List of studies included in the review – related to brain physiology

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Benuto 2013	Both genders, Adolescents	-	Numerous	Numerous
Porter JN 2014	11–13 yrs, 15–18 yrs	Cross-sectional study.	Numerous	Numerous

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Telzer EH 2013 USA	-	Longitudinal; Multi-method, longitudinal program of research, including daily diaries, experimental tasks, and neuroimaging, to examine the mechanisms by which a culturally meaningful type of family relationship – familism – buffers Mexican youth from drug use and risk taking.	-	Study 1: Family obligation values are protective, relating to dampened substance use, largely due to the links with decreased association with deviant peers and increased disclosure to parents. Study 2: Family obligation values are associated with reduced ventral striatum (VS) activation when receiving monetary rewards and increased prefrontal cortex (PFC) activation when inhibiting behavioural responses. Reduced VS activation correlates with less real-life risk taking behaviour and enhanced PFC activation correlates with better decision-making skills. Study 3: Enhanced VS activation when contributing to the family predicts decreases in

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				adolescents' risk taking behaviour over the next year.
Andrews-Hanna JR 2011 USA	Both genders, 14–17 yrs	Cross-sectional; Hybrid block/event-related fMRI stroop paradigm combined	Activation in adolescents vs adults on a Stroop task.	Adolescents showed less recruitment of a network of frontal-parietal brain regions than adults during a cognitive control task.

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		with self-report questionnaires.		
Banich MT 2013 USA	Both genders, 14–19 yrs	Cross-sectional; Questionnaires and fMRI task of participants doing an intertemporal choice task.	Behaviour and fMRI activity in Now vs Later decisions during intertemporal task in a group of younger adolescents and older adolescents. Self-reported non-immediate thinking.	Older adolescents tended to choose the delayed reward more and were slower when considering an immediate reward. Activity across brain regions implicated in aiding in intertemporal choice became more differentiated for Now versus Later choices with increasing age during adolescence.
Barber AD 2013 USA	Both genders, 8–12 yrs	Cross-sectional; Resting state functional connectivity MRI (seed-region	Connectivity within and between the Task-positive and Task-negative networks.	Only left dlPFC showed differences in connectivity between groups, with tighter integration with rest of task-positive network in adults. Many task-negative regions showed

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		based, 3 regions per network). A Go/No-Go fMRI task.		increased within network connectivity in adults, and also stronger negative connectivity with task-negative regions in adults. There was a relationship between response inhibition performance and the strength of (anti)correlation between those regions that showed developmental differences in the task-negative network.
Batterink L 2010 USA	Females	Cross-sectional; fMRI task of go/no-go task with vegetables being a ‘go’ stimuli and desserts being a ‘no-go’ stimuli. BMI taken at baseline, and 1- 6-	BMI at baseline and at 1 year; Neural and behavioural response to No-Go/Go trials; ROI analysis of: superior frontal gyrus, middle frontal gyrus (MFG),	Participants w/ higher BMI responded slower to vegetable cues and failed to inhibit responses to desserts. When instructed to inhibit responses to images of appetising foods, participants with higher BMI showed less recruitment of regions involved in response inhibition and more recruitment of reward

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		and 12-month follow-ups. Seed region analyses.	inferior frontal gyrus, medial and lateral PFC, inferior parietal lobe, insula, operculum, striatum, and orbitofrontal cortex.	regions. However, no behavioural or neural response could predict BMI at the 1-year follow-up.
Bava S 2010 USA	Both genders, 16–19 yrs	Cross-sectional; Structural MRI (DTI); Neuropsychological measures; Substance use questionnaire.	White matter integrity; Several neuropsychological measures.	Decreased integrity of white matter in the temporal lobe in adolescents with histories of marijuana and alcohol use was related to poorer attention, working memory, and speeded processing. However, users had higher white matter integrity in the occipital cortex, which was associated with better working memory and complex sequencing performance.

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Beltz AM 2013 USA	Both genders, 18–19 yrs	Longitudinal; functional MRI. Go/No-Go task with alcohol-related stimuli. Effective connectivity analyses.	Activation in Go/No Go task and connectivity between cognitive control and emotional processing brain networks.	Less connectivity between brain networks involved in emotional processing when participants responded to seemingly-dominant alcohol cues than when they responded to non-alcohol cues. After first semester of college, participants recruited cognitive control brain network more when they needed to overcome a pre-potent response to alcohol stimuli and follow 'go' cue instructions.
Bjork JM 2011 USA	Both genders, 12–17 yrs	Cross-sectional; Monetary Incentive Delay task administered in fMRI; Drug Use Screening Inventory (DUSI; a	Activation by three task contrasts: 1) high and low reward cues vs non-incentive cues, 2) high and low loss avoidance cues vs non-	Psychosocial problems correlated positively with recruitment of the VS and mPFC by cues to respond for rewards, as well as right NAcc connectivity with fronto-cortical structures as a function of the presence (versus absence) of prospective rewards.

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		binary endorsement of 149 behavioural and psychosocial symptoms, including potentially-rewarding behaviours); Psychophysiological interaction between brain regions.	incentive cues, and 3) reward-anticipatory cues versus loss anticipatory cues, to index a motivational bias toward obtaining rewards over avoiding losses of equal magnitude. Frontocortical synchrony of time-series signal between reward and neutral conditions with that of a 'seed' volume-of-	

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			interest (placed anatomically) in the bilateral NAcc. Drug Use Screening Inventory Overall Problem Density (DUSI-OPD) score.	
Braams BR 2014 Netherlands	Both genders, 8–25 yrs	Cross-sectional; Task fMRI, playing gambling task for self, friend, and antagonist. Friendship quality questionnaire.	Neural activity when learning for whom they were playing (friend, antagonist or self), and neural activity when seeing the outcome of the gamble (win or lose). Friendship	Peak in striatum activity in adolescence when winning for self. Reward-related striatal response depended on the kind of beneficiary for all ages. Activity in the mPFC when winning versus losing for antagonists peaked in mid-to-late adolescence.

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			quality.	
Braet W 2009 Belgium, Ireland, Australia	Males adolescents 10–14 yrs, but both genders for adults	Cross-sectional; Compared SART performance of adults and young adolescents to understand further the development of inhibitory control and its associated neural networks.	Number of errors of omission (not going when you need to go) and commission (going when you should not have), and RT on Go/No-Go trials. Brain activation.	Unlike what was hypothesised, there were no differences in the ACC between adolescents and adults for unsuccessful inhibitions. Adults had fewer commission errors and fewer errors of omission and lower response variability compared to adolescents. Response variability was negatively correlated with activation changes in most regions for young adolescents. During successful inhibitions, young adolescents showed increased recruitment, compared with adults, of a widely distributed network, including left (inferior, superior and middle) and right (middle and

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				inferior) frontal gyri, left and right insulae, bilateral anterior and posterior cingulate, as well as both left and right inferior parietal cortex and left and right precunei and cunei. Differences in frontal regions disappeared in the performance-matched groups.
Burger KS 2014 USA	Females	Longitudinal; fMRI during repeated exposures to milkshake and tasteless solution receipt that were paired with unconditioned cues and modelled the	Neural response in the caudate, ventral pallidum and putamen to: 1) cues predicting milkshake receipt and 2) receipt of milkshake. BMI.	They found repeated exposures to the cue preceding milkshake receipt was associated with greater caudate responses over time, whereas the neural response in the putamen and ventral pallidum decreased over time in the response to the receipt to the milkshake. By tracking the sample of 35 adolescent females over the next two years, this study was able to investigate if neural adaptation to

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		data to assess change response over repeated exposures. BMI assessed at baseline and at 6-month, 1-year, and 2-year follow-ups.		the receipt of milkshake predicted increased in weight over time. This analysis revealed that the adolescents who showed the greatest increase in the ventral pallidum activation when viewing cues, and the greatest decrease in the caudate activation during receipt of the milkshake, were more likely to show greater increases in BMI over the next two years.
Burger KS 2014 USA	Both genders	Cross-sectional; fMRI during intake of Coke. fMRI during intake of milkshake. fMRI while viewing advertisements. Comparisons	Neural responses to the fMRI paradigms and comparison between Coke and non-Coke drinkers.	1) Greater response to Coke logo ads in the posterior cingulate in consumers vs non-consumers. 2) Decreased vlPFC activity when anticipating intake of Coke in consumers vs non-consumers. 3) More response to milkshake vs coke in all participants. 4) Similar response to Coca-Cola products in all

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		between Coke drinkers and non-drinkers.		participants.
Campbell IG 2007 USA	Both genders, 9–15 yrs	Longitudinal; Physician-assessed pubertal stage. Actigraphy for sleep. Self-reported changes in sleepiness. Sleep schedule recorded via self-report and actigraphy.	EEG power density (power/minute) was calculated for the first 5 hours of non-rapid eye movement sleep. Subjects rated sleepiness on a modified Epworth Sleepiness Scale. Habitual sleep schedules were assessed with self-	Daytime sleepiness increased across ages 9-15 years. Bedtimes later. Sleep duration declined with age. NREM EEG power decreased with age. Sleepiness significantly related to delta power density after other measures of sleep-schedule change controlled.

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			reports and actigraphy.	
Cheetham A 2012 Australia	Both genders, 12–16 yrs	Longitudinal; Brain structure assessed at age 12 years and cannabis use at age 16 years.	Brain volumes. Substance use. SES. IQ.	Smaller OFC volumes at age 12 were correlated with cannabis use by age 16 years. After controlling for other substance use, only right OFC volumes remained significant. Only lateral regions.
Cheetham, A 2014 Australia	Both genders, 12 and 16 yrs	Longitudinal; Brain structure assessed at age 12 years and cannabis use at age 16 years.	Brain volumes. Substance use. SES. IQ.	1) Gender and age were not significant predictors of alcohol-related problems for any analysis. 2) Smaller volumes of the left dorsal and rostral paralimbic ACC at age 12 years increased the odds of experiencing alcohol problems at age 16.

