Barkley-Levenson & Galván (2014)

Adolescence is characterised by heightened sensitivity to rewards (Galvan, 2013). This is shown by exaggerated neural response in the ventral striatum (VS) inside the brain, to the anticipation and receipt of either an expected or an unexpected reward is adolescents compared to other age groups. Subjective value (SV) is defined as the value that an individual places on a stimulus, (Knutson et al, 2008). To make a choice, an organism determines the SV of each alternative and then selects the one with the greatest SV. Research has found that the ventromedial prefrontal cortex (VMPFC) and ventral striatum (VS) regions represent SV during choice for monetary stimuli, charitable donations, consumer goods, and food. One approach to understanding the neural computation of SV is through measurement of expected value (EV), the sum of all of the possible outcomes of a particular choice multiplied by their probabilities, (Trepel et al, 2005).

Despite the wealth of knowledge on the neural correlates of SV in adults, no previous studies had examined the neurobiological development of SV, which precludes ruling out the possibility that previous findings in support of a hyperactive adolescent reward system were confounded by differences in participant valuation.

This study sheds light on brain development and the impact of this on risk taking behaviour.

There were three hypotheses:

> (a) Adolescents will exhibit greater behavioural sensitivity (accept more gambles) to increasing EV than adults.
>
> (b) Neurobiologically VS activation will modulate in proportion to increasing EV more for adolescents than adults.
>
> (c) Adults who behave like adolescents in terms of gambling behaviour will not exhibit hyperactive striatal activation.

This was a quasi-experiment using an independent measures design, conducted in a laboratory. The independent variable (IV) was whether the participant was an adult or an adolescent. The dependent variable (DV) was the performance on a simple mixed gambles game during an fMRI brain scan.

A secondary analysis was conducted to test the hypothesis that an exaggerated VS activation (in the brain) of adolescents would be observed even after matching adolescents and adults on subjective valuation (acceptance of gambles).

The sample was made up of 19 healthy, right-handed adults (ages 25-30, 11F, 8M) and 22 healthy, right-handed adolescents (ages 13-17, 11F, 11M). All participants were recruited through poster and internet advertisements approved through the University of California, Los Angeles (UCLA), Institutional Review Board and through a database of prior research participants. All participants reported no prior diagnosis of psychiatric or neurologic illness or development delays, had no metal in their bodies, and were not taking psychoactive medication.

In the procedure, each participant was asked to provide their primary source and amount of spending money per month. This was because the valuation of monetary rewards might be influenced by available spending money/ income, so had to be accounted for. There was a significant effect of age on spending money each month; for example the mean for adolescents = $52.50, whereas the mean for adults = $467.11. Participants were also familiarised with the MRI scanner.

Participants were given $20 for completing the initial intake session and were informed that they would use the $20 as "playing" money during the fMRI task on the subsequent laboratory session. They were also informed that there was an opportunity to win up to $20 more in addition to their playing money (for a total of $40) but that there was a possibility that they would lose the $20 during the gambling fMRI task.

Approximately one week after the intake session, participants returned to the laboratory for the fMRI session. During the fMRI scan, participants completed a gambling task. In this task, participants were presented with a series of gambles with a 50% probability of gaining the amount shown on one side of a "spinner" and a 50% probability of losing the amount shown on the other side. The gain and loss amounts were independently manipulated, with gain amounts selected from the range of whole-dollar values between +$5 and +$20 and loss amounts selected from the range of whole-dollar values between −$5 and −$20, for a total of 144 trials. For each trial, participants decided whether or not they would be willing to play that gamble for real money.

Results showed that acceptance rates did not change in either adolescents or adults when there was no risk involved in both gain-only and loss-only trials, suggesting that adolescents behave similarly to adults when there is no risk involved. No significant differences were observed between adolescent and adult participants in reaction time. Activation in some brain areas increased with increasing EV activation whilst activation in other brain areas decreased with increasing EV. This unique adolescent ventral striatum response remained even after matching groups on acceptance behaviour.

Barkley-Levenson & Galván (2014) were able to conclude that the value of available options has a greater influence in adolescent versus adult choices, even when objective value and subjective choice are held constant. Neural differences in sensitivity to EV change across development. Also, adolescents behave similarly to adults when there is no risk involved (in gambling). This supports the idea that biological differences in brain activity are present when both adolescents and adults make decisions related to risk-taking behaviour.

Reference:

Barkley-Levenson, E. & Galván, A. (2014) Neural representation of expected value in the adolescent brain Proceedings of the National Academy of Sciences of the United States of America, 111, 1646–1651.