1-A-1 Atypical rich-club organization in brain connectivity as an endophenotype of attention deficit hyperactivity disorder

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Attention deficit hyperactivity disorder (ADHD) is a prevalent psychiatric disorder that emerges early in childhood. Though ADHD exhibits high heritability and numerous genes that have been identified that convey risk for ADHD, their collective risk explained is very small. Brain imaging may serve as a tool to identify reliable endophenotypes to improve our understanding of the link between the genetics of the disorder and the behavioral symptoms. Based on current models of ADHD, cortical-subcortical interactions critical for typical development is atypical in children with this disorder. Additionally, large-scale network properties with regard to cortico-cortical interactions are likely also atypical. To examine these interactions as possible endophenotypes, we used resting state functional magnetic resonance imaging (rs-fcMRI) to measure neural circuits thought to be involved in ADHD, including the nucleus accumbens and amygdala, along with graph theory analyses to identify atypical functional patterns in ADHD probands and their unaffected siblings. We found no similarities in connectivity between ADHD probands and their unaffected siblings when examining connectivity between the nucleus accumbens or amygdala and the cortex, compared to control siblings. When examining network patterns such as rich-club organization, whereby highly connected nodes within a network are also highly connected to each other, we observed atypical organization in functional networks of both ADHD probands and unaffected siblings.

2-A-2 The relationship between cortical thickness and executive functions in 5-7 year olds with and without ADHD

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Typical cognitive development is marked by improvements in executive functions, including the ability to hold information in working memory (WM) and to control interference (IC) from irrelevant information. Children with attention-deficit/hyperactivity disorder (ADHD), in contrast, show poor executive functions relative to age-matched controls. However, the precise nature of cognitive and neural deficits in ADHD has not been elucidated: some researchers suggest that IC is critically impaired, while others fault the WM system. We aim to adjudicate between these possibilities by using a paradigm both separately and interactively examines the contributions of WM and IC in children both with and without ADHD, ages 5-7. Results suggest that children with ADHD (N=15) have difficulty with both WM and IC, relative to typically developing controls (N=19). In addition, we obtained structural MRI data on all children, which allows us to estimate cortical thickness using the morphometric procedures from the FreeSurfer image analysis suite. Cortical grey-matter thinning, which is thought to be a correlate of increases in myelination and synaptic pruning, is one potential explanation for age-related improvements on measures of executive function. We predict that thinner cortex in the dorsal

prefrontal and superior parietal regions will be associated with better performance on the WM aspect of the task, while thinner anterior cingulate cortex and basal ganglia will be associated with better performance on the IC aspect of the task. Results and implications will be discussed.

1-A-3 Abnormal White Matter Diffusivity in Preschool-Age Children with ADHD

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Abstract: To investigate the early neural development of ADHD, DTI data were collected in 51 children, ages 4-5 years (25 with ADHD, 26 TD controls). Voxel-wise analysis of diffusivity measures revealed large regions of abnormally decreased diffusivity. Background ADHD is the most common psychopathology in preschool children; however, few studies have employed neuroimaging methods to examine brain development in this age range. Examination of white matter development in preschoolers can help clarify early neurodevelopmental pathways that lead to behavioral dysfunction. Methods DTI data were collected in 51 preschool children ages 4-5 years. ADHD was diagnosed using modified DSM-IV criteria. Voxel-wise analyses of group differences examining fractional anisotropy (FA) and mean diffusivity (MD) were subsequently performed using the FSL software package ('randomise' program). Analyses were restricted to voxels in which mean FA across all participants was>0.20 Results When comparing MD images, a test of suprathreshold cluster extent reached significance at p=0.04, yielding three large clusters for which MD was reduced in the ADHD group: left medial-frontal white matter; bilateral posterior thalamus/pulvinar; bilateral cerebellar peduncle. Discussion These regions identified as anomalous by voxel-wise analysis in preschoolers with ADHD comprise a cerebellar-thalamic-cortical network shown to be important for cognitive control and error processing.

2-A-4 Examination of frontal lobe cortical thickness and symptom severity in girls with ADHD

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Anomalous cortical development is a consistent finding across neuroimaging studies in children with ADHD. Given the prevalence of boys with ADHD, few studies have examined frontal lobe morphometry exclusively in girls with ADHD. In an effort to better characterize the neural correlates of ADHD in girls, we employed a detailed parcellation of the frontal lobes to examine functionally distinct subdivisions and associations with ADHD symptom severity and motor control. High-resolution T1-weighted MPRAGE images were acquired in 24 girls with ADHD and 33 age-, SES-, and IQ-matched typically-developing (TD) girls, ages 8-12 years. Cortical measurements were extracted using FreeSurfer. MANCOVA was used to examine group differences in regional subdivisions, controlling for total cerebral volume (TCV). Partial correlations (controlling for TCV) were used to examine associations among prefrontal ROIs ADHD symptoms, and motor control. Using a novel frontal lobe atlas, we found that decreased cortical thickness was specific to bilateral medial prefrontal and left dorsolateral prefrontal cortex in girls with

ADHD. Surprisingly, we observed that increased cortical thickness in girls with ADHD girls was associated with increased symptom severity and impaired motor control. Among girls, within the age range examined, frontal lobe gray matter undergoes significant pruning and progressively reduced volume. As such, the positive correlation between prefrontal cortical thickness and ADHD symptoms in girls with ADHD is also suggestive of delayed cortical maturation in this age range.

1-A-5 Atypical development of functional connectivity during face processing in autism

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Face processing impairments increase from adolescence to adulthood over in typical development (TD) but not in autism (ASD). There is evidence that differences in frontotemporal connectivity contribute to this deficit in ASD; however, a developmental comparison to TD has not yet been done. We hypothesized the increasing deficits on face processing in ASD would reflect a lack of TD of connectivity between frontal and temporal regions. We scanned 88 individuals 9-36 year olds with and without ASD on a modified Cambridge Face Memory Task. Regions of interest in the fusiform face area (FFA) bilaterally were used as seed regions, and connectivity with the whole brain was examined using the beta series ($p < .02$, corrected). The TD group exhibited developmental decreases in connectivity strength between L FFA and bilateral middle temporal lobe and precuneus while the group with ASD showed the opposite pattern, with activation increasing with age. Connections between L FFA and R frontal cortex exhibited a peak during adolescence in TD, while ASD exhibited the opposite pattern. The R FFA also exhibited increased connectivity with the frontal cortex, L insula and the R superior temporal gyrus in TD while the ASD group showed a decrease over development. We found support for our hypothesis that the development of frontotemporal connectivity is atypical in autism, suggesting a lack of maturation of top-down processing that occurs typically, potentially underlying the disruption in the development of face processing.

2-A-6 Maturation of the neural substrates underlying face recognition typically and in autism

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While there has been substantial focus on the early development of visual processing in Autism Spectrum Disorders (ASD) and its relation to social deficits, very little is known about later developmental processes. In particular, the transition from adolescence to adulthood is a time of increased social motivation that may be disrupted in ASD, potentially impacting social cognitive skills such as face recognition. Our previous work illustrates this pattern, with face recognition (on the Cambridge Face Memory Test; CFMT) improving from adolescence to adulthood typically but not in ASD. The current work examines the neurobiological basis of this differential development, again using the CFMT, modified slightly for the scanner environment. In this well-established paradigm, 6 faces are

memorized from 3 angles and then recognition is tested. We analyzed 32 13-17 year olds and 28 18-36 year olds with and without ASD, matched on age, gender and IQ. We performed a 2 (Diagnostic group) x 2 (Age Group) ANOVA to determine regions above threshold for a group by age group interaction (individual voxel $p<0.01$; group $p<0.05$). Examination of the Group x Age interaction revealed a number of regions, though none in the fusiform gyri regions thought to be specific for faces, including bilateral thalamus, insula, cuneous, medial superior frontal gyrus, R middle occipital and L superior temporal gyrus. All these regions showed increases from adolescence to adulthood typically, and either no change or decreased activation in ASD, indicating an arrest in maturation during adolescence in ASD.

1-A-7 Visuomotor functional connectivity relates to autism severity

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Autism Spectrum Disorder (ASD) affects many areas of development, including motor skills. Research suggests that motor, communication, and social skill learning may share a common brain-basis. ASD-associated deficits in imitating others' actions likely impact both motor and social skill acquisition; however, it is unclear what brain mechanisms contribute to these deficits. This study investigated the relationship between visuomotor functional connectivity (FC) and both imitation ability and autistic trait severity in children with ASD. Resting state fMRI scans from 80 children (40 ASD and 40 typically-developing [TD]) were combined to estimate visual and motor networks using independent component analysis (ICA). Participant-specific spatial maps and timecourses were back-reconstructed from the group-level components. To estimate visuomotor FC, the correlation between each pair of participant-specific motor and visual network timecourses was computed. Brain-behavior relationships were assessed by regressing visuomotor FC with imitation and autistic trait severity scores. In ASDs, motor networks were significantly more negatively correlated with a higher-order visual network compared to TDs. In TDs, stronger visuomotor FC was associated with better imitation and better overall performance of gestures on praxis examination. No significant relationship was observed between visuomotor FC and imitation ability in ASDs. However, ASDs with more abnormal visuomotor FC displayed more severe ASD traits, further supporting a link between motor and social deficits associated with ASD.

2-A-8 Functional Connectivity of the Amygdala in Very Early Childhood Depression: A Resting-State fMRI Study

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Background: Disrupted amygdala-prefrontal cortex (PFC) connectivity has frequently been reported in depression. However, very little is known about how this disordered relationship develops and impacts future regulatory and adaptive behavior. Interestingly, recent data suggest that amygdala-PFC functional connectivity undergoes a prolonged period of maturation, involving changes in strength and valence

beginning in early childhood. As such, very early occurring depression may disrupt amygdala-PFC connectivity during an important phase of development within this circuit, but data supporting this is lacking. The current study addressed this question by examining functional connectivity of the amygdala in depressed 4-6 year old children and their healthy peers. Methods: Fifty-three medication naïve 4-6 year olds (20 depressed/33 healthy) participated in a case-control study using resting-state functional magnetic resonance imaging. Amygdala functional connectivity in children with and without depression was compared. Results: Controls were found to have greater positive right amygdala-medial PFC connectivity when compared to depressed preschoolers. Increased negative connectivity between the right amygdala and dorsal anterior cingulate was present in healthy controls as well. Right amygdala-mPFC connectivity was negatively correlated with depression severity. Conclusions: Study findings converge with previous research suggesting a key role for disrupted cortico-limbic connectivity in depression and provide the earliest evidence of altered functional connectivity in depression.

1-A-9 Child Maltreatment and Prefrontal Cortex and Amygdala Function during Effortful Emotion Regulation

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Childhood trauma (CT) exposure is a robust predictor of mental disorders throughout the life-course, but the neurodevelopmental mechanisms underlying these associations remain inadequately understood. We examined whether CT influences prefrontal cortex (PFC) and amygdala structure and patterns of neural function and functional connectivity between these regions during effortful emotion regulation. A sample of 40 adolescents (aged 13-19 years) participated. Half of the sample had exposure to physical or sexual abuse, and half were age and gender matched controls. Maltreated adolescents exhibited significant reductions in cortical thickness in the orbitofrontal cortex (OFC), rostral anterior cingulate, inferior frontal gyrus, and medial temporal cortex as well as reduced fractional anisotropy in the uncinate fasiculus, cingulum, and superior longitudinal fasciculus. Maltreated adolescents had greater activation than controls in the right amygdala, medial OFC, and middle frontal gyrus during trials in which they used reappraisal strategies to try to decrease emotional responses evoked by a negative picture relative to trials where they simply viewed a negative picture, indicating that the PFC-linked reduction in amygdala response during regulation compared to look trials was significantly lower for maltreated adolescents than controls. No difference in amygdala response between groups was observed in trials where participants simply viewed negative stimuli. Results indicate reduced structural and functional connectivity of the PFC and amygdala in youths exposed to CT.