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Choudhury S 2012 UK	Females, 13–14 yrs	Cross-sectional; Questionnaire and focus group.	Participants' own definitions of adolescence, representations of adolescents in society, and exposure to, and perceptions of, neuroscientific research about adolescence.	Social explanations referring to the difficulty of teenage life and the generation gap between parents and their children were both rated highly relative to the biological explanations (neuroplasticity, neurochemicals, and evolution, with the exception of hormones). Neuroscience has the potential to defeat stereotypes, to dehomogenise teenagers as a group, and to present a scientific and de-stigmatising picture of who teenagers really are 'from [their] point of view'. The teenage behaviours that neuroscientists explained misrepresented adolescence, using the model of the teen brain to explain, but at the same time reinforce, the 'unbalanced' 'negative

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				stereotype' of teenagers in society.
Christakou A 2011 UK	Males, 12–32 yrs	Cross-sectional; task fMRI during temporal discounting task.	fMRI activation for immediate vs delayed reward. Interaction of increasing age and delay discounting on functional connectivity	Maturing age and reduced discounting (i.e. higher AUC measures) were associated with increased activation during immediate choices in the vmPFC cluster, and decreased activation in the ventral striatum. Correlational connectivity analysis revealed that the two regions exhibited enhanced coupling with age and with less discounting behaviour.
Christakou A 2013 UK	Males, 12–18 yrs	Cross-sectional; fMRI of Iowa gambling task variant.	Behavioural and fMRI changes in adolescents and adults. Preference ratio (the ratio of advantageous choices	Preference for advantageous compared with disadvantageous decks improved with age through adolescence stabilising in adulthood. Differential responsivity to positive and negative prediction errors was predictive of

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			over all choices). Brain areas where the utilisation of decision values (during the decision phase) and PEs (during the outcome evaluation phase) matured with age.	performance and matured with age. Adolescents learned similarly from negative and positive prediction errors, whereas adults were more sensitive to negative predictions errors compared to positive. More vmPFC activity during prediction error was associated with better performance for adults, but more activity in vlPFC, VS, putamen, and subgenual cingulate during prediction error was associated with worse performance for adolescents.
Churchwell JC 2013 USA	Both genders, 10–22 yrs	Cross-sectional; Structural MRI (cortical thickness) and self-report	Cortical thickness of anterior and posterior insula. Impulsivity measure.	Cortical thickness in insula decreased with age. Impulsivity decreased with age. Reductions in cortical thickness of the anterior insula were related to reductions in impulsivity.

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		measure of impulsivity (BIS).		
Cohen JR 2010 USA	14–19 yrs	Cross-sectional; probabilistic fMRI task.	Accuracy, RT, and fMRI activation.	All participants became more accurate and faster with training for predictable stimuli. Adolescents were the only age group to respond significantly more quickly to stimuli associated with large rewards as compared with small rewards. Younger participants had a stronger decision value signal in medial PFC as compared with older participants.
Cohen-Gilbert JE 2014 USA	Both genders, 12–15 yrs	Cross-sectional; Social threat go/no-go task with faces.	Accuracy and RT during go/no-go task. Four conditions: Threat vs Safe & No Go vs Go trials.	Inhibitory control increased across age.

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Delgado-Rico E 2013 Spain	Both genders, 12–17 yrs	Cross-sectional; Comparison of three groups. fMRI task of risky decision making in 'Risky-gains task', which opposes a less rewarding safe choice with more rewarding risky choices.	Brain activation during risky versus safe choice contrast and a reward versus punishment feedback contrast.	1) Excess weight adolescents, compared to normal weight peers, show decreased left insular activation and increased midbrain activation during risk-based decision-making. 2) Excess weight adolescents have increased inferior frontal gyrus, thalamus, parahippocampal, and posterior activations in response to reward receipt.
Engelmann JB 2012 USA, Switzerland	Both genders, 12–17 yrs	Cross-sectional; fMRI task involving the evaluation of two choice options (risky/safe) in order to investigate the extent	Response time. How advice affected choices. Brain activation during valuation. Advice effects and developmental effects	Advice had a significantly greater impact on risky choice in both adolescent groups than in adult groups. Advice increased the correlation strength between brain activity and parameters reflective of safe choice options in adolescent DLPFC and decreased correlation strength

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		to which advice influences brain correlates of valuation across the three age groups.	on the significant contrast ROIs.	between activity and parameters reflective of risky choice options in adult vmPFC.
Ernst M 2005 USA	Both genders, 9–17 yrs	Cross-sectional; fMRI Wheel of Fortune Task: a two-choice decision-making task involving probabilistic monetary outcomes.	Behaviour (feelings and money won). fMRI activation in Nacc and amygdala ROIs, and also whole brain. Contrasts: win vs no-win, win vs win & no-win vs no-win of small vs large amounts, correlation with self-	Win vs no-win revealed stronger activation of ventral striatum in adolescents compared to adults, but this was due to differences in how adolescents and adults process negative (no-win) scenarios rather than developmental differences in processing positive outcomes.

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			report ratings of satisfaction.	
Feinberg I 2006 USA	Both genders, 9–14 yrs	Longitudinal; In-home sleep EEG recordings at 6-month intervals over 2 years. Tanner stage, height and weight also obtained at each time point.	Delta decline, pubertal maturation, physical growth, sleep schedule, and age.	No change in DPD between ages 9–11 years. DPD declined by 25% between 12–14 years. DPD was strongly related to age with Tanner stage, height, weight and body mass index controlled. No other measure of physical and sexual development was related to DPD with age controlled.
Feldstein Ewing, S. W. 2015 USA	Both genders, 14–18 yrs	Cross-sectional; Task fMRI and real world behaviours. Examined relationship between response during (Go/NoGo) and past	Response in the middle frontal gyrus (MFG), inferior parietal lobules (IPL), and insula during the response inhibition (NoGo N Go) contrast	In high-risk youth, there was a negative correlation between past month substance use and response inhibition within the left inferior frontal gyrus (IFG) and right insula, but a positive correlation between past month risky sex and activation within the right IFG and left

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		month risk behaviour (number of substance use days; number of unprotected sex days).	in our fMRI-based Go/NoGo task.	middle occipital gyrus.
Figner B 2009 Switzerland	Both genders, 14–19 yrs	Cross-sectional; Four experiments investigating risk taking and use of relevant information by adolescents and adults in both a 'hot' affective and a 'cold' deliberative condition. Columbia Card Task	1) Compared behaviour (risk taking and information use) across the hot and cold CCT versions. 2) Compared adolescents' versus adults' task performance. 3) Used individual differences measures to establish	Increased adolescent risk taking, coupled with simplified information use, was found in the hot but not the cold condition. Need-for-arousal predicted risk taking only in the hot condition, whereas executive functions predicted information use in the cold condition.

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		(CCT), where risk taking is assessed via participants' voluntary stopping point in a series of incrementally increasingly risky choices. CCT assesses the complexity of the decision maker's information use and determines which of three factors that should be affecting	convergent validity for the dual-system explanation of adolescent risk taking versus alternative explanations.	

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		risk taking have been taken into account (outcome probability, gain amount, and loss amount), and it also differentially triggers affective versus deliberative decision-making processes.		
Forbes EE 2010 USA	Both genders, 11–13 yrs; Reward-related brain function	Cross-sectional; Task fMRI during reward processing (guessing-card game) in relation to pubertal development.	Assessed reward anticipation and outcome evaluation. Pubertal evaluation by trained nurse. Circulating	Groups did not differ in neural activity during reward anticipation. Pre/early and mid/late pubertal groups differed in neural activity during reward outcome processing: with the mid/late group showing less striatal activity and more mPFC activity than the pre/early group.

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	would differ between pre/early pubertal and mid/late pubertal adolescents. Striatal reactivity would be positively associated with positive affect and negatively		testosterone. Subjective positive affect (PANAS) and depressive symptoms (MFQ).	Striatal activity during reward outcome/anticipation positively associated with positive mood, striatal activity during reward outcome processing was negatively associated with depressive symptoms. Testosterone in boys positively correlated with striatal activity in reward anticipation. However, testosterone was negative correlated with reward outcome processing in both females and males.

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	associated with depressive symptoms (and the opposite pattern for mPFC reactivity)			
Forbes EE 2012 USA	Both genders, 1–13 yrs	Cross-sectional; Genotyping. Physical assessment of puberty. Actigraphy to measure sleep. Monetary-Incentive	PER2 SNPs: (rs2304672, rs2304674). Sleep mid-point: individual differences in bedtime/wake time and	One of the two SNPs examined was able to predict the neural response to monetary reward, which differed based on an individual's sleep midpoint. Adolescents with later sleep midpoint showed reduced activity in the medial prefrontal cortex to reward outcome.

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		Delay task fMRI.	reflects circadian alignment. Pubertal status. Activity when responding to monetary reward.	Individuals who carried the G allele showed reduced activity in mPFC relative to CC homozygotes.
Galvan A 2013 USA	Both genders, 13–17 yrs	Cross-sectional; task fMRI: participants received squirts of appetitive or aversive liquid while undergoing fMRI.	Behaviour (ratings of appetitive and aversive liquids). Brain activation during anticipation, reception of liquid, and during value ratings.	Adolescents report stronger positive and negative ratings of appetitive and aversive primary reinforcers, respectively. Reception of aversive liquid recruited the striatum, amygdala, insula, and sensory regions in all participants. Adolescents showed greater striatal activation and adults exhibited greater insular activation. There was no developmental difference in neural response to reception of appetitive liquid.

