics at the interface of science, faith, and pop culture. His writing has been featured on the BioLogos forum and PLOS Blogs. Aaron and his wife, Ange, are passionate about women's rights, especially in their home country, India. You are invited to follow him on Twitter @UnctionFunction.

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