1-A-10 Altered Amygdala Connectivity in Youth Exposed to Trauma

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Early life exposure to trauma represents a potent risk factor for emotional psychopathology. The amygdala plays a central role in emotion-related processing, and converging evidence suggests that disruption in amygdala connectivity underlies emotional psychopathology. Here we used resting state MRI to examine amygdala functional connectivity (FC) in youth (children and adolescents) exposed to trauma, compared to those without a history of trauma (n=42). Probabilistic maps for bilateral (a) basolateral, (b) superficial, and (c) centromedial regions of the amygdala were used as starting points in 3 seed-based FC analyses. Results showed that FC to frontal, temporal, and parietal cortices, along with select subcortical regions, was altered in youth exposed to trauma. Notably, FC between the amygdala and prefrontal cortices (PFC) was negative in the non-trauma group, but this relationship was absent in the trauma group. Further, dorsal, compared to ventral PFC showed the greatest FC differences between groups. Finally, trauma frequency was related to the strength of the observed FC effects. Reduced amygdala-PFC FC is consistent with the theory that emotion dysregulation may arise from an inability to exert prefrontal control over potent, instinctual emotional responses. Our results underscore a relationship between early adversity and alterations in amygdala connectivity, which may underlie vulnerability to psychiatric illness.

1-A-11 Along-tract statistics reveal alterations in structural connectivity in male and female adolescents with a fetal alcohol spectrum disorder

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Prenatal alcohol exposure (AE) produces a highly complex pattern of cognitive and behavioral impairments, which correspond with alterations in brain structure. However, little is known about how white matter connectivity among regions is altered by AE. Diffusion imaging metrics (fractional anisotropy, FA) were utilized as an index of white matter tract integrity. DTI images were obtained in prenatal AE and Control adolescents (n=48, 8-18 yrs, mean=13±2 years, 48% female). Along-tract statistics were utilized to investigate integrity of white matter at specific points along 9 major tracts across boys and girls, controlling for multiple Point by Tract comparisons at $p<0.05$. An overall decrease in whole brain FA was observed among adolescents with AE compared to Control counterparts ($p=0.014$). Importantly, this effect was driven largely by lower FA in the right anterior thalamic radiation (ATR) and right corticospinal tract (CST) ($p's<0.0001$) and a similar statistical trend for the left CST ($p=0.004$). These novel results identify specific points along white matter tracts that may be more vulnerable to the effects of AE. The present findings have implications for understanding cognitive and behavioral alterations commonly observed among adolescents with a FASD that specifically implicate connections between the: 1) thalamus and prefrontal cortex (ATR), or 2) motor system and spinal tract (CST). These findings demonstrate specific alterations related to AE and have potential to enhance future interventions. Funded by CIFASD.

2-A-12 Cognitive change and white matter maturation in children prenatally exposed to alcohol: comparisons with typical controls

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We tested if changes in processing speed and episodic recall were differentially related to white matter (WM) development in children with fetal alcohol spectrum disorders (FASD) compared to typical children. 124 subjects [n= 80 (38 FASD), longitudinal (2yrs apart) /cross-sectional, n=64 (25 FASD)] were studied with diffusion tensor imaging, T1-weighted images, and neurocognitive tests. Groups were age-matched [Controls=11.8 years; FASD= 11.6 years]. Bilateral frontal, parietal, and callosal volumes (FreeSurferv5.1), and fractional anisotropy (FA) values were acquired (tractography). Using linear mixed modeling, cognitive change was predicted by 1) white matter volumes, age, intracranial volume, sex, and exposure status by white matter volume interactions 2) interactions among age, exposure status, and average FA values per white matter tract. Significantly better cognitive performance, larger WM volumes, and higher FA was seen over time in controls compared with FASD subjects. WM volumes were significantly related to change in processing speed and recall in both groups. Significant interactions between exposure status and processing speed were observed for Forceps minor, and with recall and inferior longitudinal fasciculus and fronto-occipital fasciculus after controlling for age and sex; All p's <0.01. The results indicate that both WM volume and integrity are differentially associated with rates cognitive change in FASD and control children. As WM is important in executive functions, these ongoing alterations could lead to cumulative cognitive effects over time in FASD.

1-A-13 Motor Overflow is Associated with Reduced Motor Cortex Activation in Attention-Deficit/Hyperactivity Disorder

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Objective: Motor overflow is a developmental phenomenon that typically disappears by late childhood. Abnormal persistence of motor overflow is often present in children with Attention Deficit Hyperactivity Disorder (ADHD), with impaired inhibition of unintended movement paralleling dyscontrol of impulsive, hyperactive, and off-task behavior. This study employed fMRI during a finger-sequencing task to examine the hypothesis that excessive motor overflow in children with ADHD is associated with decreased extent of motor cortex (M1) activation, possibly reflecting reduced intracortical inhibition. Method: Thirty-four right-handed children (18 typically developing (TD), 16 ADHD) completed fMRI while performing a simple finger sequencing task. The presence and extent of motor overflow was evaluated during both in-scanner and out-of-scanner finger-sequencing and using a motor examination standardized for children (the PANESS). Results: Children with ADHD demonstrated lesser extent of activation, compared to TD controls, in left primary motor cortex as well as bilateral premotor and supplementary motor cortex (SMC) during right-hand finger-sequencing. Decreased extent of M1 activation correlated with increased hand-related overflow movements across multiple measures in the ADHD group but not the TD group Conclusions: These findings suggest that overflow movements in

children with ADHD may reflect decreased recruitment of neural circuitry involved in active inhibition of homologous motor circuitry unnecessary to task execution.

2-A-14 Relationship Between Early Deprivation and Pubertal Development in Structural Brain Development of Post-Institutionalized Adolescents

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Recent studies have highlighted the relationship between puberty and structural brain development. Both pubertal timing and neural development are altered following early life stress. We investigated the convergence of early life stress and puberty on structural brain development in 12-14 year olds adopted from orphanage care between 4-72 months of age. Ninety-nine post-institutionalized children (PI) and 38 comparison children raised with their biological families (controls) completed a self-report scale of pubertal development and a T1-weighted anatomical scan on a Siemens 3T Trio MRI Scanner. Cortical reconstruction and volumetric segmentation was performed using Freesurfer. Analyses included age, sex, and intracranial volume as covariates and were restricted to prefrontal and limbic regions known to vary with both puberty and early life stress. Control children had larger prefrontal volumes than PI children across pubertal status groups. Puberty was associated with decreases in prefrontal volumes, but these effects were comparable for PI and control youth. Control children also had larger hippocampal volumes than PI children across pubertal status groups. However, only control children showed evidence of pubertal-related decreases in hippocampal volumes. Joint effects of pubertal and group status were not present in the amygdala. These data suggest there are persisting effects of early deprivation on prefrontal and limbic regions in young adolescent PI children that may alter normative, puberty-specific changes in brain development.

1-A-15 Cognitive outcome of very preterm born children predicted with a DTI multivariate model

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Children born very preterm experience difficulties in a wide range of cognitive functions such as Working Memory (WM) and numerical ability. The group is heterogeneous and the variance in cognitive outcome can only partly be predicted from clinical factors in the perinatal period. Here we present a multivariate pattern model based on Diffusion Tensor Imaging (DTI) data that can predict individual outcome in WM and numerical ability at 5 years of age. DTI data was gathered from 93 very preterm born children at term equivalent age. WM and numerical ability was evaluated at five years of age. The machine learning model was trained after employing a feature reduction algorithm to predict cognitive outcome. The model could significantly predict cognitive outcome five years after DTI scanning (WM: $r = 0.36$, $p < 0.001$, numerical ability: $r = 0.35$, $p < 0.001$). Clinical variables known to influence general cognitive functioning at 2 years of age were recorded during the neonatal period. These variables as well as general cognitive function at 2 years of age (Mental Developmental Index from BSID-II) was co-varied

for in a regression model to predict the cognitive outcome. The significance of the DTI prediction was retained for WM and numerical ability indicating that DTI in the neonatal period contains information about cognitive outcome at 5 years of age that can not easily be measured with standard clinical and cognitive evaluations during the first 2 years of life. The results show that DTI can be used to predict cognitive development in very preterm born children.

2-A-16 Neural Network Multistability and Evidence of Aberrant Development in Adolescents with Psychosis

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Adolescence entails substantial changes in the functional properties of the brain's large-scale neural networks. Many of these changes involve shifts in the efficiency with which functional networks are created and disintegrated to meet ongoing cognitive demands. Also, during adolescence the incidence of psychosis increases dramatically. In fact, many have argued that abnormal neurodevelopment during adolescence is a precursor to psychotic syndromes such as schizophrenia. We conducted a cross-sectional study of age-related (12-18 yrs) changes in the behavior of core functional networks in the resting brain in typically developing adolescents, adolescents at clinical high risk for developing psychosis (CHR), and youth with an adolescent-onset psychotic disorder (AOP). Surface EEG (64 channels) was examined for fast synchronization dynamics as the brain shifts between stable network configurations. The number of occurrences of each of these configurations was measured, as was the duration of each iteration, the density of the functional connectivity within each configuration (efficiency), and the segregation of synchronization clusters within each configuration (modularity). Relative to typically developing adolescents, AOP participants demonstrated a significant increase in network modularity with age, indicating sparser connectivity, with CHR participants intermediate between AOP patients and controls. Modularity of stable network configurations shows promise as a biomarker of the aberrant neurodevelopmental processes associated with psychosis risk and symptom expression.

1-A-17 Maladaptive Decision Making, Variation in 5-HTTLPR, and Substance Use Outcomes in High Risk Individuals

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Background: Individuals with multiple alcohol dependent (AD) relatives are at increased risk for substance use disorders (SUD). Prospective, longitudinal studies of high risk (HR) individuals afford the opportunity to determine potential risk markers of later SUD. The current study assessed the effect of familial risk, genetic variation, and orbitofrontal cortex (OFC) volume on Iowa Gambling Task performance, as well as whether IGT performance related to SUD outcomes. Methods: 108 individuals from multiplex AD families and control families, ages 16-34, were tested using a computerized version of

the IGT. SUD outcomes were assessed at approximately yearly intervals. 5-HTTLPR genotype and OFC volume were available for the majority of participants (n=86). Results: HR offspring performed significantly worse on the IGT than low risk (LR) control and IGT performance was also associated with 5-HTTLPR genetic variation. IGT performance was significantly related to age of SUD onset. The important role of the OFC in response inhibition and its relation to IGT performance will be discussed. Conclusions: This is the first study to show that both familial risk for SUD and 5-HTTLPR impact performance on the IGT. Poorer IGT performance was associated with earlier onset of SUD, suggesting that failure to attend appropriately to long-term costs and benefits during a decision-making task is associated with SUD outcomes.

2-A-18 The differential role of parental socioeconomic status in the neural basis of arithmetic

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Although large differences exist in children's arithmetic skill starting from the early grades, little is known about the sources of individual differences in the neural bases of arithmetic in children. Behavioral studies show that socioeconomic status (SES) is a strong predictor of arithmetic skill starting from the early years. However, how parental SES is related to neural bases of children's arithmetic skill is not known. Here we examined the relations between SES, as measured by parental education in years, and the neural bases of single-digit multiplication and subtraction in school-aged children (N=35). Previous research suggests that multiplication relies on verbal representations, whereas subtraction relies on spatial representations, so we identified brain regions supporting these representations via independent localizer scans. When controlling for accuracy on tasks and standardized measures of mathematical skill, results showed that SES differentially influences children's subtraction but not multiplication. For subtraction problems, higher SES was associated with greater recruitment of right parietal cortex, as identified by the spatial localizer, whereas lower SES was associated with greater recruitment of the left temporal cortex, as identified by the verbal localizer. The results suggest that an enriched home environment aids children's mappings of mathematical symbols to spatial representations, whereas lack of such input leads to greater reliance on verbal representations in solving subtraction problems.