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Geier CF 2010 USA	Both genders, 13–17 yrs	Cross-sectional; fMRI during rewarded antisaccade task (cognitive control task with two conditions: rewarded and unrewarded).	Behaviour (eye saccade accuracy). Brain activation during incentive cue, response preparation/anticipation, and behavioural (saccade) response.	Reward trials compared with neutral trials resulted in faster correct inhibitory responses across ages and in fewer inhibitory errors in adolescents. Adolescents, compared with adults, demonstrated attenuated responses in the VS during incentive cues. Adolescents showed heightened response in the VS and sPCS during response preparation (reward anticipation) on reward trials.
Grose-Fifer J 2014 USA	Both genders, 13–17 yrs	Cross-sectional; Task event-related potential study during gambling game for monetary reward. Four possible outcomes: large win,	Event-related potentials (ERPs) for electrode sites – specifically feedback related negativity amplitude, ratio, and latency.	No age/gender differences in behaviour (all participants selected high magnitude cards more often than low magnitude cards). Losses elicited larger FRNs than gains and that gains elicited earlier FRNs than losses. In females, FRN amplitude was modulated by the valence

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		small win, small loss, large loss.	Magnitude (large, small) and valence (win, loss) as within-subject factors and age (adolescent, adult) and gender (male, female) as between subject factors.	but not the magnitude of the outcome. In males, FRN to losses was insensitive to the size of the loss, but small wins elicited a significantly larger FRN than big wins. FRNs for adolescents were larger and later compared to adults.
Hämmerer D 2011 Germany	Both genders, 13–14 yrs	Cross-sectional; EEG recorded during probabilistic reinforcement learning task.	Monitoring positive and negative outcomes during probabilistic reinforcement learning. ERPs assessed processing differences as a function of	1) Amplitude of feedback-related negativity after gains or losses decreased monotonically from childhood to old age. 2) Children and older adults showed smaller differences between the FRN after losses and the FRN after gains, needed more trials to learn from choice outcomes, and showed relatively less

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			outcome valence and the degree of differences in reward probability between choice options.	trial-to-trial learning from gains than from losses.
Hare TA 2008 USA	Both genders, 13–18 yrs	Cross-sectional; task fMRI: emotional go/no-go task where participants had to detect fearful, happy, or calm emotional expressions (target expression) while ignoring non- target expressions. Anxiety	Trait anxiety. Effects of age, gender, and emotional expression on reaction time and accuracy. Brain activity in amygdala and ventral prefrontal cortex during go/no-go during happy, fearful and neural face presentations.	Adolescents showed greater amygdala activity relative to children and adults, but this difference decreased with repeated exposures to the stimuli. Individual differences in self-ratings of anxiety predicted the extent of adaptation or habituation in amygdala. Individuals with higher trait anxiety showed less habituation over repeated exposures. This failure to habituate was associated with less functional connectivity between ventral

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		levels were measured with the Spielberger state-trait anxiety inventory. Study investigated initial reactivity and subsequent regulation/adaptation of limbic regions with repeated presentations of affective stimuli. Individual and developmental differences were	Connectivity between these regions. Response latency.	prefrontal cortex and amygdala. The strength of coupling between vPFC and the amygdala was correlated with greater habituation of amygdala activity in adolescents.

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		taken into account.		
Hasler BP 2012 USA	Both genders, 1–13 yrs	Cross-sectional; Physician-assessed pubertal stage. Actigraphy for sleep. Task fMRI reward paradigm.	Reward-related activity (anticipation and outcome evaluation) in mPFC and striatum. Pubertal stage. Shift in mid-sleep from Saturday night to Sunday night. Measures of positive affect and depressive symptoms.	Larger advances in the timing of mid-sleep from Saturday to Sunday night – which reflect later natural sleep phase – were associated with diminished activation during the anticipation and receipt of reward in regions within the mPFC and ventral striatum. This held even after controlling for total sleep time.

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He Q 2014 USA, China	Both genders, 14–21 yrs	Cross-sectional; Examined the activity of neural systems hypothesised to subserve decision-making, using the Iowa Gabling Task (IGT), as well as the relationship between this neural activity and real life eating behaviour. The IGT has been shown to tap into aspects of decision-making that	Activity in the contrast between advantageous decisions vs disadvantageous decisions on the IGT.	Higher consumption of vegetables positively correlated with activity in the left superior frontal gyrus (SFG) (i.e. a component of the reflective system), but negatively correlated with activity in the right insular cortex (part of the urge network). In contrast, high consumption of snacks negatively correlated with activity in the left frontal pole (a part of the reflective system), but positively correlated with activity in the right ventral striatum and right insula cortex (part of the urge network).

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		are influenced by affect and emotion.		
Herting MM 2014 USA	Males, 15–18 yrs	Cross-sectional; Examined the relationship between white matter microstructure and aerobic exercise in adolescent males. DTI to assess white matter microstructure. Ambulatory actigraphy using an Actiwatch to measure daytime activity	Tract-based spatial statistics (a voxelwise approach for examining white matter integrity). Along-tract measurements (tract-specific white matter integrity). Streamline counts, fractional anisotropy, and radial diffusivity. VO2 peak. Self-report puberty. SES. BMI. Mean	High-fit youth had an overall higher number of streamline counts compared to LF peers, which was driven by group differences in corticospinal tract and anterior corpus callosum. VO2 peak was negatively related to fractional anisotropy in the left corticospinal tract.

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		levels. VO2 (aerobic uptake) peak to measure aerobic fitness.	activity levels. Lifestyle factors.	
Holm SM 2009 USA	Both genders, 1–13 yrs	Cross-sectional; Pubertal stage assessed by trained physician. Task fMRI of card-guessing game, designed to probe striatal response to reward during anticipation and outcome phases. Sleep behaviours	Pubertal stage (early vs late). Sleep onset, sleep offset, minutes asleep, and sleep quality (self-report). Brain activation during two different contrasts: reward anticipation>baseline and reward outcome>baseline.	Adolescents with lower sleep quality show decreased activity in the caudate when anticipating rewards or processing reward outcomes. In the reward anticipation phase, subjects with fewer minutes asleep and later sleep onset time exhibited less caudate activation. In the reward outcome phase, subjects with later sleep onset time showed less caudate activation, but later sleep offset time was associated with greater caudate activation. No significant sleep by development

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		measured by actigraphy as well as self-report.		or sleep by gender interactions.
Hoogendam JM 2013 Netherlands	Both genders, 10–25 years	Cross-sectional; Examined age-related changes in reward-related brain activity in a sample of children, adolescents and adults aged 10–25 during anticipation and outcome of reward. Task fMRI modified version of the Monetary	Brain activation during reward processing (Reward Anticipation and Reward Outcome) in six predefined anatomical Regions of Interest (ROIs): the bilateral ventral striatum, dorsal caudate, putamen, insula, cingulate cortex, and orbitofrontal cortex.	Brain activation during the anticipation of reward increased with age, while activation during reward outcome processing decreased with age.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		Incentive Delay task.		
Hooper CJ 2004 USA	Both genders, 9–17 yrs	Cross-sectional; Examined the pattern of performance on the Iowa Gambling Task across groups of adolescents varying in age from 9–17 years in relation to performance on working memory and behavioural inhibition tasks.	Behaviour on Iowa Gambling task. Go/No-Go task. Digit Span.	Age group differences were found for all three tasks. For IGT, 14–17-year-olds made more overall advantageous choices than 9–10-year-olds and began to shift their choices to advantageous decks earlier in the task than either of the other age groups. For the Go/No-Go task and Digit span, each age group performed better than the younger age groups.

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Jacobus J 2013 USA	Both genders, 16–20 yrs	Longitudinal; Compare substance to non-substance using youth. Substance users were individuals that had >200 lifetime experiences with cannabinoids by ages 16–19 years; Non-users had to have less than 10. White matter integrity as assessed by DTI. Substance use and	White matter integrity in 4 apriori ROIs 1) body of the fornix 2) superior corona radiata 3) superior longitudinal fasciculus 4) the superior fronto-occipital fasciculus. Substance use and risky behaviours.	1) Lower white matter integrity at baseline in the fornix and superior corona radiata predicted follow-up substance use. 2) Fronto-limbic white matter integrity was linked to a greater propensity for future risk taking behaviours among youth who initiated heavy substance use by mid-adolescence.

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		risky behaviours by participant-report and parental-report questionnaires/scales.		
Jarcho JM 2012 USA	Both genders	Cross-sectional; task fMRI during reward anticipation. Task had two components of decision-making (no-choice vs choice), and incentive size (small vs large), and anticipation and outcome of reward was analysed for	Brain activation during responses with–vs–without decision-making, to obtain large–vs–small rewards, and during reward receipt.	When reward-receipt required decision-making, neural activity did not differ by age. When reward receipt did not require decision making, neural activity varied by development, reward magnitude, and stage of the reward task.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		adolescents and adults.		
Javadi AH 2014 Germany	Both genders, 14–15 yrs	Cross-sectional; Used novel way of examining signal (transforming continuous signal into discrete states). Probabilistic reversal learning task to investigate how adolescents and adults incorporate feedback (both rewarding and	In Anterior Cingulate Cortex (ACC); Ventral Striatum (VS); and Ventromedial Prefrontal cortex (vmPFC).	ACC activity reflected both feedback and decision making in adolescents, but only decision making in adults. vmPFC activity represented feedback in adolescents, but reflected both feedback and decision in adults. VS activity reflected solely feedback for both groups.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		punishing) in their decisions in a dynamic and uncertain environment, where feedback is probabilistic and contingencies change from time to time.		
Keulers EH 2011 Netherlands	Males, 13–17 yrs	Cross-sectional; fMRI gambling task in which participants decide to either gamble or pass in order to earn as many	Extent and magnitude during decision phase of gambling task.	Magnitude increased with age. There was neither an age-related decrease in activation extent, nor any qualitative shifts in activated areas as suggested by the focalisation hypothesis. Developmental changes in activation magnitude evolved from no

