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COMMENTARY
Puberty and shifting values (Commentary on Bell *et al.*)

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The article by Bell, De Lorme, Figueira, Kashy and Sisk describes two very interesting experiments demonstrating that during sexual maturation in the male hamster, stimuli that were previously unrewarding acquire rewarding properties, independent of experience with the stimuli. The idea that puberty is a time of dramatic changes in the brain is not new, ask any parent. What is new here is the clear demonstration that a sexually relevant stimulus can become an unconditioned reward without any social or sexual experience with the stimulus, simply as a consequence of sexual maturation.

Puberty has been described as a time of raging hormones, where the increase in hormone secretions from the adrenal glands and gonads activates moods and other behaviors (Buchanan *et al.*, 1992). This view assumes for the most part that sexual differentiation of the brain occurs during early sensitive periods, and then the onset of hormone secretions at puberty activates the previously differentiated brain. The idea is that the brain is organized early in life and then specific behaviors are activated by hormones with puberty onset.

The problem with this interpretation of hormone-behavior relations for scientists, clinicians and parents has been that even though there is a documented increase in the onset of mood disorders, use of illicit drugs and other psychiatric conditions at puberty, the direct effects of hormones on these behaviors have not been clear. The amount of circulating hormone does not correlate with changes in behavior. Furthermore, neuroendocrine triggers for the onset of mood disorders, drug use or other conditions have been evasive (Young & Altemus, 2004; Costello *et al.*, 2007; Viveros *et al.*, 2011).

The brain is still developing during adolescence, so of course further brain development is occurring. What has not been widely appreciated, previously, is that the development is still occurring in a sexually dimorphic way. This sex-specific developmental path may be dependent on hormone exposure, or occur in the absence of exposure to the hormones associated with puberty. Thus, adolescence and puberty are periods of important sex-specific developmental processes with wide-ranging consequences for brain and behavior.

Let us now consider the implications of the Bell *et al.* (2012) paper. The adult male hamster does not initiate sexual behavior with a female hamster unless the female is in estrus. Female hamsters are larger and when not in estrus they are more aggressive than males. When a female is in estrus, males can readily approach a female and engage in copulation, and this is highly adaptive behavior for the male, ensuring his reproductive success Prior to puberty, males will not initiate sexual behavior, so the vaginal secretions (VS) are not relevant stimuli for the juvenile male. The authors show convincingly that juvenile hamsters are able to form a conditioned place preference (CPP) for cocaine, demonstrating their ability to form a CPP, but they do not form a CPP for VS. On the other hand, adult males that have not had sexual experience will form a CPP for VS, demonstrating that ontogenetic changes, but not experience, are necessary for the expression of this preference.

The authors go on to demonstrate that VS activates the amygdala in both juveniles and adults, demonstrating that the VS is being detected and produces neuronal responses in both adults and juveniles. Importantly, VS selectively activates neurons in the nucleus accumbens core, ventral tegmental area and infralimbic medial prefrontal cortex of sexually inexperienced adult male hamsters, but not juvenile male hamsters. These findings are important as they highlight the selective nature of the maturation of the unconditioned neural responses induced by VS in reward-related brain regions.

The idea that areas of the brain not directly implicated in sexual behavior, such as the reward system, are undergoing sex-specific development at puberty has been previously suggested (Becker, 2009; Kuhn *et al.*, 2010). What is important about the article by Bell *et al.* (2012) is that it very clearly demonstrates the adaptive value for reproductive success of the role of puberty in development of the brain reward systems.

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