1-A-19 Structural alterations in the dorsal visual processing system in children with Williams syndrome

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Individuals with Williams syndrome (WS), the result of a hemizygous deletion of ~25 genes on 7q11.23, have significant visuospatial construction impairments that are likely related to structural alterations in the dorsal visual processing system. Research on adults with WS has demonstrated reduced gray matter

volume (GMV) in the intraparietal sulcus (IPS), a finding that has been associated with reduced sulcal depth in the same brain region. We acquired and averaged three sagittal, multi-echo MPRAGE (MEMPR) structural MRIs from 25 controls (mean age=13.9, range=7-18, 16 males) and 16 children with WS of average intelligence (mean age=10.8, range=5-17, 7 males). We used SPM8/DARTEL tools to segment images and spatially normalize the individual gray-matter maps, and then computed Jacobian modulated gray matter images. We applied 6mm FWHM smoothing and performed voxelwise ANCOVA analyses with SPM5, covarying age and total brain volume. We analyzed sulcal depth based on an average geometric cortical surface representation created using surface-based analysis tools (Freesurfer, Caret, SUMA). In our group of children with WS, we found bilateral GMV reductions in the IPS compared to controls. Reductions were particularly robust on the right side (peak T=5.0, p=0.002 FDR corrected). We also found bilateral reduced sulcal depth in this same brain region (peak T=7.4, p=2·10-6 FDR corrected). These results are consistent with previous findings in adults with WS and support the geometric interpretation that GMV is reduced in proportion to a concomitant reduction in IPS surface area.

2-B-20 Functional magnetic resonance imaging in mice: bridging the gap in translational research for psychiatric diseases

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A considerable challenge in neuropsychiatric disease is the development of approaches that can readily translate between animal models and human disease. Resting state functional connectivity magnetic resonance imaging (rs-fcMRI) is an emerging tool that promises to provide a common measure that links disease models to the clinical manifestations of pyschiatric disorders. Rodent models provide an exciting avenue for research due to the precise manipulation of genetic, environmental, and behavioral factors; however, it has been difficult to employ rs-fcMRI given their size, physiology, and technical constraints of the MRI and associated data processing. In addition, there has been little work in validating connectivity profiles in rodent, particularly mouse, models. Here we examine mouse functional connectivity profiles in relation to publically available structural connectivity data. Our approach thus far has yielded connectivity maps that corroborate connectivity data obtained in other rodent functional imaging studies. Furthermore, preliminary data indicate that many of the functional connections observed in the MR imaging have some structural underpinnings. These results demonstrate a successful MR imaging approach in mouse models that correlates with human rs-fcMRI findings. The approach should allow for a "bridge" between animal models and human conditions and should provide for detailed explorations into the physiological underpinnings of observed findings in human functional studies.

1-B-21 Human-Macaque Comparisons Using Functional and Structural Connectivity

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Appropriate animal models enable us to calibrate and design diagnostic and therapeutic tools to be used in humans. Functional connectivity MRI (fcMRI) provides a powerful and non-invasive method for assessing brain functioning in both humans and nonhuman primates. However, validation of interspecies fcMRI comparisons has not yet been established. Our approach begins by deforming macaque brains to a human atlas according to previous work by Van Essen et al. (2004). This process was repeated for four macaque atlases (Markov, Paxinos, LVE, FVE). We then examined connectivity of the primary motor cortex and an anterior node in the default network in both species. Then, we examined correspondence via a comparison index that calculates the percentage of matched connections and non-connections between species across a range of thresholds. Finally, we compared connectivity matrices using an ROC analysis from the human to structural connectivity matrices from the macaque derived from a previous retrograde tracer study. At the optimal threshold a ~40% match in connectivity patterns was found between species. Impressively, ROC curves shows that at the optimal threshold, there is an approximately 80% success rate in matching a true connection, with a ~20% false discovery rate. In this respect the macaque and human data were nearly identical. Overall, we show that humans and macaques have a great deal of overlap in connectivity patterns and provide validation for interspecies comparisons of fcMRI which will aid in translational animal models of human disease.

2-B-22 The Nuisance of Nuisance Regression: Spectral Misspecification in a Common Approach to Resting-State fMRI Preprocessing Reintroduces Noise and Obscures Functional Connectivity

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Recent resting-state functional connectivity fMRI (RS-fcMRI) research has demonstrated that head motion during fMRI acquisition systematically influences connectivity estimates despite bandpass filtering and nuisance regression, which are intended to reduce such nuisance variability. We provide evidence that the effects of head motion and other nuisance signals are poorly controlled when the fMRI time series are bandpass-filtered but the regressors are unfiltered, resulting in the inadvertent reintroduction of nuisance-related variation into frequencies previously suppressed by the bandpass filter, as well as suboptimal correction for noise signals in the frequencies of interest. This is important because many RS-fcMRI studies, including some focusing on motion-related artifacts, have applied this approach. In two cohorts of individuals (n = 117 and 22) who completed resting-state fMRI scans, we found that the bandpass-regress approach consistently overestimated functional connectivity across the brain relative to a simultaneous bandpass filtering and nuisance regression approach. Inflated correlations under the bandpass-regress approach were associated with head motion and cardiac artifacts. Furthermore, distance-related differences in the effect of head motion on connectivity were much weaker for the simultaneous filtering approach. We advocate a simultaneous bandpass filtering and nuisance regression strategy that better controls nuisance-related variability, including the effects of head motion.

1-B-23 The importance of applying physiological regression to rsfMRI

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There is growing evidence that resting-state fMRI connectivity results can be confounded by physiological parameters, which may change through development. However, resting state fMRI studies typically do not consider physiological measures. We studied 100 10-20 year-old subjects who completed a resting-state fMRI scan that included cardiac and respiratory monitoring. We present the effects of physiological noise on connectivity estimates for 244 functional regions of interest, demonstrating how controlling for physiological noise influences individual ROIs, interregional correlations, and inferences about neurocognitive development.

2-B-24 Development of Cingulo-Opercular and Default Mode Networks across Childhood and Adolescence

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Introduction Developmental differences in resting-state connectivity have been found in the cingulo-opercular network (CON) and the default mode network (DMN) between children and adults (Barber et al., 2012). The current study examines the trajectory of developmental changes in these networks in a large cohort of children ranging in age from 3 to 21 years. Methods 460 typically-developing subjects (Mean= 14.74, SD=4.44, Range=3.25-21) participated in the multi-site Pediatric, Imaging, Neurocognitive and Genetics (PING) study and passed quality control measures for image quality, subject motion (<3mm and 3 degrees), and post-processing. Resting state preprocessing was performed and 6mm radius seeds were placed at CON and DMN locations (Barber et al., 2013; Fox et al., 2005). Average pairwise-connectivity was found across all connections within a network and between the two networks. Results and Conclusions Generalized additive models predicted mean network connectivity. These models allowed for a nonlinear effect of age (Hastie & Tibshirani, 1986; Wood, 2006) and included linear terms for in-scanner motion, collection site, handedness, gender, and genetic ancestry factor. There was a significant relationship between age and mean CON ($F(2,432)= 7.99$, $p<0.001$) and age and mean CON-DMN ($F(2,432)= 3.485$, $p=0.015$), but not for age and mean DMN ($F(1,432)=0.79$, $p=0.37$). The current study confirmed previous findings that between-network connectivity is developing through childhood and adolescence and found that the CON is developing into adulthood.

1-B-25 The development of human amygdala-cortical functional connectivity at rest

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Connectivity between the amygdala and both cortical and subcortical regions comprises the neural substrates moderating a range of affective and cognitive processes (Adolphs and Spezio, 2006; Ochsner

et al., 2012). Despite the central role amygdala networks have in these functions, the normative developmental progression of functional connections between the amygdala and the rest of the brain is still undefined (Tottenham et al., 2010). Resting-state functional magnetic resonance imaging (rsfMRI) methodology provides a robust approach for characterizing such network organization during development as it has been shown to index the functional integrity of network connections (Pizoli et al., 2011). This study employed amygdala subregion maps and rsfMRI to characterize the typical development of amygdala-subcortical and amygdala-cortical functional connectivity from age 4 to 23 years. Adult connectivity patterns were replicated in this age-independent analysis in several regions, suggesting early maturation of these connections. However, three cortical regions exhibited age-dependent changes in connectivity: the medial prefrontal cortex (mPFC), a region including the insula and superior temporal sulcus, and a region encompassing the cerebellum and posterior cingulate. These findings show that a subset of cortical regions continues to exhibit developmental change with the amygdala between early childhood and adulthood.

2-B-26 Conservation of network properties in resting-state functional connectivity in humans and non-human primates

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Previous studies have shown that functional connectivity as measured with fMRI is present across species during resting periods with no stimulus or task demand, and this organization is maintained even under anesthesia. There is evidence that at least some of this spontaneous functional organization is constrained by underlying anatomical connectivity, though the precise relationship of function to structure is poorly understood. In this study we perform network analysis of continuous resting state fMRI and diffusion tensor imaging from the same subjects across a group of typical adults as well as 4 anesthetized non-human primates (macaque). In both groups the presence of structural connectivity between regions identifies a subset of connections with higher functional connectivity. We find that higher-order network properties such as commute-time provides an improved model of how underlying structure constrains the organization of intrinsic functional activity. We go on to investigate additional network properties, such as brain modularity, small-worldness, and the identification of the most integral nodes in the network, and identify how these change across different time-scales of fMRI , from the typically reported 0.01-0.1hz band to higher frequencies. The correspondence between these models of functional and structural brain organization in the two species may provide evidence for evolutionarily conserved elements within resting state networks, and suggests that some network properties are constant across species and may be important for typical brain development.

1-B-27 Investigation of Language Networks During Infancy Using Functional Connectivity MRI

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Background: Functional connectivity MRI (fcMRI) has been used to define networks of functional connections in the developing brain. Investigations of adults have demonstrated a neural network critical for language function incorporating the bilateral inferior frontal and posterior temporal lobes. The presence and configuration of this network during infancy remains unexplored. Objective: Identify and characterize the language network during the neonatal period by performing fcMRI analysis on term and preterm infants studied at term equivalent postmenstrual age (PMA). Methods: fcMRI investigations were performed in 25 healthy, term infants (mean PMA at scan 39.1 wks) and 25 preterm infants without cerebral injury (mean gestational age at birth 26.8 wks) studied at 38.1 wks PMA. Images were acquired using a 3T scanner with an EPI sequence (TR/TE 2910/28 ms, voxel size 2.4 mm^3) and analyzed using seed correlation analysis with regions of interest in the inferior frontal and posterior temporal lobes. Results: fcMRI results for term and preterm infants demonstrated neural networks incorporating hallmark regions of the language network, similar to findings reported in adults. Identified networks were comparable between groups, though interhemispheric correlations were weaker in preterm infants. Conclusions: Functional connections critical for language are established by term in preterm and term infants, bearing similarity to those in older populations. Further investigation of the role of the language network in normal and aberrant language development is necessary.

2-C-28 Differences between adolescent and adult rats in behavior and sensitivity to methylphenidate during a response inhibition task

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Adolescent rats provide a useful animal model for investigating the differences in behavior between adults and adolescents that stem from age-related neurobiological differences. We developed the Cued Response Inhibition Task (CRIT) to measure ability to withhold a response during an inhibitory cue, then to respond promptly following cue termination. We found no difference between adult and adolescent rats in ability to appropriately inhibit a response during the cue. Adolescents, however, were unable to respond as quickly as adults after cue termination. Further, we observed that this difference in responding was abolished after adolescent rats aged to adulthood with no additional training. We then tested the effects of methylphenidate exposure on CRIT performance in adult and adolescent rats, and observed that low dose methylphenidate improved response inhibition while high dose caused impairment in adult rats. Conversely, these same doses did not affect behavior in adolescent rats. Finally, a separate group of adult and adolescent rats were trained in CRIT, then trained in a protocol in which the inhibitory cue from CRIT was shifted to a cue predictive of reward. Adolescents demonstrated more reward seeking behavior during the previously inhibitory Pavlovian cue than adults, indicative of greater behavioral flexibility. Taken together, these data provide novel behavioral and pharmacological distinctions between adult and adolescent rats.