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		points as possible. Controlled for confounders that may bias towards focalisation by: 1) investigating small age ranges, 2) correcting for head motion, and 3) defining regions of interest for each participant separately to overcome inter-individual variability in anatomy and		differential response in most task-related areas to an enhanced response to more difficult, endogenous task conditions with increasing age. Deciding to pass as opposed to gamble exerted more effort in 13-year-olds.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		functional organisation.		
Lamm C 2014 USA	Both genders, 13.7–21 yrs	Longitudinal; Monetary Incentive Delay fMRI task in mid-adolescence and late adolescent/early adulthood.	Activation in selected regions dorsal caudate, ventral caudate, putamen, globus pallidus, and nucleus accumbens) and also whole brain analysis for trials that varied by valence (gain, loss) in the contrast: high-incentive vs low-incentive. Compared acrossage. Repeated	Increased incentive-related striatal activation from mid-adolescence to late adolescence/early adulthood in the cue-anticipation-for-action stage of the MID task. The developmental increase in striatal response was similar for reward and punishment conditions. Findings were specific to the dorsal striatum and no age-related change was detected in regions of the ventral striatum or in primary sensory-motor cortical areas.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			measures ancova.	
Liston C 2006 USA	Both genders, 10–15 yrs	Cross-sectional; DTI, behavioural Go/No-Go task.	Accuracy & RT for Go/No-Go trials. Fiber integrity of frontostrital and corticospinal tracts.	Changes in diffusivity (an index of fiber integrity) were associated with developmental changes in performance on the go/no-go task. Individual differences in frontostriatal, but not corticospinal, diffusivities predicted individual differences in performance independent of age.
Liu ZX 2014 Canada	Both genders, 7–18 yrs	Cross-sectional; EEG during Go/No-Go task.	Theta activity in fronto-midline regions. Behaviour on Go/No-Go task.	Response control improved linearly with age. Theta power, calculated in proportion to the baseline, increased with age during response control processing. This developmental effect was source-localised to the ACC, correlated with behavioural performance, partially

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				mediated the age-related improvement on response control, and stronger when older children exerted more effort on the task.
Lotfipour S 2009 Canada	Both genders, 12–18 yrs	Cross-sectional; Examined the relationship between OFC thickness and drug experimentation in a population-based sample of adolescents (12-18 years of age), half of whom had been exposed to maternal cigarette smoking	OFC thickness; BDNF Genotype; Prenatal exposure to maternal cigarette smoking.	BDNF genotype, prenatal exposure to maternal cigarette smoking, and the number of drugs tried interacted to predict OFC thickness. Prenatal exposure to maternal cigarette smoking was associated with a greater likelihood of drug experimentation during adolescence. For exposed adolescents, more drugs tried was negatively correlated with OFC thickness, whereas the opposite (a positive) relationship was found for non-exposed adolescents (which was moderated by BDNF genotype).

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		during gestation, matched to non-exposed adolescents by maternal educational level.		
Luciana M 2013 USA	Both genders, 14–22 yrs	Longitudinal; Prospective examination of the effects of alcohol use initiation on ongoing structural brain development. Structural MRI two years apart and self-reported alcohol use.	Alcohol use at baseline and follow-up. Cortical thickness. White matter extent. DTI measures: fractional anisotropy and mean diffusivity.	Initiators demonstrated a greater-than-expected decline in cortical thickness in the right hemisphere middle frontal gyral region. Cortical white matter extent, particularly in right hemisphere regions associated with motor function (precentral gyrus), complex visual processing/visual integration (lingual gyrus), recognition memory (middle temporal gyrus) and conflict monitoring/cognitive control (anterior cingulate cortex) failed to show the

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				expected rate of increase over time in alcohol initiators. Non-users showed a relative increases in FA over time in the dorsal caudate in left hemisphere and mid-temporal/polar-temporal region of inferior fronto-occipital fasciculus in right hemisphere relative to alcohol use initiators.
Mills KL 2014 USA	Both genders, 7–30 yrs	Longitudinal; Longitudinal structural MRI; self-report questionnaires.	Grey matter volume of nucleus accumbens, amygdala, and prefrontal cortex. Retrospective, self-reported risk- taking, sensation-seeking and impulsive behaviours.	There was substantial heterogeneity in brain development patterns across participants, but most participants showed an earlier developing amygdala compared with the PFC (and some participants likewise showed an earlier development of the nucleus accumbens compared to the PFC). There was no clear relationship between the presence of a

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				mismatch and adolescent risk-taking or sensation-seeking behaviours.
Moreno-López L 2012 Spain	Both genders, 12–17 yrs	Cross-sectional; Voxel-based morphometry (brain structure) analysis of adolescents divided into typical and excess weight groups. Correlate brain structure to questionnaire measures of Sensitivity to Punishment,	Brain sizes (both regional volumes and whole brain analyses). Measures of impulsivity, inhibitory control, and reward sensitivity.	In the group of adolescents with typical BMI, the size of the second somatosensory cortex was negatively correlated with reward sensitivity and the size of the dlPFC was positively correlated with inhibitory control, whereas these relationships were absent in the groups of adolescents with excess weight. Adolescents with excess weight had, on average, larger right hippocampi.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		Sensitivity to Reward, Impulsivity, and behaviour on the Stroop task.		
Naneix F 2012 France	Males, adolescents	Longitudinal; A series of behavioural experiments in rats, as well as measurement of their dopaminergic fibers and tissues.	A series of behavioural experiments in rats, as well as measurement of their dopaminergic fibers and tissues.	Dopaminergic fibers and tissue content continue to increase in the medial prefrontal cortex from juvenile to adult age, but dopaminergic development in the striatum and Nacc is limited to the juvenile stage.
Olson EA 2009 USA	Both genders, 9–23 yrs	Cross-sectional; DTI; Behaviour; Questionnaires.	White matter integrity (fractional anisotropy and medial diffusivity). Delay discounting	Higher FA and lower MD values in white matter pathways that interconnect the lateral prefrontal and temporal–parietal cortices with other brain regions were associated with lower

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			(AUC). Verbal IQ (WASI). Self-reported pubertal status (PDS).	rates of delay discounting across adolescence. White matter microarchitecture in right frontal and left temporal regions (as well as near the globus pallidus and the amygdala for MD only) was associated with individual differences in delay discounting performance that were not attributable to age in this sample. In contrast, white matter tracts in left frontal and right temporal and parietal regions, as well as pathways near the amygdala, hippocampus, thalamus, anterior cingulate / paracingulate gyrus, and splenium of the corpus callosum, showed age-dependent associations between white matter organisation and delay discounting behaviour.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Ordaz SJ 2013 USA	Both genders, 9–26 yrs	Longitudinal; Longitudinal task fMRI during antisaccade paradigm. Hierarchical linear modelling.	Growth curves for behaviour and brain function.	Cognitive control protracted through adolescence; sex nor IQ explained variance. Mean growth curves for brain activation in a priori regions of interest revealed little developmental change in motor response control regions and increased activation in an error-processing regions. Decelerating rates of activation right dlPFC in as children proceed into adolescence. Only error processing activation was associated with performance, and this was shown to mediate the relationship between age and inhibitory error rates.
Padmanabhan A 2011	Both genders, 14–17 yrs	Cross-sectional; task fMRI during rewarded antisaccade task.	Behaviour: antisaccade performance during rewarded vs	Rewards enhanced task performance (i.e. reduced latencies and error rates) for all groups. Heightened VS activation during

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
USA			unrewarded trials. Brain activation for time x incentive x group.	rewarded relative to neutral trials was specific to adolescence. Rewards enhanced activity in regions associated with oculomotor and inhibitory control in adolescence. Basic neural circuitry underlying response inhibition and incentive processing is established in childhood. Adolescents showed increased activity in regions supporting performance that resulted in reward receipt reflect enhancements in motivation.
Peper JS 2013 Netherlands	Both genders, 8–25 yrs	Cross-sectional; structural MRI. Behaviour: Balloon Analog Risk Task (risk taking task).	Pubertal effects (PDS and testosterone) on behavioural performance (risk taking: number of	Testosterone levels and OFC morphology modulate risk taking across pubertal development: higher testosterone levels were associated with increased risk taking. OFC morphology (smaller OFC gray matter volume

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		Hormonal assays. Self-reported puberty (PDS).	balloon explosions). OFC volume, thickness, and surface areas.	in males and smaller OFC surface areas in girls) amplifies risk taking.
Peters BD 2014 Netherlands	Both genders, 8–18 yrs	Cross-sectional; DTI. A neurocognitive test battery. Linear mediation models.	The corpus callosum, two projection tracts, and five association tracts were traced using probabilistic tractography. Speed of processing, attention, spatial working memory, verbal functioning, visual learning, and executive functioning.	From childhood to early adulthood, higher FA of the cingulum bundle and inferior frontooccipital fasciculus (IFOF) was associated with higher executive functioning and global cognitive functioning, respectively, independent of the effect of age. When adjusting for speed of processing, FA of the IFOF was no longer associated with performance in the other cognitive domains with the exception of visual learning. From early adulthood to late adulthood, white matter tract FA was not associated with cognitive

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				performance independent of the age effect.
Pfeifer JH 2011 USA	Both genders,10–13 years	Longitudinal; Longitudinal task fMRI during affective displays. Self-reported resistance to peer influence. Self-reported pubertal development with PDS. Connectivity analysis (PPI).	Activation during face-viewing task for VS, VMPFC, and amygdala for neutral, happy, angry, fearful, or sad faces. Resistance to peer influence.	Responses to affective facial displays in VS and VMPFC increased from late childhood to early adolescence. VS response increases to all expressions were correlated with increases in RPI and decreases in IRBD.
Pharo H 2011 New Zealand	Both genders, 13–17 yrs	Cross-sectional; Battery of neuropsychological	Self-reported risk-taking (LEQ); Personality measure (ZKPQ-SF);	Personality traits of impulsivity, sensation-seeking, aggression, and sociability were related to increased levels of risky behaviour.

