

# Prenatal testosterone levels influence later response to reward

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New findings led by Dr. Michael Lombardo, Prof. Simon Baron-Cohen and colleagues at the University of Cambridge indicate that testosterone levels early in fetal development influence later sensitivity of brain regions related to reward processing and affect an individual's susceptibility to engage in behavior, that in extremes, are related to several neuropsychiatric conditions that asymmetrically affect one sex more than the other.

Although present at low levels in females, testosterone is one of the primary [sex hormones](#) that exerts substantial influence over the emergence of differences between [males and females](#). In adults and adolescents, heightened testosterone has been shown to reduce fear, lower sensitivity to punishment, increase risk-tasking, and enhance attention to threat. These effects interact substantially with context to affect social behavior.

This knowledge about the effects of testosterone in adolescence and adulthood suggests that it is related to influencing the balance between approach and [avoidance behavior](#). These same behaviors are heightened in the teenage years and also emerge in extremes in many [neuropsychiatric conditions](#), including conduct disorder, depression, substance abuse, autism, and psychopathy.

Scientists have long known that sex differences influence many aspects of psychiatric disorders, including age of disease onset, prevalence, and susceptibility. For example, according to the [World Health Organization](#),

depression is twice as common in women than men, whereas [alcohol dependence](#) shows the reverse pattern. In addition to many other factors, sex hormone levels are likely to be important factors contributing to sex differences in psychopathology.

However, research to date has mainly focused on sex hormone levels during adolescence and adulthood, when hormone levels are heightened and built upon substantial prior developmental experience. Sex hormone levels are also heightened during critical periods of [fetal brain](#) development, but the impact of such prenatal surges in sex hormone levels on subsequent adult brain and behavioral development has received relatively little attention.

"This study is the first to directly examine whether testosterone in fetal development predicts tendencies later in life to engage in approach-related behavior (e.g., fun-seeking, impulsivity, reward responsivity) and also how it may influence later [brain development](#) that is relevant to such behaviors," said first author Lombardo.

In this study, they tested a unique cohort of boys, 8 years of age, whose fetal testosterone had been previously measured from amniotic fluid at 13 weeks gestation. The boys were scanned with functional magnetic resonance imaging technology to assess changes in brain activity while viewing pictures of negative (fear), positive (happy), neutral, or scrambled faces.

They found that increased fetal testosterone predicted more sensitivity in the brain's reward system to positively, compared to negatively, valenced facial cues. This means that reward-related [brain regions](#) of boys with higher fetal testosterone levels respond more to positive facial emotion compared to negative facial emotion than boys who with smaller levels of fetal testosterone.

In addition, increased fetal [testosterone levels](#) predicted increased behavioral approach tendencies later in life via its influence on the brain's reward system. Lombardo explained, "This work highlights how testosterone in fetal development acts as a programming mechanism for shaping sensitivity of the brain's reward system later in life and for predicting later tendency to engage in approach-related behaviors. These insights may be especially relevant to a number of neuropsychiatric conditions with skewed sex ratios and which affect approach-related behavior and the brain's reward system."

Dr. John Krystal, Editor of *Biological Psychiatry*, commented, "These remarkable data provide new evidence that hormonal exposures early in life can have lasting impact on brain function and behavior."

**More information:** The article is "Fetal Programming Effects of Testosterone on the Reward System and Behavioral Approach Tendencies in Humans" by Michael V. Lombardo, Emma Ashwin, Bonnie Auyeung, Bhisudev Chakrabarti, Meng-Chuan Lai, Kevin Taylor, Gerald Hackett, Edward T. Bullmore, and Simon Baron-Cohen ([doi:10.1016/j.biopsych.2012.05.027](https://doi.org/10.1016/j.biopsych.2012.05.027)). The article appears in *Biological Psychiatry*, Volume 72, Issue 10 (November 15, 2012)

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