1-C-29 Polymorphisms in the dopamine receptor 2 gene region influence improvements during working memory training in children and adolescents

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Studying the effects of cognitive training can help finding better treatments, but it can also be a tool for learning about factors important for brain plasticity and acquisition of cognitive skills. In this study we investigated how single nucleotide polymorphisms (SNPs) and ratings of intrinsic motivation were associated to inter-individual differences in improvement during working memory training. The study included 256 children aged 7-19 years who were genotyped for 13 SNPs within or near eight candidate genes previously implicated in learning. Ratings on the Intrinsic Motivation Inventory were also available for 156 of these children. All participants performed at least 20 sessions of working memory training and performance during the training was logged and used as the outcome variable. We found that two SNPs, rs1800497 and rs2283265, located near and within the dopamine receptor 2 gene (DRD2) respectively, were significantly associated with improvements during training ($p < 0.003$ and $p < 0.0004$, respectively). We observed both main effect of genotype at those 2 loci as well as an interaction between genotypes and ratings of perceived competence. Both SNPs have previously been shown to affect DRD2 receptor density primarily in the basal ganglia. Our results suggest that genetic variation is accounting for some inter-individual differences in how children acquire cognitive skills and that part of this effect is also seen on intrinsic motivation. Moreover, they suggest that dopamine D2-transmission in the basal ganglia is a key factor for cognitive plasticity.

2-C-30 Neural response to inhibitory load depends on Dopamine transporter genotype in healthy children

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[1]Georgetown University

Inheritance of two copies of the 10-repeat allele (10/10) of the dopamine transporter gene (DAT1) is associated with susceptibility to Attention Deficit Hyperactivity Disorder as well as more impulsivity in healthy children. We examined whether DAT1 influences the neural basis of response inhibition, particularly in frontal-striatal response to inhibitory load. Eleven10/10 and ten 9/10 carriers (age 7-13 years) performed a Go/No-go task, with alternating Go ("press for all letters") and No-go ("press for all letters except the letter "X") blocks. Children performed two runs, varying in the number of No-go trials in No-go blocks, 12.5% for high load and 25% for low load. Overall, high load had more sustained attention (omission) and inhibitory (commission) errors. Additionally, individual differences in hyperactivity/impulsivity were associated with increased inhibitory errors in high loads for 10/10 but not 9/10 children. For No-go vs Go activation, a DAT1 X load interaction ($p < .05$ corrected) was observed in right dorsolateral prefrontal cortex (BA 9/46) such that load modulated activation in 9/10 carriers (low > high load) but not in 10/10 carriers. No interaction was observed in the striatum, Thus, right prefrontal involvement in inhibitory function is modulated by differences in dopaminergic functioning in healthy children.

1-C-31 DRD2 Variation Predicts Resilience to Substance Use Disorders in High Risk Offspring from Multiplex Alcohol Dependence Families

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Introduction: Offspring from families with a high density of alcohol dependence are at increased risk for both alcohol and drug use disorders, yet the precise mechanisms by which risk is conferred remains poorly understood. The identification of predictors of resilience to any substance use disorder (SUD) would be of great clinical relevance. Methods: Structural neuroimaging was used to examine orbitofrontal cortex (OFC) volume along with DRD2 variation (SNPrs2677) as predictors of resilience to SUD in a sample of high-risk (HR) offspring from multiplex alcohol dependence families and low-risk (LR) control families. The Multidimensional Personality Questionnaire Control subscale and the Novelty Seeking subscale of the Tridimensional Personality Questionnaire were obtained as measures of impulsivity. Resilience was defined by the absence of any SUD diagnosis by age 20, based on annual clinical assessments. Results: Main effects on SUD outcome were observed for familial risk status (p=.022) and DRD2 genotype (p=.020), such that LR status and the presence of the c-allele independently predicted resilience in young adulthood. HR offspring also exhibited reduced ratio of right/left OFC volume compared to offspring from control families (p=.008), which was associated with lesser inhibitory control (p=.026) and greater novelty seeking (p=.036). Conclusions: Familial risk is associated with greater likelihood of SUD, reduced volume of the OFC in the right hemisphere, and increased impulsivity. Importantly, familial risk and DRD2 variation predict resilience at age 20.

2-C-32 The influence of COMT genotype and sex on reward processing during adolescence

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Adolescence is a period characterised by increases in reward seeking behaviour and risk-taking. It has been suggested that these behaviours are related to changes in dopamine (DA) concentrations in the adolescent brain. In adults, the Val158Met polymorphism of the catechol-O-methyltransferase (COMT) gene accounts for interindividual variations in DA availability in prefrontal and striatal pathways. Research suggests that COMT genotype influences reward processing through this mechanism. However, the relationship between COMT genotype and reward processing has not previously been examined during adolescence, despite the reorganisation of the DA system which occurs during this period. The sample comprised 1100 mid-adolescents (target age 14) from the multicentre IMAGEN project. All participants completed the Monetary Incentive Delay task (MID), which examines the anticipatory and outcome components of reward processing. Analyses will examine whether COMT genotype affects neural activation associated with the anticipation small and large rewards, as well activation associated with feedback about whether or not these rewards were obtained. Furthermore, as sex has been shown to moderate COMT effects on cognition (Harrison & Tunbridge, 2008), we will also examine if these effects are sexually dimorphic. Preliminary results based on whole brain analyses suggest that sex but not COMT genotype influences MID task activation. More detailed results, including region of interest analyses will be presented during the conference.

1-C-33 Influence of variability in dopamine availability on resting state functional connectivity over adolescence

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Immaturities in the connectivity within frontostriatal systems that are innervated by dopamine (DA) may contribute to vulnerabilities for psychopathology as well as mediate heightened risk taking behaviors over adolescence. Polymorphisms in genes that code for DA enzymes including Catechol-O-methyltransferase (COMT) Monoamine Oxidase-A (MAOA) and the Dopamine Transporter Gene (DAT1) influence fronto-striatal functional connectivity and may help explain the basis of inter-individual variability in brain function over development. 111 participants (aged 10-20) were asked to close their eyes, relax but not fall asleep during a 5-minute resting state 3T fMRI scan. Physiological parameters were monitored and recorded. Voxel-wise time-series correlation analyses were run with seed regions in the left and right ventral striatum, caudate, and putamen that were anatomically defined. Individual correlation maps were entered into a mixed effects model with genotype coded as an ordinal variable and the inverse of age as a continuous variable. Genotypes for the COMTval158met, DAT1 3'-UTR VNTR and the MAOA-uVNTR were acquired with saliva samples using PCR. We also calculated a multilocus composite score combining all genotypes. An age effect was found in inferior PFC, ACC and thalamus with a decrease in connectivity strength over development. Age by composite score interactions were apparent in cognitive circuits; between the caudate and dorsal ACC.

2-D-34 Developmental changes in amygdala-based fear learning from early childhood through adulthood

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The amygdala is a subcortical brain region with critical roles in many affective processes and atypical functioning of the amygdala has been associated with several psychopathologies such as anxiety disorders. We used a classical conditioning framework to examine the development of human amygdala function because conditioning paradigms reduce amygdala-based learning to its very basic components. This study examined fear learning in 79 typically developing youths between the ages of 4-22 years old (M-12.01, SD- 5.02) during a functional magnetic resonance imaging (fMRI) task utilizing a mixed-block Pavlovian fear conditioning paradigm. In the task two geometric shapes were presented (conditioned stimuli; CS) and one of which was paired with an aversive high-frequency noise (unconditioned stimulus; UCS) at a 50% reinforcement rate. Results suggest that this task effectively induced learning as indexed via differential reaction times to the paired stimulus (CS+) versus the non-paired stimulus on both reinforced and non-reinforced trials. Presentation of the CS+ recruited amygdala activity across the full age range. Importantly, this recruitment was greatest for the youngest subjects and attenuated with increasing age. These data contribute to the characterization of human amygdala functional

development and can provide insight for understanding the normative changes in emotional behaviors across childhood and adolescence.

1-D-35 Developmental changes in amygdala connectivity during involuntary attention to positive and negative emotions

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Spontaneous attention towards faces is a core requirement of social competence. We investigated amygdala functional connectivity during spontaneous attention to positive and negative facial expressions across late childhood and adolescence. Forty-seven typically developing children (N=19:8-10 years, N=14:11-13 years, N=14:14-19 years) underwent fMRI while performing an event-related dot-probe task with happy (happy-neutral face pair), angry (angry-neutral face pair), and neutral (neutral-neutral face pair) trials. Psychophysiological (PPI) connectivity maps for angry and happy trials relative to neutral trials were created for left and right amygdala, and for each, regions showing age X valence interaction ($p<.05$ corrected) were identified with ANOVA. Right amygdala connectivity with parietal-temporal regions important for attention and cingulate-prefrontal regions important for response control differed by valence in the youngest group (angry > happy) and this difference was reduced in the 11-13 year-olds and to a further extent in the oldest group. Left-amygdala connectivity with response control regions also showed a similar pattern. Thus, maturation of amygdala networks during childhood development involves modulation of valence-selective attentional response.

2-D-36 The Relationship Between Anxiety and Brain Activity During an Emotional Inhibitory Control Task in Adolescents and Young Adults

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Adolescence is characterized as a period of limited inhibitory control and hypersensitivity to emotion, as well as increased incidence of mood disorders and psychopathology. Understanding developmental changes in the interaction between cognitive control and emotions may clarify mechanisms underlying typical and atypical adolescent behavior. The current study utilizes fMRI to investigate the relationship between anxiety symptoms and neural activity associated with cognitive control and emotional distraction. Seventeen adolescents(13-14yrs) and 13 adults(20-22yrs) performed an inhibitory control go-nogo task with emotional images (negative, positive, neutral) in the background. Participants were asked to press for every letter except for X and to ignore background images. Stimuli were presented in emotion blocks with scrambled images as a control. Data were analyzed in FSL using predictors for each block. We hypothesized there would be developmental changes in the relationship between anxiety symptoms and activity during the task. Age differences in correlations between anxiety and activity were observed in superior frontal, orbitofrontal, left caudate, and left parahippocampal gyrus during negative emotion blocks. Adolescents showed a negative correlation between anxiety and activity in superior

frontal gyrus and caudate, but a positive correlation between anxiety and activity in orbitofrontal cortex. These data suggest that perhaps children with fewer anxiety symptoms are better able to recruit inhibitory control circuits in the face of negative emotional distraction.

1-D-37 Developmental Changes in Brain Function Supporting Emotionally-Modulated Cognitive Control

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Neuroimaging studies indicate that adolescents utilize brain regions involved in planning and preparing a goal-oriented response similarly to adults, but they show continued immaturities in the ability to monitor their errors and sustain brain function supporting correct performance, suggesting the capacity to utilize still-maturing neural circuitries to exhibit adult-like cognitive control of behavior is inflexible and limited. Little is known about how emotional circumstances differentially modulate the activity of still-maturing cognitive control systems, despite evidence that poor adolescent decision-making occurs more frequently in contexts that elicit emotions. To characterize vulnerabilities in adolescent brain functioning, we examined developmental changes in brain function supporting inhibitory control in contexts of varying emotionality. Healthy individuals (n=46) ages 14-30 completed an antisaccade task administered in an event-related design while listening to negative, positive, neutral sounds or silence. We will report on age by emotional condition interactions in regions associated with emotion regulation and error monitoring. We will also characterize developmental changes in functional connectivity between identified regions in emotional and unemotional contexts. We hypothesize younger participants will show greater decrements in activity in emotion regulation and error monitoring activity during the emotional condition and also greater declines in functional connectivity, suggesting that with maturity comes greater stability across situations.

2-D-38 Effects of emotional distracters and reinforcement on neural systems of attentional control in adolescents

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Compared to adults and children, adolescents tend to show greater reactivity to emotionally salient stimuli and better performance during reward-modulated cognitive control tasks. Recent work in adults using an emotional delayed working memory task has shown that presenting negative emotional stimuli during delay periods can elicit activations in limbic regions (e.g., amygdala) and capture attention in ways that disrupt goal-directed behavior. This study examined these effects in adolescence and whether differential reinforcement of correct responding would enhance attention in ways that minimize the effects of negative emotional distracters. During fMRI, adolescents (ages 9-15; N=14) completed an emotional delayed working memory task with emotional distracter (none, neutral, negative) and reward conditions (reward vs. no reward of correct responses). Results were consistent with those in adults.