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		testing; Self-report personality questionnaires, risk-taking questionnaire.	Neuro-cognition (Neuro-function).	Individual differences in performance on a Neuro-Function battery were uniquely predictive of participants' real-life risky behaviour above and beyond the variation that was accounted for by personality, age, and sex. Participants who scored lower on the neuropsychological battery engaged in higher levels of risky behaviour than did individuals who scored higher on the neuropsychological battery.
Ripke S 2012 Germany	Both genders, 13.7–15.5 yrs	Task fMRI during temporal discounting task.	Signal when deciding on whether to choose an immediate versus long-term reward.	When controlling for discounting behaviour, neural processing the value of delayed rewards does not differ between adolescents and adults. Adolescents' brain regions processing reward value were neither hyper-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				nor hypo- sensitive compared to adults'.
Ripke, S 2015 Germany	Both genders, 13.7–15.5 yrs	Cross-sectional; task fMRI during temporal discounting task. General IQ test.	Brain activation during amount dependent and amount independent decision processing. IQ (g). Temporal discounting behaviour (k and AUC).	Higher intelligence was associated with higher activation during value-dependent processing in a frontal network consisting of the perigenual ACC, the IFG, and the ventromedial pFC as well as the VS (value-dependent network). responses in these regions were negatively correlated with the temporal discounting rate. Higher intelligence was related to higher in the dorsolateral pFC, the precuneus, and the occipital lobe (value-independent network) during the value-independent decision processing, which in turn was positively correlated with the consistency of choices.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				Associations between intelligence and temporal discounting or consistency of choices are at least partly mediated by activation in the respective brain network.
Rodrigo MJ 2014 Spain, Germany	Both genders, 17–18 yrs	Cross-sectional; fMRI during Social Context Decision task (SCDT), which consisted of short stories that describe social situations involving risk and ambiguous decision-making.	Behaviour in task. Brain activation during risky vs ambiguous scenarios and within risk scenario: dangerous vs safe.	Participants spent more time in making a dangerous choice than a safe choice (no age or gender difference). SCDT in risk scenarios (compared to ambiguous scenarios) activated control-related network and social cognitive network. Adolescents showed greater recruitment of the right DLPFC and the right TPJ in risk situations than young adults. When choosing the dangerous option, young adults showed a further engagement in ToM related regions (bilateral MTG) and in motor control

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				regions related to the planning of actions (pre-supplementary motor area). Finally, the right insula and the right superior temporal gyrus were more activated in women than in men, suggesting more emotional involvement and more intensive modelling of the others' perspective in the risky conditions.
Romer D 2011 USA	Both genders, 10–12 at baseline, 10–15 overall	Longitudinal; Longitudinal assessments at three waves. Task measures of executive function (working memory) and questionnaire	Measures of: risk taking, acting without thinking, sensation seeking, and working memory.	Risk taking, impulsivity, and working memory increased across age. Working memory performance was inversely related to subsequent risk behaviour. Sensation seeking was positively related to working memory performance and acting without thinking was negatively related to working memory performance.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		measurement of risk taking, impulsivity, sensation seeking, and externalising problems.		
Rubia K 2007 UK	Males, 10–17 yrs	Cross-sectional; task fMRI during stop signal task (withhold motor response when cue is followed by another ‘error’ signal). IQ used as covariate (raven's progressive matrices).	Task performance and brain activation during successful and unsuccessful stop trials.	Despite comparable task performance, adults showed increased brain activation compared with children/adolescents in right inferior prefrontal cortex during successful inhibition and in rostral anterior cingulate gyrus during stop failures.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Rubia K 2006 UK	Males, 10–17 yrs	Cross-sectional; task fMRI during Go/No-Go task (selective motor response inhibition), Simon task (interference inhibition), and Switch task (inhibition of irrelevance).	Task performance. Brain activation during no-go vs go trials; incongruent vs congruent trials; switch vs repeated trials.	1) Increased brain activation in task-specific frontostriatal networks in adults compared to adolescents, including right orbital and mesial prefrontal cortex and caudate during the Go/no-go task, right mesial and inferior prefrontal cortex, parietal lobe, and putamen during the Switch task and left dorsolateral and inferior frontotemporoparietal regions and putamen during the Simon task. 2) Progressive age-related changes in similar and extended clusters of task-specific frontostriatal, frontotemporal, and frontoparietal networks.
Silveri MM 2013 USA	Both genders, 12–14 yrs	Cross-sectional; Proton magnetic resonance	Metabolite data for GABA from the anterior cingulate cortex (ACC)	Adolescents have lower GABA than early adults. Lower ACC GABA/Cr was significantly associated with greater impulsiveness and less

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		spectroscopy. Go/No-Go task. Barrett Impulsivity Scale.	and the parieto-occipital cortex (POC). Impulsivity (BIS score). Response Inhibition (Go/No-Go).	cognitive control, with lower ACC GABA/Cr most strongly predicting worse accuracy on No-Go trials in adolescent males.
Simmonds DJ 2014 USA	Both genders, 13–17 yrs	Longitudinal; DTI. Two oculomotor tasks: the visually-guided saccade task and the antisaccade task.	White matter integrity (tract-based): Fractional anisotropy; Medial diffusivity; Radial diffusivity. Latency and Inhibitory errors on oculomotor tasks.	The majority of white matter reached maturation during adolescence. Several late-maturing regions including those connected to prefrontal regions, distinct phases of growth were seen, with rapid growth in childhood, followed by a slowing of growth in early–middle adolescence and acceleration of growth again in late adolescence/early adulthood. Males showed larger and more protracted WM microstructural growth, with lower levels of FA

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				than females in childhood and greater levels in adulthood. Differences in the timing of white matter changes may underlie developmental changes in behaviour. RT variability and inhibitory performance continued to mature through adolescence, whereas latency matured earlier. RT variability was associated with the timing of white matter development across the whole brain.
Smith AB 2011 USA	Both genders, 10–17 yrs	Cross-sectional; Task fmri, sustained attention task with two versions: rewarded and non-rewarded.	Brain activation during contrast of non-rewarded target versus non-target trials and contrast of rewarded target versus non-	Adolescents were significantly slower than adults to non-rewarded sustained attention target trials, but more sensitive to incentives, so that this difference was normalised in the reward condition. Non-rewarded vs non-target: Linear increases in activation with age in brain

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			rewarded target trials.	regions associated with sustained attention: right hemispheric lateral inferior frontal, superior temporal and inferior parietal cortices with decreases in linear activation with age in earlier developing limbic and paralimbic medial temporal, posterior insular and posterior cingulate regions known to be important for saliency detection. Reward further enhanced the age-dependent activation increases observed in the non-rewarded sustained attention regions in inferior frontal, temporal and cerebellar brain regions and elicited additional activation increases within top-down executive attention and motivation control areas such as dorsolateral and ventromedial

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				orbital PFC and dorsal striatum.
Somerville LH 2011 USA	Both genders, 13–17 yrs	Cross-sectional; task fMRI during Go/No-Go task with emotional faces.	Behaviour and brain activation during the following outcomes: misses (failure to press during go trial) and false alarms (erroneously pressing during no-go trial). Investigated differences between happy vs calm faces. Brain connectivity during task.	Adolescents show a failure to suppress responses to happy vs calm faces more than children or adults. The VS showed maximal activity in teens to happy faces. During no-go trials, prefrontal recruitment was greater in younger individuals, and prefrontal activity also predicted performance, such that individuals who were overall less successful at suppressing approach responses showed more right IFG activity for successful suppression trials. Striatocortical responses show a relatively greater degree of functional organisation in teens and adults relative to

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				children.
Spielberg JM 2014 USA	Both genders, 11–15 yrs	Longitudinal; fMRI task of threat reactivity.	Neural responses to threat cues, serum testosterone levels. Correlation of changes between timepoint2 and timepoint1.	Increases in testosterone over a 2-year period of pubertal maturation predicted increases in brain activation to stimuli typically associated with threat, observed in both a brain region typically associated with threat avoidance (amygdala) and a region typically associated with reward pursuit (NAc). Moreover, increased activation in both amygdala and NAc was related to greater approach behaviour (shorter RT to threat faces).
Stevens MC 2007 USA	Both genders, 11–17 yrs	Cross-sectional; task fMRI during Go/No-Go task. Dynamic	Brain network structure and interactions related to successful response	There were three distinct neural circuits comprising brain regions associated with response inhibition: a fronto-striatal-thalamic

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		Causal Modelling. ICA.	inhibition. Behavioural performance.	network (specifically, the indirect pathway); a network comprising bilateral precentral gyri, inferotemporal cortex, anterior insula, and right inferior frontal cortex; and a frontal-parietal circuit. Adolescents and adults differed in response inhibition network engagement, regional connectivity, and network dynamics.
Stice E 2010 USA	Females	Longitudinal; task fMRI imaging eating palatable, unpalatable foods compared to water. BMI measured at baseline and 6 and 1 year follow-up. Two dopamine genotypes	BMI at baseline, change in BMI over the following year. Neural responses to palatable vs unpalatable foods or palatable foods vs water. Differences in groups with different	Less activation in brain regions involves in reward processing was related to increases in BMI only for groups with allelic variants suggestive of reduced dopamine signalling. Greater activation in brain regions involves in reward processing predicted elevated future weight gain for those not at genetic risk for reduced dopamine signalling.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		analysed.	TaqIA1 allele of the DRD2 gene or the exon 3 7-repeat allele of the DRD4 gene.	
Strang NM 2014 USA, Canada	14–16 yrs	Cross-sectional; task fMRI.	Sustained activation in reward vs neutral blocks.	All participants demonstrated a shift to proactive cognitive control in the context of reward.
Strang NM 2011 USA	Males, 12–15 yrs	Cross-sectional; task fMRI during a stressful task that involves both an intellectual challenge and social evaluation.	Heart rate. Behaviour. Brain activation and functional connectivity in response to challenge.	Both adults and adolescents had increases in heart rate during the challenge condition. Both adolescents and adults engaged the DLPFC and dACC in a similar manner. Adults, but not adolescents, recruited the anterior insula. In adults, prefrontal regions were more strongly functionally connected to the anterior insula,