Compared to no distracters, neutral and negative distracters produced a decrease in accuracy and increased activation in amygdala and dorsal/ventral prefrontal cortex. Differential reinforcement increased accuracy and counteracted the effects of negative distracters, particularly in older adolescents, as shown by reduced amygdalar and VLPFC activation. These findings suggest that differential reinforcement can serve as a mechanism that can mediate emotional interference. They also show how increased reward reactivity in adolescence can be harnessed to counteract negative environmental influences thus having implications for the development of attention training programs in youth.

1-D-39 Stress-System Genetic Variation and Early Life Stress Predict Limbic Reactivity to Emotional Faces in School-Age Children

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Relatively recent work has shown that children as young as 3-5 years old can experience a form of early onset depression termed preschool-onset major depressive disorder (PO-MDD). As in adult depression, child with early onset depression exhibit hyper-reactivity of the limbic system to emotional stimuli. Yet, it is unclear how and why this type of alteration arises in adults or children. One main hypothesized mechanism of change in depression is stress. Animal studies suggest that chronic stress or glucocorticoid administration can lead to alterations in limbic structure and function. Relatedly, early life stress is one of the main risk factors for depression and variation in stress-system genes has been related to increased prevalence and severity of depression. Previous work has shown that a genetic profile score combining variation across four stress-system genes - CRHR1, NR3C2, NR3C1, FKBP5 - and early life stress both predict stress cortisol levels at preschool age (3-5 years old). The interaction of these stress-related genetic and environmental factors was shown to predict changes in amygdala and hippocampal volume in these same children at school age (7-13 years old). The goal of the current study was to test whether stress-system genetic profile scores, early life stress, and preschool-age stress cortisol would predict limbic reactivity to emotional faces in these children at school age. The current findings may help to elucidate the mechanisms by which limbic hyper-reactivity to emotional stimuli arises in depression by examining stress as a key factor.

2-D-40 Development of emotional face processing in infants as measured with near-infrared spectroscopy

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The goal of this work is to elucidate the neural basis of the development of face processing in infants over the first year of life. Prior work has shown that infants at 7 and 12 months show enhanced attention to fearful faces as opposed to happy faces, while 5 month old infants do not show this bias.

Event-related potentials as recorded by electroencephalography (EEG) have shown an increased neural response to fearful faces also for older infants, however the poor spatial localization capability of EEG has left unanswered questions. In this study, near-infrared spectroscopy (NIRS) was used to measure brain activity during the presentation of happy, angry and fearful faces to infants. Separate groups of 5, 7, and 12 month old infants were tested with a 46 channel NIRS system which recorded brain activity over the frontal, temporal, and parietal cortex. Differences in brain activation time courses between emotional conditions were calculated, and these patterns of activation were compared between ages. Heart rate was simultaneously calculated from the NIRS signals as a measure of attention. Preliminary results indicate that our attention results as measured by change in heart rate appear to agree with prior work, with a differential response to fearful faces in 7 and 12 month old infants but not 5 month old infants. Brain imaging results showing changes in oxyhemoglobin and deoxyhemoglobin concentrations in response to the face stimuli are forthcoming.

1-D-41 Brain Mechanisms for Frustration in Children: Atypical Processing of Social Reward

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Background: Although it exists in all members of the population is measurable at an early age, irritability is a symptom linked to multiple psychiatric disorders. Frustration is a key behavioral construct inherent in irritability. Thus, investigating the neural mechanisms underlying social frustration in children, at typical and atypical levels, could further our understanding of a possible developmental trajectory towards psychopathology. Methods: We induced frustration during fMRI scanning in 26 children who were being treated for clinical levels of irritability and 28 age, race, IQ, and SES matched control children (ages 6-9). We used a novel frustration task in which children raced a sneaky dog to capture bones, which were redeemable for a desired prize. The task included trials in which the child was rewarded by beating the dog to the bone, but also trials in which the dog was able to steal bones from the child, socially inducing frustration. Results: Whole-brain analyses revealed a main effect of condition for reward vs. frustration in the striatum and percuneus. A group x condition interaction revealed that control children increased activation in the anterior cingulate during frustration, which was contrary to the clinical group, who most employed this region during receipt of reward. Conclusion: These findings indicate separable neural systems related to social reward and frustration. Neural activity related to the experience of irritability may be an early indicator of the development of psychopathology.

2-E-42 Separate Cue and Target Processing in Typical Development

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There is great interest in the development of different control networks in the brain and their respective roles in task control abilities. This study was interested in exploring short-term, adaptive control processing, and the fronto-parietal networks that are hypothesized to underlie adaptive control's

successful engagement. 28 children/adolescents (ages 9-15 years) and 30 adults (ages 21-29 years) were compared on a trial-by-trial task-switching game (the "Nemo task") using event-related fMRI. By mixing cue-only trials within the cue+target event-related design, cue signals were separable from target signals. Each subject had at least 500 frames of post-scrubbed (frame-wise displacement max of 0.7mm) data and overall task accuracy of at least 80%. Brain activity during the cue and target periods for all correct trials was compared to activity during the incongruent trials, when cue processing is more critical. There were a number of differences between children and adults during the cue period that were largely robust to matching on a variety of behavioral factors. In general, adults appeared to engage the cue more than the children in many control-related regions of the brain. During the target period, there was greater activity in the children compared to the adults in a number of regions, including bilateral occipital cortex. This greater processing of the target may be reflective of a compensatory strategy used by children who were less successful at engaging the cue signal appropriately. Results are interpreted in the larger context of control development.

1-E-43 Behavioral and neural substrates of self-control

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The ability to resist temptation for the sake of larger, delayed gains (i.e., delay of gratification) is a critical component of self-control. Longitudinal studies have linked those who choose to wait for the larger, delayed reward (high-delayers) with higher academic achievement, lower body mass index and less substance abuse than low-delayers. Frontostriatal circuitry has been implicated in self-control in adults, but the neural substrates of self-control in children remains unclear given significant changes in frontostriatal circuitry during this period. The current study tested 15 children, aged 6-11 years on the delay of gratification task and on a go/no-go imagig task that included appetitive and neutral stimuli. No difference was observed between high- and low-delayers in overall false alarm rate, but low-delayers made more false alarms when suppressing a response to an appetitive cue. This pattern was paralleled by equivalent recruitment of the vlPFC when having to suppress a response, but increased ventral striatal activity in low-delayers to appetitive cues versus neutral ones. These results are consistent with a recent longitudinal study (Casey et al., 2011) suggesting that delay ability is more tightly associated with a heightened sensitivity to appetitive cues than impulse control. Together, these studies implicate core components of delay ability that could be targeted with novel interventions to achieve maximal change in behavior, and when during childhood to target these components.

2-E-44 Age-related increases in preparatory frontal alpha and beta band neural oscillations support developmental improvements in inhibitory control from adolescence to adulthood

Kai Hwang[1], **Avniel Ghuman**[1], **Beatriz Luna**[1]

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Inhibitory control, the ability to inhibit impulsive responses in favor of voluntary responses, remains immature during adolescence. Leveraging magnetoencephalography's (MEG) high temporal resolution, our goal was to delineate developmental changes in the spatiotemporal brain dynamics of neural oscillations associated with inhibitory control. We collected MEG data from 17 adolescents (age 14-16) and 20 adult participants (age 20-30), where participants performed the antisaccade (AS) and control prosaccade (PS) tasks. Neural activity estimates from a priori brain regions of interest (ROIs) including the lateral prefrontal cortex (PFC), the frontal eye field (FEF), and the intraparietal sulcus (IPS) were then extracted for spectral power Compared to adults, we found decreased alpha-band power (8-14 Hz) in adolescents in the oculomotor regions in preparation to inhibit an upcoming reflexive saccade, suggesting immaturities in functional inhibition of task-inappropriate activity. Furthermore, adolescents showed weaker beta-band power (15-30 Hz) in prefrontal cognitive control regions, which could reflect less robust top-down biasing of sensory and motor processes. In addition, stronger preparatory alpha-band power in the FEF is associated with better AS task performance in adults. Collectively our results suggest that immaturities in functional inhibition of task-irrelevant neural signals and weaker top-down signaling together contribute to immature inhibitory control in adolescence.

1-E-45 Impulsive Decision-Making in Adolescents is Associated with Decreased Structural Integrity of Cortico-Striatal White Matter

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In the United States, the majority of all deaths of youth aged 10-24 are from unnatural causes, due in large part to risky decision-making. Adolescent risk-taking is associated with developmental changes in neural regions implicated in reward and cognitive control (i.e., striatum and prefrontal cortex). The goal of this study was to use Diffusion Tensor Imaging (DTI) to examine the relationship between cortico-striatal white matter integrity and impulsive decision-making in adolescents. Forty-eight adolescents (ages 14-16 years, 56% female) were recruited from local schools. Impulsive decision-making was assessed with a subscale of the Flinder's Decision-Making Questionnaire (e.g. "Whenever I get upset at having to make a decision, I choose on the spur of the moment."). Participants underwent magnetic resonance imaging (MRI) on a 3T Siemens scanner, during which a DTI sequence was collected to evaluate integrity of white matter microstructure. Analyses using Tract-Based Spatial Statistics (TBSS) identified a significant negative correlation between adolescents' impulsive decision-making and fractional anisotropy (FA) values, a measure of fiber organization, in the left anterior corona radiata, the cingulum, and bilateral anterior thalamic radiations ($p<.05$). In other words, adolescents reporting greater difficulty making thoughtful decisions exhibited less structural connectivity of tracts connecting limbic regions to the outer layers of cerebral cortex; furthermore, these tracts have been associated with motivation and reward-related learning.

2-E-46 Relations between Neurophysiological and Behavioral Measures of Children?s Error Processing

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As evidence for linkages between children's executive functions (EF) and achievement has accumulated in recent years, there has been increased focus on understanding the neurophysiological correlates of EF and educationally relevant skills. In this investigation, event-related potentials (ERPs), including the Error Related Negativity (ERN) and Error Positivity (Pe), were examined as neurophysiological indices of EF abilities (e.g., attention control). Data from a school-based investigation of 4-7 yr. old children (N=78), including assessments of error processing on a Go/No-Go task, were collected to examine age-related differences in error processing and response inhibition. Preliminary results revealed the presence of the ERN and Pe on error trials in the Go/No-Go task in all ages of children. Coding of children's behaviors while engaged in the Go/No-Go task was conducted to provide online measures of their engagement, motivation, and anxiety during the ERP testing. Relating the results of behavioral coding with ERP data revealed that when children were observed to be were more attentive, turned to the experimenter less frequently, required fewer reminders, and exhibited lower levels of anxiety, the ERN was more negative and the Pe was more positive. These findings show that observable behaviors reflecting increased task engagement were related to increases in neurophysiological measures of EF and highlight the importance of combining behavioral and biological measures to study the development of children's cognition.

1-E-47 Individual differences in executive function related to BOLD activation on a go/no-go task in typically developing children and adolescents

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Cortical and subcortical activation for a hybrid design go/no-go task was evaluated in typically developing children, including relationships with Stroop task performance (CWI). It was hypothesized that activation in the no-go condition would occur in inferior frontal cortex (IFC), medial superior frontal, anterior-posterior cingulate, basal ganglia, and thalamus, mostly right lateralized with some bilateral activation in left homologues. Better performance on CWI was expected to relate positively with IFC, superior frontal, and cingulate activation. With fMRI at 3T (slice thickness=4mm/1 skip, 33 slices, TR=2.0s, TE=30 ms), 29 children (mean age=12.1, sd=2.4; 14 males) participated. fMRI data were analyzed with FSL 4.1.9 (no-go>go primary contrast). Z-statistic images were thresholded with clusters determined by z>2.3 for the primary analysis and z>1.7 for the correlation analysis (corrected cluster significance p=0.01). Activation occurred in regions typically observed for this task: frontal-parietal attention system, IFC, visual and motor cortex, basal ganglia, and thalamus. In contrast to established lateralized findings in adults, children used both hemispheres to complete this nonverbal task. Contrary to predictions positive correlations between CWI and activation were not observed. Negative correlations, however, were observed in the thalamus such that children with poorer CWI inhibition had increased thalamic activation bilaterally, suggesting that individual differences in executive skills predict increased need for thalamic recruitment to inhibit motor action.

2-E-48 Behavioral Inhibition and Altered Frontolimbic Functioning in Late Childhood

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Behaviorally inhibited (BI) children are at increased risk for internalizing problems, relative to their non-BI peers (Hirshfeld et al., 1992). Selective attention to threat may play a causal role in anxiety (Mathews & MacLeod, 1994), and children who are BI are known to exhibit biased attention for threatening information (Perez-Edgar et al., 2010). Research has shown that threat bias is associated with altered frontolimbic functioning in anxious adolescents (Monk et al., 2006) and BI children (Pérez-Edgar et al., 2007). The present fMRI study examined the role of the frontolimbic system in threat processing in BI children. Children categorized as high-BI (N=13 to date in this ongoing study; Mage=10) perform a dot-probe task with face stimuli in an event related fMRI design. In the critical contrast of trials where task performance may be impacted by the presence of threat (neutral-threat versus neutral-neutral trials) increased ventrolateral prefrontal cortex (vlPFC) activation was observed ($t(12) = 2.1$, $p = 0.058$, $d = 0.6$). Moreover, vlPFC activation was correlated with behavioral inhibition score ($r = 0.63$, $p = 0.03$). These results point toward the role of vlPFC in threat processing in children with BI, and are consistent with the literature implicating the frontolimbic system in anxiety and threat bias. These data have implications for the mechanisms of early risk for anxiety (Fox & Pine, 2012) and the vlPFC and threat bias as targets of preventive intervention for anxiety (Bar-Haim, 2010).

1-E-49 Task control systems are implicated for mapping meaning onto letter strings

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This study aimed to test the ability of adults to assign new meaning to, i.e. lexicalize pseudowords (PWs), using multiple sentential contexts; and to examine the lexicalization-related functional neuroanatomy. The findings from this study will be integral in establishing the platform for an ensuing lexicalization study across development. Young adults (n=28, 21-30 yrs, 14 m) participated in a 3-day study. PWs were either lexicalized through sentential training or made familiar through exposure in a PW-detection task. Slow event-related fMRI data was collected while subjects made a word/non-word lexical decision (LD), before and after behavioral training. Recognition and semantic memory tests, the LD test described above, and a semantic priming test were used to examine behavior. Subjects were faster and more accurate in recognizing lexicalized than familiar PWs. They completed semantic memory sentences with 87% accuracy and showed a 32ms facilitation when newly lexicalized PWs primed their synonym word targets, relative to a neutral condition. The results indicate the formation of novel semantic associations. A repeated-measures ANOVA revealed a pattern of higher BOLD activity, for regions in task control and default systems, during lexicalized relative to familiar trials. Finally, significant correlations were observed between BOLD activity in the above regions, and behavioral metrics such as recognition and semantic memory accuracy. Together, these results suggest that, in young adults, task-control systems are implicated for mapping meaning onto letter strings.

2-E-50 Attention moderates the effects of memory encoding and subsequent item recognition: Evidence from combined eye tracking and fMRI

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We intuitively understand that paying attention helps us learn. Many studies have shown that frontoparietal selective attention mechanisms modulate activity in visual cortex, with enhanced signal for attended locations and concurrent suppression of the signal for unattended locations. We propose that this modulation of visual cortex activity results in a more robust, less noisy input signal for memory encoding in medial temporal lobe (MTL) regions. The present study used combined eye tracking/fMRI methods and a spatial cueing task to compare incidental encoding of items presented in an attended location vs. those appearing in a competing, suppressed location. Participants were not informed of the upcoming recognition memory test during encoding. FMRI data were collected for a subset of participants during both the encoding and test phases. Our behavioral results showed enhanced recognition memory for items in the attended location relative to those appearing in the competing, suppressed location among child, adolescent, and adult participants. We additionally report a corresponding increase in activity in MTL regions for the attended items relative to the suppressed items during both the encoding and retrieval phases. These results are consistent with the proposal that selective attention mechanisms support enhanced memory encoding via modulation of activity in visual cortex, which in turn generates more robust activity in MTL.

1-E-51 Neural audience effect on relational reasoning in adolescence

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With the transition from childhood to adolescence, relationships with peers become increasingly elaborate. Adolescents also are particularly susceptible to peer influence and it is thought this might at least partly be due to peers increasing in salience during adolescence. Previous observational, behavioural and neuroimaging studies of peer influence have mostly focused on the effect of peer influence on risk-taking. In the current study, we were interested in the effect of the presence of peers on a cognitively challenging task - relational reasoning. In a behavioural study, we have found that the presence of an audience affects relational reasoning performance in adolescents but not in adults. Relational reasoning tasks usually engage a frontoparietal network of regions including the parietal cortex, dorsolateral, ventrolateral and rostrolateral prefrontal cortex. Here we present an fMRI study that investigated how the presence of a peer relative to being alone affects the recruitment of the frontoparietal network associated with relational reasoning and how this effect differs between mid-adolescents (14-16 years) and adults (22-30 years). We tested this in a 2x2x2 factorial design, comprising within-subjects factors social condition (peer-present vs. alone) and task condition (relational vs. control), and between-subjects factor age group (mid-adolescent vs. adult). Findings from this study

might have implications for educational contexts in which adolescents do classwork or homework in the presence of an audience of peers.

2-E-52 The Development of Hierarchical Cognitive Control and Rule Abstraction

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The prefrontal cortex (PFC) undergoes a protracted developmental course that continues through late adolescence. This PFC maturation is accompanied by an increased capacity for cognitive control of thought and action. The transition from middle childhood into adolescence is marked by extensive change in the child's environment, including changes in peer relations, independence, and academic demand. To manage this complexity, children must develop the ability to use abstract rules that guide the choice of behavior across a range of circumstances. Neuroimaging data in adults suggests that subregions of PFC are organized in a hierarchical manner. In this functional hierarchy, more abstract cognitive representations in rostral PFC guide selection of less abstract rule representations, in caudal PFC, that are more closely tied to motor actions. Here, we tested children through adults in a task that requires increasing levels of rule abstraction, while separately manipulating competition among alternatives in working memory. We found that developmental change in rule-guided behavior can be explained only in terms of improvement in PFC-dependent rule abstraction. Moreover, our results can be understood within the frame of current mechanistic models of selective updating of working memory. Finally, family socioeconomic status (SES) uniquely predicted change in rule abstraction, such that higher SES predicted more efficient developmental profiles. As such, variability and enrichment in a child's environment may influence developmental change in abstract rule use and PFC function.

1-E-53 A longitudinal study of fronto-parietal and fronto-striatal networks during working memory development

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Working memory (WM) capacity develops throughout childhood and adolescence. In cross-sectional studies, the development of WM has been associated with increase in brain activity as well as white matter maturation in fronto-parietal network. Here, we assessed the relationship between WM performance and brain function and structure, in fronto-parietal and fronto-striatal networks, longitudinally. We investigated associations between concurrent measures, as well as the extent to which future WM performance could be predicted. 89 individuals, 6-25 years old, were scanned 1-3 times at two year intervals. We identified activated areas in intra-parietal, superior frontal and caudate, during performance on a visuo-spatial WM task. Probabilistic fiber tracking identified white matter tracts connecting these three regions. We extracted BOLD and cortical thickness from cortical regions. White matter volume and fractional anisotropy (FA) were also measured for white matter tracts. In cross-sectional analysis, cortical brain activity correlated with current WM, while caudate activity was a

predictor for future WM capacity in longitudinal prediction analysis. This suggests the implication of cortical activity on explanation of inter-individual WM differences, and the role of caudate activity in learning during development. White matter FA was the only brain measure that could explain the current inter-individual differences in WM, and could predict future WM capacity. This indicates an important role of white matter microstructure in driving WM development.

2-E-54 Association of DLPFC BOLD activity and gamma oscillations during working memory in early adolescence

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Working Memory (WM) is supported by dorsolateral prefrontal cortex (DLPFC), which shows protracted change through adolescence; however, there is minimal evidence of mechanisms underlying age-related change in DLPFC activity. One possibility reflects the role of inhibitory neurons, critical for generation of gamma oscillations (>30Hz). The present study utilized functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) to elucidate mechanisms underlying DLPFC activity in early adolescence, when WM is still immature. 61 12-year olds performed a spatial WM task during fMRI and EEG in separate sessions on the same day. In the task, 3 cue stimuli were sequentially presented, followed by a delay, then a target with 4 stimuli; participants responded whether there was a match with a button press. For fMRI, standard preprocessing and a general linear model were used to estimate cue and delay activity in DLPFC. For EEG, wavelet transformation was used and average induced gamma activity across the cue and delay periods was calculated in DLPFC. During cue, there was a significant negative correlation between fMRI activity and gamma power in right DLPFC ($r=-0.33$, $p=0.018$) but not left ($p>0.1$). Further, there was a significant association between load-related fMRI activity and gamma power in left DLPFC ($r=-0.33$, $p=0.018$), but not right ($p>0.1$). There were no significant correlations in delay (all $p>0.1$). Negative correlation between fMRI activity and gamma power may reflect increased but inefficient neural activity, underlying known limitations in WM performance.

1-E-55 Development of Cognitive Control in Early Childhood: Working Memory Filtering

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The development of one's ability to self regulate is thought to result from the enhanced ability across age to suppress unwanted thoughts and actions, designated cognitive control. Early childhood is thought to be an important period for this development, yet to date, little work has been completed examining neural recruitment in support of cognitive control processes in this young children. In the current study thirty participants ages 5 to 35 years old participated in a working memory task while undergoing functional magnetic resonance imaging (fMRI). Each subject first participated in a delayed match to sample task in which they saw 1, 2, 3, or 4 different colored circles, after a jittered delay of 1.5-2.5 seconds, they were shown a single probe and asked if this probe was the same color as previously

presented. Next all subjects participated in an identical task that included distractors (triangles) during encoding. Children and adults achieved high levels of accuracy, though adults significantly outperformed children. Across all participants a network of areas, commonly recruited in the service of working memory tasks, was activated, including bilateral superior parietal and middle frontal gyrus (MFG). Consistent with previous findings, when children (N=15) were directly compared to adults (N=16) increased activation in many of these areas was observed for adults > children ($p < .05$, corrected). However, consistent with previous studies of cognitive control tasks in our lab, children activated the anterior cingulate cortex (ACC) more than adults.

2-E-56 Visual-spatial working memory and the development of mathematical cognition

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Much of an individual's cognitive development takes places within a formal educational context. Thus, a critical challenge for developmental cognitive neuroscience is understanding how fundamental cognitive constructs, like working memory (WM), contribute to success in academic domains, like mathematics. Emerging evidence suggests that these two abilities are intimately linked through their engagement of common brain structures including the intraparietal sulcus (IPS). We examined the relationship between multi-component WM and mathematical abilities in a sample of 17 children with mathematical disabilities (MD) and 17 IQ- and reading-matched typically developing (TD) controls. Visual-spatial working memory (VSWM) was the unique predictor of calculation ability relative to phonological and central executive measures of WM. Whole brain imaging analyses revealed that for TD children, VSWM ability was positively related to brain activity during arithmetic problems solving in several frontal, medial temporal and parietal brain regions, including the IPS. However, in children with MD, there was no evidence for any relationship between VSWM and brain activity. These results suggest that unlike TD children, children with MD do not use VSWM resources appropriately during arithmetic problem solving and further point to VSWM as an important domain-general cognitive process crucial for the typical development of mathematical skills.