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				than they were in adolescents.
Tamm L 2002 USA	Both genders, 8–20 yrs	Cross-sectional; task fMRI during Go/No-Go task.	Behaviour: Accuracy & RT for errors of omission (misses) or errors or commission (false alarms).	Reaction times decreased with age during correct NoGo trials. No age differences in accuracy. There are both positive and negative age-related changes in specific brain regions associated with response inhibition: younger participants recruited the left superior and middle frontal gyri more than older participants to perform the task adequately, whereas older participants showed increased focal activation in the left inferior frontal gyrus.
Telzer EH 2013 USA	Both genders, 14–16.5 yrs	Cross-sectional; Task fMRI (Risk taking task and Self Control task).	Self-report: 1) Family obligation 2) Family cohesion 3) Risky	Family obligation was associated with less risk-taking, dampened activation in the VS to increasing monetary rewards, and greater

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		Self-report Questionnaires on family obligation, decision making competence, and risk-taking.	behaviour 4) Decision-making competence. Behavioural: 1) Risk-taking 2) Response inhibition. Brain: 1) Gender differences during risk taking. 2) Age differences in response inhibition. 3) How neural activation during the two imaging tasks related to questionnaire measures.	activation in the DLPFC during successful behavioural inhibition. Dampened VS activation was associated with less self-reported risk-taking behaviours. Greater DLPFC activation was associated with greater decision making competence.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Treit S 2014 Canada	Both genders, 5–16 yrs	Cross-sectional; DTI; Cognitive testing.	Behaviour: IQ, Naming, Inhibition, Switching. Voxel-based analysis of fractional anisotropy. Cluster tractography. Manual tractography.	In frontal and posterior white matter regions, worse inhibition performance correlated with higher FA. In posterior and brainstem regions, better cognitive flexibility was associated with higher FA.
Urošević S 2012 USA	Both genders, 9–17 yrs	Longitudinal; Demographics, diagnostic interview assessment, a set of questionnaires, a neurocognitive battery, psychophysiological testing, and a	BIS/BAS sensitivities; OFC, Nacc, and amygdala volumes.	There was increased reward sensitivity from early to late adolescence, with a decline starting in the early 20s. There was also a decrease in left nucleus accumbens volume from the late teens into the early 20s. Longitudinal increases in sensitivity to reward to be predicted by individual differences in the nucleus accumbens and medial orbitofrontal cortex volumes at baseline.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		structural MRI scan.		
Urošević S, Collins P 2014 USA	Both genders, 9–18 yrs	Cross-sectional; Questionnaires, a neurocognitive battery, psychophysiological testing, and structural brain imaging, two self-report puberty measures.	BIS/BAS sensitivities; Pubertal stage; Brain volumes for amygdala, caudate, hippocampus, Nacc, pallidum, putamen, and thalamus.	After controlling for effects of age and sex, pubertal status, as indexed by a PCA-derived puberty factor score, significantly predicted greater reward sensitivity as measured by the BAS Total and BAS Fun Seeking scales in adolescents. There were no unique main effects of chronological age after controlling for puberty and sex effects on reward sensitivity. There were significant sex-specific effects of advanced pubertal status on nucleus accumbens and pallidum volumes, as well as volumes of the right thalamus.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
van den Bos W 2012 Netherlands	Both genders, 13–16 yrs	Cross-sectional; Probabilistic Learning Task during fMRI.	Behaviour: reinforcement learning. Brain activation during prediction errors (negative and positive). Striatal functional connectivity during task.	1) With increasing age, negative feedback had decreasing effects on future expected values. 2) Neural activation to prediction errors did not differ between age groups. 3) Age differences in learning rates were associated with an age-related increase in functional connectivity between the ventral striatum and the mPFC.
van Duijvenvoorde AC 2015 USA, Netherlands	Both genders, 16–19 yrs	Cross-sectional; Behavioural and parametric fMRI analyses during decision making task (fMRI-compatible version of the 'hot' Columbia Card Task	Neural and behavioural processing of risk, return, gain and loss. Monotonic and adolescent-specific developmental differences.	Children were insensitive to changing levels of risk, but showed significant sensitivity to changing levels of return. Adolescents and adults showed sensitivity to risk and return, on average seeming to avoid increasing risk and to approach increasing return. Neural responses to risk showed adolescent-specific changes, whereas neural responses to return

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		(CCT).		showed monotonic age-related changes.
van Duijvenvoorde AC 2014 USA, Netherlands	Both genders, 10–19 yrs	Cross-sectional and Longitudinal; Examined the effects of reward-related brain activation, age, puberty, and individuals' reward sensitivity on risk-taking. Two experiments, one cross-sectional and one longitudinal extension of the	Risk taking on task. BAS Drive, Fun-seeking, and Reward-responsiveness. Brain activation during reward vs loss and as a proportion of plays. Brain connectivity during contrast.	1) A reward-related network including VS and medial PFC was consistently activated over time 2) the propensity to choose the risky option was related to increased reward-related activation in VS and medial PFC, and 3) Longitudinal comparisons indicated that self-reported reward sensitivity was specifically related to VS activation over time. 4) Risk-taking propensity was generally stable across time and was not related to developmental factors and individual differences.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		cross-sectional study. Task fMRI and connectivity during Jackpot Task, a risky decision task. Behavioural inhibition system/behavioural approach system scale. Puberty assessed with PDS.		
Van Leijenhorst L 2010 Netherlands	Both genders, 12–17 yrs	Cross-sectional; task fMRI during The Cake Gambling Task. Participants were asked to choose	Risk taking behaviour (# of risks and RT). Brain regions involved in High-Risk versus Low-Risk decisions;	There were no age differences in risk-taking when the reward at stake was high, however, for the more ambiguous 2 Euro gambles participants were more risk averse as they were older. No age differences in response

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		between a low-risk gamble and a high-risk gamble associated with a probabilistic monetary reward.	Neural correlates of age-related differences in risk-taking and individual differences in risk-taking; Brain regions related to the processing of outcomes of High-Risk gambles; Effects of reward magnitude on outcome processing; Neural correlates of age-related differences in outcome processing.	times. Across ages, risky choices were associated with activation in the medial PFC and the ventral striatum, whereas cautious choices were associated with activation in the DLPFC. A linear decrease in activation with age associated with risky choices in the dorsal ACC. There was an adolescent specific peak in activation in a region in VMPFC during the decision phase of trials, and in the VS during the outcome phase. The behavioural data do not reveal a peak in risk-taking in adolescence. Individual differences in risk-taking behaviour in the task were associated with activation in regions in medial PFC, and not with activation in the VS.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Vara AS 2014 Canada	Both genders, 13–17 yrs	Cross-sectional; task MEG during Go/No-Go task.	Behaviour: Hits Rate, False Alarms, RT on Go/No-Go. Brain activity during task as measured by MEG.	Right dominant inferior frontal activity in adults; Left dominant, bilateral activity in the inferior frontal regions for adolescents. Delay of the inferior frontal activity in adolescents compared with adults. Supplemental cortical recruitment helped adolescents maintain adequate inhibitory performance.
Velanova K 2008 USA	13–17 yrs	Cross-sectional; task fMRI during oculomotor task.	Eye tracking; behaviour; brain activation (time course x response type).	Children made significantly more AS errors than adolescents, who made more errors than adults. Regions known to support the voluntary control of eye movements showed greater activity during correctly performed AS trials than on error trials, but little developmental change. The dACC showed greater activity for error trials than for correct trials with the

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				magnitude of that difference increasing and extending in time from childhood to adulthood – despite children showing significantly longer response latencies. Finally, children showed increased involvement of dlPFC relative to adolescents and adults, with an anterior to posterior shift evidenced with increasing age.
Velanova K 2009 USA	13–17 yrs	Cross-sectional; task fMRI during oculomotor task.	Eye tracking; behaviour; brain activation (sustained statistical activation change during antisaccades).	The rate of successful inhibitory responding improved from childhood through young adulthood: processes implicated in sustained performance continue to mature after those supporting trial-specific performance (competence) are in place. Transient trial-specific activation is mostly mature by adolescence, but sustained brain activation, as

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				evident in adults, follows a more protracted developmental trajectory that mirrors improvements in performance between adolescence and young adulthood. Transient activation in prefrontal regions supporting controlled processing decreases with age, but sustained activation increases.
Verdejo-Garcia A 2010 Spain	Both genders, 13–16 yrs	Cross-sectional; A comprehensive battery of executive functioning tests including measures of working memory, analogical reasoning, planning, response	BMI; IQ–Kaufman brief intelligence test; Working memory–letter-number sequencing; Analogical reasoning–similarities; Planning–zoo map; Interference/response	Adolescents with excess weight have poorer neuropsychological performance on tests of response inhibition, flexibility, and decision-making. Individuals with excess BMI have worse flexibility performance: cognitive flexibility (measured by the TMT) was the ability most significantly decreased in adolescents with excess weight. Excess-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		inhibition, flexibility, self-regulation, and emotional decision-making.	inhibition–Stroop test; Inhibition and shifting–five-digit test; Set-shifting–trail-making test A and B; Self-regulation–Revised Strategy Application Test; Effective decision-making–IGT.	weight adolescents do not differ from normal-weight controls in their performance on tests of working memory, planning, and analogical reasoning, or in self-report measures of impulsivity.
Vijayakumar N 2014 Australia	Both genders, 12.7–17.7 yrs	Longitudinal; Longitudinally acquired structural MRI and behavioural measure of cognitive control (proactive vs	Annualised percent change of cortical thickness for the ACC, dlPFC, and vlPFC.	There were longitudinal improvements in reactive control between early and mid-adolescence. The magnitude of the improvement in proactive control was associated with reduced thinning of the right vlPFC. The magnitude of the improvements in