1-E-57 Changes in pupillary responses during a working memory task

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Pupillary responses are a reliable measure of cognitive effort (Beatty, 1982); pupils typically dilate until reaching cognitive capacity, then plateau or constrict (Granholm et al., 1996). Karatekin (2004) found that pupil dilation was lower in children compared with adults during longer digit span tasks, suggesting a limited capacity to meet cognitive demand. We administered the WISC Digit Span task to 25 fifth-graders (average age 10.9) and recorded pupillary responses during a separate digit span overload task before and after 50 hours of chess instruction. The mean forward raw WISC score was 7.57 at pretest and 7.79 at posttest, indicating trending improvement in working memory ($p = .12$). For the overload digit

span task, we calculated pupil dilation upon hearing each digit. Mean peak dilation was observed at Digit 5 (D5) at pretest (5.94% increase) and D7 at posttest (3.35% increase), indicating trending improvement (p=.10). Contrary to previous results, this increase in cognitive capacity was accompanied by a decrease in slope. At pretest, mean slope was 1.07 until peak dilation (D5) and -.71 after peak dilation, whereas mean slope was .43 until peak dilation (D7) and -.34 after peak dilation at posttest. A highly variable slope was found at pretest for the highest improving participants on WISC (n=5, 29% mean increase), while a consistent linear increase (0.69) was observed at posttest. These individual differences in the changes in pupillary response in association with improved working memory reveal interesting developmental patterns.

2-F-58 Chronic Nicotine Exposure Results in Increased Sweet Food Consumption but Not Increased Body Weight in Adolescent Female Mice

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Adolescent smokers, especially girls, report smoking to reduce weight yet human studies examining this smoking-bodyweight relationship yield mixed results. Exposure to nicotine, the primary addictive ingredient in cigarettes, reduces feeding and body weight in adolescent male but not female rats. No adolescent rodent studies have examined the effects of nicotine on body weight and feeding in the presence of different types of food (e.g., sweet, high fat), which could alter the effects of nicotine on body weight. In this experiment, 31 adolescent (PND 28) female mice were given 14-day continuous access to 200ug/ml nicotine dissolved in tap water, along with 1 of 3 food types [bland chow, high fat (60% fat), high sweet (70% carb)]. Separate linear regressions were conducted for each treatment group to examine the effects of nicotine intake on body weight and food intake at the end of nicotine exposure. Nicotine intake did not predict body weight change for any of 3 food treatment groups, nor did it predict food intake for mice in the control or high fat group. However, nicotine intake predicted increased food intake among mice provided sweet food (beta=0.39, $p<0.05$). Results suggest that nicotine may not affect body weight and may increase consumption of certain types of hedonic foods (e.g., high sweet) during adolescence. Although increased sweet food consumption during nicotine exposure did not alter body weight, it is important for future studies to examine how nicotine exposure modifies neurobiological pathways that could set females up for weight gain in adulthood.

1-F-59 Adolescent stress or impulsivity effects on alcoholism vulnerability in adulthood: role of gap junction intracellular communication

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Individual differences in the risk of developing alcohol dependence are not well understood. However, previous work has described a correlation between impulsivity and alcohol use. The delay-discounting task, which tests the propensity to forgo a delayed, large reward in favor of a small, immediate reward,

is used to test individual differences in impulsivity. Rats selectively bred for high ethanol (EtOH) drinking discount delays more than their low-drinking counterparts and alcoholics make more impulsive choices on the delay-discounting task. We've previously shown that rats subjected to adolescent stress, modeled by corticosterone (CORT) in drinking water, exhibit increased impulsivity. We tested whether adolescent stress or innate differences in impulsivity predicts an increase in alcohol-motivated behaviors. Moreover, we determined potential biological mechanisms mediating increased risk for alcoholism using phosphoproteomics in amygdala micropunches. We found that adolescent CORT increases alcohol-motivated behaviors and phosphorylation of gap junction protein, connexin 43 (Cx43), compared to control. The relevance of gap junction communication in alcohol-taking behavior was tested by infusion of the gap junction inhibitor, carbenoxolone (CBX), into the amygdala. CBX reduced EtOH self-administration in adolescent CORT treated animals. Identification of individual differences in adolescent impulsivity/stress exposure may help predict alcoholism in adulthood, and Cx43 may be a putative target for the treatment of alcoholism.

2-F-60 Neural representation of expected value in the adolescent brain

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While the neurobiological valuation system has been well characterized in adults, the neural ontogeny of value representation remains poorly understood. In this study, adult and adolescent participants underwent functional magnetic resonance imaging (fMRI) while choosing to accept or reject mixed gambles (50/50 probability of gain and loss) of varying expected value (EV). Increasing EV had a stronger influence over gambling choices in adolescents relative to adults. All participants showed parametric activation in predicted "valuation system" regions, including medial prefrontal cortex (mPFC) and dorsolateral prefrontal cortex (DLFPC), in response to increasing EV; however, increasing activation in the VS was unique to adolescents during EV computation. These behavioral and neural data suggest that adolescents are biased to a greater extent than adults by the value of available options and may partially explain the observed adolescent sensitivity to reward and positive prediction error in previous studies. This research provides evidence for ontogenetic differences in how computation of value is used to bias reward-related behavior.

1-F-61 Developmental and individual differences in craving for food

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The ability to delay gratification in childhood predicts wellbeing throughout the lifespan. However, few studies have examined the neural correlates of delay ability. The present study examined links between delay ability and the neural bases of regulation of craving for food in healthy children aged 6-13. Delay ability was assessed using Mischel's classic paradigm wherein children may have a small treat

immediately or wait for a larger treat. In a separate testing session, participants completed a fMRI experiment that involved looking at pictures of appetizing, unhealthy foods. On each experimental trial, participants were instructed to either imagine the food was right in front of them and to focus on its appetitive features, or to imagine it was further away and to focus on its visual properties. On each trial, participants indicated how much they wanted to eat the food that they had just viewed. Participants reported less craving when distancing themselves from food stimuli than when imagining food as being right in front of them and participants with lower delay ability reported more craving across both trial types. Looking at food stimuli strongly recruited brain regions associated with reward processing and affective valuation, including the ventromedial PFC (vmPFC) and ventral striatum (VS). Distancing attenuated activity in these regions and delay ability predicted differential prefrontal recruitment and VS modulation. These data suggest that children can use cognitive strategies to regulate craving and that delay ability predicts regulation success.

2-F-62 Kids, Candy, Brain and Behavior: Developmental Differences in Responses to Candy Gains and Losses

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Functional development of neural systems involved in incentive processing may be important to understanding the unique window of vulnerability to risk and psychopathology during adolescence. Investigating responses to both gains and losses prior to puberty will provide an important baseline for future studies investigating the relationship between typical/atypical development and risk for psychopathology. Healthy children aged 7-11 years and young adults completed an fMRI card-guessing game using candy pieces delivered post-scan as an incentive. Age differences in behavioral and neural responses to gains/losses were investigated. Children and adults displayed similar activation patterns modulated by feedback type in portions of the striatum and anterior cingulate. When trials of different valence were investigated separately, age differences related mostly to loss and were observed in the striatum, insula, and amygdala/hippocampus. Participants generally displayed win-stay/lose-shift (WSLS) behavior, with children shifting more in general. Thus, relationships between behavior, age, and activation were also investigated. Mediation and ANOVA analyses revealed effects of both choice behavior and age within the striatum while insular regions displayed only effects of age. Children and adults displaying WSLS behavior showed delayed/extended striatal responses to loss, with remaining participants displaying more canonical responses. These results suggest that both behavioral choice and development influence incentive responses within the extended reward circuitry.

1-F-63 Developmental Changes in Incentive Processing During Inhibitory Control: A Longitudinal fMRI Study

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Cross-sectional studies suggest that reward processing and its effects on cognitive control are unique in adolescence. Yet only longitudinal studies can assess the trajectory of developmental change. We used an accelerated longitudinal design to estimate age-related changes in BOLD response to different stages of an incentivized anti-saccade task. Subjects between the ages of 10- and 24-years saw cues indicating whether correct performance would be rewarded with points (Rew), avoid losing points (Loss), or have no impact on point accrual (Neu). Additional catch trials with either a cue or a cue and preparatory period were presented to better estimate the BOLD response to each event type. Behaviorally, children committed significantly more inhibitory errors than adolescents and adults. We found significantly increasing activation with age in response to Cue stimuli in a number of executive and motor control regions including dorsal ACC, frontal (FEF) and supplementary eye fields, and putamen in all conditions. U-shaped patterns were found in response to Cues in OFC, dlPFC, and FEF to saccades, while an inverted U-shaped pattern was found in dorsal ACC and FEF to saccade preparation in the Rew > Neu contrast. Posterior parietal cortex showed a U-shaped pattern to saccades in both this and the Loss > Neu contrasts. These results suggest that incentives affect activation in reward and motor control regions differentially across age and that adolescents may process incentive information in a manner distinct to other periods of development.

2-F-64 Incentive effects on inhibitory control across developmental and cigarette-smoking samples

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Examining the interaction of reward and inhibitory control brain systems may inform us on the emergence of risk-taking behaviors during the adolescent period. Investigating these systems in cigarette smokers may guide interventions attempting to modify substance use behaviors through the use of incentives. In this presentation, we use an incentivized antisaccade task to characterize the effects of monetary rewards and losses on inhibitory control in two populations: 1) adult daily smokers (project 1), and 2) late adolescents and young adults (project 2). For project 1, smokers performed the task twice, once under conditions of smoking satiety and once following verified abstinence, to assess how hypothesized altered reward sensitivities across these contexts affect performance. Results indicate that abstinent smokers made more errors on 'loss' trials relative to their performance when satiated ($p<.05$). For project 2, results revealed significant improvements in terms of the proportion of correct trials and reaction times on 'reward' ($p<.05$), but not on 'loss' or 'neutral' trials ($ps>.05$) across groups. Developmental differences were also observed, with adolescents performing worse than adults on 'loss' trials ($p<.05$). All participants underwent fast, event-related functional magnetic resonance imaging (fMRI) while performing the task. We present data focused on key reward and inhibitory control related brain systems and highlight specific group and incentive by time differences. Overall, this paradigm will likely yield insights into decision making across various contexts.

1-F-65 Adolescent risky decisions: The influence of pubertal hormones, reward magnitude, and social comparison feedback

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This study on adolescent brain development and risky decision-making focuses on the influence of pubertal development, reward magnitude and social comparison, using a revised version of the Jackpot task (Op de Macks et al., 2011). Participants chose to "play" or "pass" based on information about risk (low or high), reward magnitude (small or large), and type of feedback (monetary or social ranking). To date 44 healthy, female subjects (age 11-13 years) have participated. Preliminary behavioral results demonstrate that the decision to "play" is driven by both risk, $F(1, 43) = 160.52$, $p < .001$ and reward magnitude, $F(1, 43) = 8.69$, $p = .005$. The percentage of "play" choices in the high-risk condition is positively associated with testosterone levels for both monetary ($r = .33$, $p = .042$) and social feedback ($r = .40$, $p = .011$)--but this is true only when a small reward is at stake. Preliminary whole-brain analyses (n=40) demonstrated bilateral VS activation for gain versus loss. Reward-related activation shows an inverted U-shaped relationship with the percentage of "play" choices on high-risk/small reward trials. Interestingly, this relationship was found for reward-related activation in the social feedback condition, $F(2, 36) = 3.81$, $p = .031$, but not in the monetary feedback condition, $F(2, 36) = 1.40$, $p = .260$. These findings raise a series of questions about the neurodevelopmental underpinnings of social influences on risk taking during pubertal maturation.

2-F-66 Sex difference in striatal brain response during reward processing in adolescence

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Adolescence is characterized by increased risk-taking and changes in the neural correlates of reward processing. Understanding this course of normative development in the context of sex-differences can provide important insight on the emergence of affective disorders, substance use, and risky behaviors, which often manifest in a sex-specific fashion. Male (n=77) and female (n=57) adolescents between the ages of 12-16 years performed a modified version of the Wheel of Fortune (WOF) Task in a 3T MRI scanner. This decision-making task calls for a choice between two portions of a wheel that represent different probabilities of winning various monetary amounts. To examine brain activity during reward processing, only the feedback phase (Win and NoWin) of the trials was analyzed. A whole-brain ANCOVA was conducted to examine sex differences. Results were modeled with sex, puberty and sex-by-puberty interaction. Boys made a significantly higher percentage of risky decisions compared with girls. Boys also had significantly more activation in right striatum (including nucleus accumbens) than girls ($p<.001$, cluster threshold $p<.05$ for comparisons correction). There was also a trend correlation between striatal brain response and risky decision-making ($r2=.12$, $p=.056$) across the sample. These findings suggest greater striatal response during reward processing in boys, which may be associated with risky decision-making in adolescence.