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		reactive) as assessed by Stroop task.		reactive control was associated with reduced thinning of the left ACC (males only).
Vink M 2014 Netherlands	Both genders, 10–25 years	Cross-sectional; task fMRI during a stop-signal task (which measures two forms of inhibitory control: reactive inhibition (outright stopping) and proactive inhibition (anticipation of stopping).	Behaviour/performance on the SSRT (latency and success). Brain activation during two these reactive inhibition contrasts. Also a priori ROI activation in a fronto-parietal network. Functional connectivity of a right striatal seed.	Reactive inhibition improved across development, where older subjects were faster in reactive inhibition, and this was paralleled by an increase in motor cortex suppression. While proactive inhibition increased with age, it was more to do with older subjects slowing down responding more compared to younger subjects when anticipating a stop-signal, and this was paralleled by increased activation in the right striatum, right ventral and dorsal inferior frontal gyrus, and supplementary motor area. Functional connectivity during proactive inhibition increased between striatum and

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				frontal regions with age.
Weiland BJ 2015 USA	Both genders, 14–18 yrs	Cross-sectional; Structural MRI. Comparison groups of daily marijuana users vs non-users matched on alcohol use.	Voxel-based morphometry, surface-based morphometry, and shape analysis of specific ROIs: nucleus accumbens, amygdala, hippocampus, and cerebellum.	No statistically significant differences were found between daily users and nonusers on volume or shape in the regions of interest. Effect sizes suggest that the failure to find differences was not due to a lack of statistical power, but rather was due to the lack of even a modest effect.
Weiland BJ 2014 USA	Both genders, 18–23 yrs	Cross-sectional; Diagnostic interview: Substance risk score. Youth self-report questionnaire:	Brain structure (grey matter volume). Externalising behaviours. Substance use risk.	The early risk sample had smaller volumes in the left frontal cortex, when controlling for total GM volume, substance use, and family history. There was a negative relationship between total GM, left frontal, and left superior frontal,

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		externalising behaviours. Family history of alcohol use. Structural MRI (grey matter volume).		cortical volumes and early externalising behaviours.
Yaxley RH 2011 USA	Both genders, 12–17.7 yrs	Cross-sectional; fMRI task designed to challenge the dorsal lateral prefrontal executive control and ventral medial prefrontal reward circuits (Decision–Reward Uncertainty task)	Group average as well as age correlations with three contrasts: Behavioural risk; Reward risk; No Risk. Focused on two conditions per contrast: choice selection and outcome evaluation.	Increased activity of the frontal pole with age during decision making, no association with age and Vstr during reward evaluation. Decision making during the task elicited activation in executive-control regions typically implicated in studies of adult decision making and behavioural risk trials evoked greater activation than the other conditions in executive-control regions. Results were similar to those of young adults using the same task.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				Reward versus no reward elicited significant activations in brain regions typically implicated in decision and reward processing.
Yokum S 2013 USA	Both genders	Cross-sectional; Task fMRI viewing appetising and unappetising food images based on the individual's food preferences. Participants instructed to think about the food in the pictures in one of four ways: (1) imagine eating, (2)	Neural responses to three contrasts: suppress craving>imagine eating, costs of eating>imagine eating, benefits of not eating>imagine eating.	The costs of eating and benefits of not eating strategies are more successful in increasing inhibitory region activation than the suppress craving strategy. There was no difference between BMI groups.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		costs of eating, (3) benefits of not eating and (4) suppress craving.		
National Inst. on Alcohol Abuse and Alcoholism 2004/2005	Both genders, adolescents and young adults	Integrate studies of the effects of genes on alcohol initiation, use, and dependence with studies of physiological development measuring brain, pubertal, and other changes to analyse how adolescence is a	Genes, puberty, brain, alcohol use, rodent studies, macaque studies, human studies.	Genes have a large influence on the development of problematic alcohol use, and environmental factors have a large influence on the age of alcohol use initiation. Changes in how alcohol is absorbed, distributed and eliminated occur during adolescence, which impact how alcohol affects an individual. Adolescent rats are less sensitive to the negative effects of alcohol than adult rats, and adolescent rats drink more alcohol than adult counterparts. Genetic influence on alcohol use

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		sensitive period for the effects of alcohol.		increases across adolescence.
Arain M 2013	Adolescents	-	-	-
Bava S 2010 USA	Both genders, adolescents	Reviews papers on adolescent brain development, with particular attention to studies on reward seeking, risky behaviour. Also reviews papers that measure how substance use can	MRI measures; neurotransmitter systems; behaviour.	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		affect brain maturation.		
Blakemore SJ 2014	Both genders, adolescents	Review	brain measures, cognitive measures, behavioural measures	Adolescence is a time of substantial changes in brain structure and function in regions related to social processing, especially understanding the mental states of others.
Blakemore SJ 2012	Both genders, adolescents	Review of literature on impulsivity, inhibitory control, temporal discounting, learning and prediction errors, and the effects of emotional or social (hot) contexts on	Activation in adolescents during decision-making tasks.	Adolescents are more likely than children and adults to make risky decisions in 'hot' contexts, where emotions are at stake or peers are present and social cognition is involved.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		decision making. Comparison with adult literature.		
Blakemore S 2006	Both genders, adolescents	Review of early cognitive and neuroimaging literatures.	Brain structure and function.	One of the first reviews to suggest that social cognitive processing and executive functions continue to change through adolescence given the changes occurring in the brain during this time.
Brown GR 2013	Both genders, adolescents	Review of mammal and bird literature on stress and development.	Effects of adolescence stress on behaviour and brain development.	'Exposure to stress during adolescence appears to impact upon numerous brain areas and to influence several neurotransmitter systems, including the serotonergic and dopaminergic systems.'
Cameron JL 2004	Both genders,	Overview of animal and human literature	GnRH secretion is impaired under stress.	Most evidence supports stress leading to suppressed or delayed pubertal development,

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
	adolescents	on how stress impacts puberty and the neural mechanisms.		but there is some evidence that stress can speed up pubertal development.
Cameron JL 2004	Both genders, adolescents	Review of studies about neural responses to hormones. Mostly animal studies.	Measures of hormones; measures of sexual behaviour; neuronal measures.	Hormone changes at puberty affect reproductive behaviour in animals.
Casey BJ 2010	Both genders	-	-	-
Casey BJ 2015	Both genders, adolescents	Review of the literature	Self-control in the face of incentives: Appetitive Cues, Performance-Based Incentives,	The results of this literature review challenge simple models such as the dual-system or triadic models of adolescent behaviour. The review findings support the idea that changes

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			Social Contexts. Self-control in the face of threat: Cues of Potential Danger, Cued Fear, Contextual Fear.	in self-control during adolescence are related to changes in connections within fronto-limbic circuitry.
Chambers RA 2003	Both genders	Review papers on the neurocircuitry of motivation, impulsivity, addiction and neurodevelopment.	Brain anatomy, function, synapses, and metabolism. Behaviour. Epidemiological studies.	Regions of the brain involved in motivation, impulsivity, and addiction are continuing to develop through adolescence. This ongoing change explains some of the 'transitional trait behaviour' observed during adolescence, including impulsivity and novelty seeking.
Champagne FA 2010	Both genders, prenatal to adult	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Check JH 2013	Both genders, adolescents	-	-	-
Choudhury S 2013	Both genders, adolescents	-	-	-
Colrain IM 2011	Both genders, adolescents	-	-	-
Crews F 2007	Both genders, adolescents	-	-	-
Crone EA 2012	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Crone EA 2009	Both genders, adolescents	-	-	-
Dahl RE 2008	Both genders, adolescents	-	-	-
Dayan J 2010	Both genders, adolescents	-	-	-
Defoe IN 2014	Both genders, children to adolescents	-	-	-
Diamond LM 2014	Both genders,	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
	Lifespan approach			
Doremus-Fitzwater TL 2010	Both genders, adolescents	-	-	-
Ernst M 2009	Adolescents	-	-	-
Ernst M 2014	Both genders, adolescents	-	-	-
Ernst M 2006	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Fareri DS 2008	Both genders, adolescents	-	-	-
Feinberg I 2010	Both genders, adolescents	-	-	-
GalvÃ¡n A 2014	Both genders, adolescents	-	-	-
Geier C 2009	Both genders, adolescents	-	-	-
Geier CF 2013	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Guerri C 2010	Both genders, adolescents	-	-	-
Hagenauer MH 2012	Both genders, adolescents	-	-	-
Halpern CT 2006	Females, adolescents	-	-	-
Johnson SB 2009	Both genders, adolescents	Literature review.	Historical attempts to use developmental benchmarks as measures of adolescent maturity. What is known	Discusses age-based policies (e.g. age of consent). Little empirical evidence to support the current legal age of majority (18) as an accurate marker of adult capacities. Discusses some weakly supported ideas about how brain

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			about adolescent brain development? What is unknown about adolescent brain development? What neuroimaging research can and cannot tell us about the adolescent brain and behaviour. Current use of the brain sciences in adolescent health policy debates. A strategy for increasing the utility of brain science in public policy	matures.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			to promote adolescents' wellbeing.	
Johnson SB 2010	Both genders, adolescents	-	-	-
Konrad K 2013 Germany	Both genders, adolescents	Selective review of pertinent articles retrieved from the PubMed database about the structural and functional development of the brain in adolescence. Focus on how development relates	Public health data on risk taking behaviours in German teenagers. Strucural and functional MRI studies. Histological studies in humans and non-human primates. The effects of hormones on brain measures in	1) In adolescence, a fundamental reorganisation of the brain takes place that continues into the beginning of the third decade of life. 2) Adolescent brain development is characterised by an imbalance between the limbic and reward systems, which mature earlier, and the not yet fully mature prefrontal control system. This imbalance may be the neural substrate for the typical emotional reactive style of adolescence, and it

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		to risk-taking behaviour.	rodents.	may promote risky behaviour. 3) Typical adolescent behaviour is the basis for the development of autonomy in adolescents and promotes their emancipation from the primary family. 4) The hormones of puberty affect the further sex-specific restructuring of the adolescent brain. 5) The reorganisation of the adolescent brain renders it particularly susceptible to environmental influences, both positive and negative.
Leyton M 2014 Canada, USA	Both genders, adolescents	Review of studies in human adolescents, young adults, and laboratory animals.	Human behavioural traits. Dopamine function (hyper and hypo) in animals.	Behavioural traits that predict drug use behaviours covary with the tendency to engage with other rewarding stimuli and individual differences in dopamine cell responsiveness. While heightened dopamine responses to

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
				emotionally intense stimuli might initially target diverse non-drug stimuli, the initiation of drug use steers the heightened dopamine reactivity toward drug-related cues, leading to drug conditioning and sensitisation.
Liang J 2014	Both genders, adolescents	Systematic review. Empirical research 1976–2013. Must have: at least one measure of neurocognitive functioning and at least one measure of obesity or weight, or at least one measure	Empirical articles with BMI, weight, or obesity-related behaviour in addition to the following kinds of cognitive functioning measures: neuropsychological tests, self-report measures, or performance-based	67 studies. Overall negative relationship between obesity and neurocognitive functioning, such as executive functioning, attention, visuo-spatial performance, and motor skill. Mixed effects among obesity, general cognitive functioning, language, learning, memory, and academic achievement. Executive dysfunction associated with obesity-related behaviours, such as increased intake, disinhibited eating, and less physical activity.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		of an obesity-related behaviour. Studies with participants of all body mass index (BMI) levels and that included participants ages 18 and under were included.	tasks.	Physical activity is positively linked with motor skill.
Lubman DI 2007 Australia	Both genders, adolescents	Review of human and rodent studies on the effects of alcohol on brain/endocrine functioning. Review of brain development. Focus on the effects	Other reviews and some empirical evidence. Brain volumes, brain functioning, neuroendocrine functioning, behaviour,	Brain volumes correlate with age at first use of alcohol/cannabis.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		of early age of onset.	cognition.	
Luciana M 2012 USA	Both genders, adolescents	Review of behavioural and neuroscience literature (rodent and human). Overview of dopamine system, structural plasticity, changes in the dopamine system during adolescence.	Behavioural changes in motivational tendencies, neurobiological changes involving the structure and functioning of this neural circuitry supporting incentive motivation. Table summarising major changes in dopaminergic signalling in primates and	Major nodes of incentive motivation circuit are: midbrain ventral tegmental area (VTA), its dopaminergic projections to medium spiny neurons of the nucleus accumbens, ventral pallidum, amygdala, hippocampus, anterior cingulate cortex, and medial orbitofrontal cortex. Many healthy typically developing teens do not apparently demonstrate unusually strong motivational drives and impulsive response tendencies. Incentive-reward motivation and behavioural activation are relatively greater in adolescence compared with other points in the lifespan because of increases in mesoaccumbens DA tonic activity

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
			rodents. Table summarising fMRI Studies of reward processing in healthy adolescents.	during this time.
Luciana M 2013 USA	Both genders, adolescents	Review of the current state of knowledge regarding neurodevelopmental models of adolescent behaviour, extensions of these models to psychopathology, and future directions within this field of	A Retrospective on Conceptual Models of Adolescent Behaviour. The Heterogeneity of the PFC and Its Striatal Connections. Shift to dual systems models.	The dorsolateral PFC is interconnected with the mediodorsal thalamus, with the dorsal striatum (primarily the caudate nucleus), with the inferior parietal cortex, and other structures within the dorsal visual system. + The ventromedial PFC is more strongly interconnected with limbic structures, such as the extended amygdala, hypothalamus, the ventral striatum, and anterior portions of the temporal cortex. = Distinct prefrontally guided

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		inquiry.		networks exist for the regulation of cognitive versus affective processes.
Luciana M 2012	Both genders, adolescents	Review of the literature.	Developmental changes in incentive motivation and implications for cognitive control/self-regulation.	Adolescents can be enormously competent in their levels of executive function, but that self-regulation falters under conditions of high stress or high demand.
Luna B 2010	Both genders, adolescents	-	-	-
Luna B 2009	-	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Luna B 2004	-	-	-	-
Lydon DM 2014	Both genders, adolescents	-	-	-
Nelson EE 2005 USA	-	-	-	-
Nixon K 2010	Both genders, adolescents	-	-	-
O'Dell LE 2011	Both genders,	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
	adolescents			
Oron Semper JV 2014	Both genders, adolescents	-	-	-
Padmanabhan A 2014	Both genders, adolescents	-	-	-
Pfeifer JH 2012	Both genders, adolescents	-	-	-
Pfeifer JH 2012	Both genders,	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
	adolescents			
Placzek AN 2009	Both genders, adolescents	-	-	-
Richards JM 2012	Both genders, adolescents	-	-	-
Richards JM 2013	Both genders, adolescents	Systematic Review of the neurodevelopmental literature on reward processing. Specifically reward-related studies of	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		healthy individuals that include both paediatric and adult samples.		
Riggs NR 2009	Both genders, adolescents	-	-	-
Romer D 2010	Both genders, adolescents	-	-	-
Sachser N 2011	Both genders, adolescents	-	-	-
Sawyer SM 2012	Both genders,	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
	adolescents			
Schulz KM 2006	Both genders, adolescents	-	-	-
Segalowitz SJ 2010	Both genders, adolescents	-	-	-
Sercombe H 2014	Both genders, adolescents	-	-	-
Silveri MM 2014	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Sisk CL 2004	-	-	-	-
Sisk CL 2005	-	-	-	-
Smith AR 2013	Both genders, adolescents	-	-	-
Smith AR 2014	Both genders, adolescents	-	-	-
Somerville LH 2010	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Somerville LH 2010	Both genders, adolescents	-	-	-
Spear LP 2002	Adolescents	-	-	-
Spear LP 2013	Both genders, adolescents	-	-	-
Spear LP 2014	Both genders, adolescents	Review of rodent and human studies.	Brain measures and behaviours in humans and rodents.	Adolescents respond differently to drugs. Adolescents are more sensitive to social facilitation effects of ethanol; adolescents are less sensitive to the 'negative' effects of ethanol, such as sedation.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Steinberg L 2005	-	-	-	-
Steinberg L 2010	Both genders, adolescents	-	-	-
Trezza V 2008	-	-	-	-
Vigil P 2011	Both genders, adolescents	-	-	-
Wahlstrom D 2010	Both genders, adolescents	A neurobehavioral systems framework to describe adolescent	Dopamine concentrations, innervation, and	During adolescence, dopamine levels are at a functional high, leading to elevated patterns of exploration, novelty-seeking, incentive

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		behaviour; a review of the dopaminergic system; a review of the development of the dopaminergic system; implications for cortical and subcortically-mediated behavioural processes; measurement issues.	receptor density. Animal and human work. COMT and cognition.	salience, and locomotor activity, all of which serve to bring the individual into contact with biologically salient incentives.
Wahlstrom D 2010	Both genders, adolescents	Background in how human neuroimaging studies have promoted 'prefrontal	Behavioural and brain development in adolescence; Dopamine activity,	There is increased dopamine availability in adolescence compared to adulthood (based on animal work). The influence of COMT on cognition may depend on state factors such as

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
		cortex' based hypotheses of adolescent behaviour. Reviews mostly animal studies to establish evidence for hypothesis: overview of dopamine system, dopamine system development, and COMT.	cells, projections, enzymes, receptors, genes, development, receptor density, transporter density, COMT and cognition at different developmental stages.	age and individual differences, such as sex, both of which are known to impact the DA system that mediates the relationship between COMT and cognitive processes.
White AM 2009	Both genders, adolescents	-	-	-

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Willoughby T 2013 Canada	Both genders, adolescents	Comparing the developmental time courses risk taking in real life to risk taking in the laboratory.	Review of public health records, epidemiological records, self-report behaviours, cognitive studies of risk-taking, neuroscience studies.	1) Most youth go through adolescence without experiencing any major problems and there are low rates of mortality/morbidity in adolescence. 2) Studies on rates of risk taking across adolescence and young adulthood do not provide unequivocal support for the Dual System Model hypothesis that risk taking should be most common among 15 year olds. University students take the most risks. 3) Risk taking is not always impulsive, can be planned and adolescents may deliberately engage in risk taking behaviour in order to gain social rewards. 4) Adults also engage in risk taking.
Windle M 2009	Both genders,	Examine the relationship between	Epidemiology, psychology, sociology,	1) Early initiation of drinking is associated with later problems with alcohol, including

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
USA	10–15 yrs	the developmental period from 10–15 years and the use of alcohol. Overview of normative human development between ages 10–15 years. Discussion of alcohol use during early and middle adolescence and the risk and protective factors related to underage drinking and to future use.	neuroscience, animal studies.	dependence, and abuse of other substances. 2) As adolescents mature they play a more active role in choosing their social relationships and physical environments, and these choices increase their risk and/or protective factors for alcohol use. 3) The number or percentage of alcohol using friends is the most potent predictor of an adolescent's alcohol use.

Authors Date Country	Population	Method	Outcomes/variables of interest	Brief summary of findings
Yurgelun-Todd D 2007 USA	Both genders, adolescents	Review of structural and functional MRI studies	Structural fMRI: morphometry, DTI. Functional MRI: Executive functions; Emotional processing.	1) Increases in executive functioning across adolescence is associated with greater recruitment of prefrontal cortex. 2) PFC activity becomes more focal. 3) Increasing modulation of emotional processing by prefrontal between adolescence and young adulthood.