1-F-67 Relating the developmental mismatch in structural brain meturation to adolescent risk-taking behaviors

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The developmental mismatch hypothesis proposes that limbic structures involved in processing affect and reward develop earlier than cortical structures involved in cognitive control, and that this mismatch in maturational timing is most exaggerated during adolescence. The mismatch in maturational timing between these two systems is thought to underlie many stereotypical adolescent behaviors e.g. risk-taking, sensation-seeking. Despite the model's popularity, few studies directly assess the relative maturational timing of these two systems within individuals, or ascertain whether any developmental mismatch actually relates to individuals' adolescent behaviors. The present study uses a longitudinal sample of structural MRI scans to test the developmental mismatch hypothesis on a group- and individual-level, and relates individual differences in brain maturation to reported adolescent behaviors. Structural trajectories of the amygdala, nucleus accumbens (NAcc) and prefrontal cortex (PFC) volumes were analyzed using Freesurfer5.3 in 33 participants (152 scans), aged 7-30 years. Each individual had at least three high-quality MRI scans spanning three developmental periods: pre-puberty, peri-puberty, and post-puberty. Retrospective self-report data of adolescent risk-taking, impulsivity and sensation-seeking were obtained. We assessed the relative developmental trajectories of the amygdala, NAcc, and PFC. The majority of individuals showed earlier maturation in the amygdala and/or NAcc relative to the PFC, providing evidence for a developmental mismatch between these structures.

2-G-68 Developmental changes in amygdala-insula connectivity mediates normative age-related increases in trust appraisals

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Accurate evaluation of others based on perceived trustworthiness is requisite for normative social function. Even when no contextual information is provided, we make "gut-based" decisions about trustworthiness, a bias that emerges early in development and may be reflected in developmentally-appropriate social wariness. A large literature indicates that these "gut-based" judgments of trustworthiness rely on the activity of limbic structures, such as the amygdala and insula, that support rapid processing of affective information. These structures undergo massive change across the life span, and therefore, we might anticipate large changes in trust-related behaviors. While neurobehavioral changes in trust behaviors have been observed in aging populations, this question has not been pursued in very young populations, when even causal observations make evident the high degree of wariness of strangers. The present study examined developmental changes in trust-related behaviors by examining explicit evaluations of trustworthiness of unknown faces, parent-reported stranger wariness, and task-based functional magnetic resonance imaging to examine developmental changes in amygdala-insula circuitry across a wide developmental age-range. Results showed that all subjects, regardless of age, reliably discriminated faces as trustworthy or untrustworthy. However, subjects demonstrated age-related changes in overall trust appraisals, such that subject's evaluations became more trusting with increasing age, paralleling the observed age related-declines in parent-rated stranger wariness.

1-G-69 The stimuli drive the response: child face stimuli alter brain response in youth

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Effective navigation of the social world relies on the correct interpretation of facial emotions. This may be particularly important in formative years. Critically, literature examining the emergence of face processing in youth (children and adolescents) has focused on the neural and behavioral correlates of processing adult faces, which are relationally different from youth participants, and whose facial expressions may convey different meaning than faces of their peers. During a functional magnetic resonance imaging (fMRI) scan, we compared concurrent neural and behavioral responses as youth (N=25) viewed validated, emotionally varied (i.e., anger, fear, happy, and neutral) adult and child face stimuli. We observed that participants made fewer errors when matching adult, compared to child, face stimuli, and that while similar brain regions were involved in processing both adult and child faces, activation in the face processing neural network was greater for adult than child faces. This was true across emotions, and also when comparing neutral adult versus neutral child faces. Additionally, a valence by stimuli-type effect was observed within the amygdala. That is, within adult face stimuli, negative and neutral face stimuli elicited the largest effects, whereas within the child face stimuli, happy face stimuli elicited the largest amygdala effects. Thus, heightened engagement of the amygdala was observed for child happy and adult angry faces, which may reflect age-specific salience of select emotions in early life.

2-G-70 Development of size- and view-invariance in LOC: an fMR-adaptation study

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Previous studies have shown that by age 5-8 years, the lateral occipital complex (LOC) shows adult-like responses when contrasting images of objects versus scrambled objects. Here, we selected complex novel shapes and manipulated both size and viewpoint of these shapes in an adaptation paradigm to assess the neural profile in LOC in children (5-10 years), adolescents (11-16 years), and adults (18-27 years). Observers were shown blocks in which the same object was shown repeatedly, the same object was shown in different sizes/views, or different objects were shown. The results showed that all 3 age groups demonstrated size-invariance, showing a reduced neural response to the same-object-same-size condition and the same-object-different-sizes conditions. However, only adults showed evidence of view-invariance. Adolescents and children showed a similar neural response to the same object different views condition and the different objects condition. The results suggest that size-invariance develops early but the neural mechanisms underlying view-invariant object recognition is not yet mature even in adolescents.

1-G-71 The joint development of hemispheric specialization for words and faces

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The adult human brain shows specialized and seemingly independent neural systems for the visual processing of words and faces. Extensive evidence has demonstrated greater selectivity for words in the left over right hemisphere, and, conversely, greater selectivity for faces in the right over left hemisphere. Much research has determined that there is a protracted developmental trajectory associated with the emergence of the selectivity for faces and for words. This study examines the emergence of the neural specificity for word processing and for face processing, as well as the relationship between them. Using behavioral and neurophysiological measures, in adults, we observed the standard finding of greater accuracy and a larger N170 ERP component in the left over right hemisphere for words, and conversely, greater accuracy and a larger N170 in the right over the left hemisphere for faces. We also found that, although children aged 7-11 years showed the adult pattern for words, they did not show either a behavioral or neural hemispheric superiority for faces. Of great interest, the strength of the N170 for faces in the RH was related to the strength of the N170 for words in LH but not to age or to accuracy of face discrimination. These findings suggest that the hemispheric organization of face and word recognition do not develop independently, and that earlier word lateralization may drive later face lateralization. A theoretical account in which competition for visual representations unfolds over the course of development is proposed to account for the findings.

2-G-72 fMRI in freely viewing non-human primates as a tool to understand functional brain development

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The familiarization novelty preference procedure (FNP; adapted from human infant research) was used in the awake, behaviorally naïve non-human primate (NHP) to examine neural substrates of face perception using fMRI. FNP can capture natural preferences for novel visual stimuli and allow for studies of visual learning. The most consistent behavior across NHPs emerged when stimulus changes were somewhat predictable: looking time (measured with an MRI-compatible eye tracker) increased on frames that had a higher probability of a change over the course of an experiment, indicating that the animals were sensitive to statistical dependencies. fMRI activation patterns, however, were not as consistent across NHPs, but controlling for inter-session and inter-subject variability in looking time increased fMRI signal sensitivity and consistency, especially in visual cortex. Consistency across NHPs was also observed using network measures computed for specific regions/nodes in the task state. Specifically, different frontal regions showed greater functional integration (measured with eigenvector centrality) associated with perceiving NHP faces (left Area 45) and objects (left Area 44, right Area 9/46). In a separate study in humans, the same functional integration measure in similar frontal regions increased from childhood to adulthood when viewing faces. We suggest that the FNP paradigm can be sensitive to visual discrimination behavior during scanning and that graph-theory based functional connectivity may capture consistent and relevant neural responses across animals.

1-G-73 Emerging Structure-Function Relations in the Developing Face Processing System

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To evaluate emerging structure-function relations in a neural circuit that mediates complex behavior, we investigated age-related differences among cortical regions that support face recognition behavior and the fiber tracts through which they transmit and receive signals using functional neuroimaging and diffusion tensor imaging. In a large sample of human participants (aged 6-23 years), we derived the microstructural and volumetric properties of the inferior longitudinal fasciculus (ILF), the inferior fronto-occipital fasciculus, and control tracts, using independently defined anatomical markers. We also determined the functional characteristics of core face- and place-selective regions that are distributed along the trajectory of the pathways of interest. We observed disproportionately large age-related differences in the volume, fractional anisotropy, and mean and radial, but not axial, diffusivities of the ILF. Critically, these differences in the structural properties of the ILF were tightly and specifically linked with an age-related increase in the size of a key face-selective functional region, the fusiform face area. This dynamic association between emerging structural and functional architecture in the developing brain may provide important clues about the mechanisms by which neural circuits become organized and optimized in the human cortex.

2-G-74 Peer influences on approach and consummatory behavior during adolescence: Evidence from humans and mice

Jason Chein[1], **Sheree Logue**[1], **Thomas Gould**[1], **Ashley Smith**[1], **Laurence Steinberg**[1]

[1] Temple University

One hallmark of adolescent risk taking is that it typically occurs when adolescents are with peers. In behavioral and neuroimaging (fMRI) work with human adolescents and adults, we experimentally manipulated social context by having participants complete a range of decision making tasks either alone, or while being observed by peers. Results provided evidence of an age by social context interaction wherein adolescents, but not adults, exhibited sensitivity to social conditions. Findings suggested that the presence of peers specifically affects adolescent decision-making by increasing the drive on a reward-sensitive motivational state in the context of a still immature capacity for inhibitory control. To further explore this hypothesis, we developed a rodent model of the phenomenon. A sample of mice were raised in same-sex triads and were tested for alcohol consumption either as adolescents or as adults, with half in each age group tested alone and half tested with their cagemates. As in our human research, the presence of "peers" was found to impact alcohol consumption among adolescent mice, but not adults. The peer effect on human adolescent risk-taking may reflect a hard-wired, evolutionarily conserved process through which the presence of age-mates increases individuals' sensitivity to potential rewards in their immediate environment.

1-G-75 Social regulation of craving for food in adolescence and adulthood

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Adolescence is a developmental period characterized by increased sensitivity to social information. While social influence has been studied in this age group with respect to rejection and risk, few studies have looked at how social influence might serve to regulate one's affective responses to primary rewards such as food. In the current study, adolescent and adult participants viewed images of food and for each image indicated on a scale of 1-7 how much they wanted to eat it. After making their rating, participants were shown what they believed to be a group rating for that same food from a sample of approximately 100 peers, or they received no feedback. After a break, participants rated the images a second time, this time without peer feedback. We assessed social influence by comparing the degree to which ratings changed as a function of the peer ratings. In both adolescents and adults, we found a robust conformity effect, such that participants significantly changed their ratings to conform to the peer ratings. When comparing groups, we found that adolescents more strongly conformed to their peers than adults, however, they also showed more variability in the degree to which they conformed. For all participants, there was no significant change in ratings when they received no peer feedback, nor when their ratings matched the peer ratings. Future directions include using fMRI to assess how neural representations of social influence might modulate affective responses across development.

2-G-76 Children's neural activity during natural viewing of educational television exhibits category-specific responses

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fMRI studies of cognitive development using highly controlled, static stimuli have found that distinct brain regions exhibit specificity for different concepts and categories, such as the intraparietal sulcus (IPS) for number (Cantlon et al., 2006). Recent fMRI studies have found that naturalistic stimuli, such as movie clips, can also elicit category-specific responses in the same neural regions (Hasson et al., 2004, Huth et al., 2013), despite being far less controlled. In a recent study (Cantlon & Li, 2013), we showed children (4-10y) and adults (18-25y) the same 20-min movie of Sesame Street clips and found that young children's neural activity showed number-specific responses in IPS. We derived the neural maturity of each child by correlating the whole neural timecourse at every brain voxel between each child and the group of adults. Children's neural maturity in bilateral IPS correlated with their math IQ scores, controlling for verbal IQ, while their neural maturity in Broca's area correlated with their verbal IQ scores, controlling for math IQ. Here, we extend our natural viewing analyses to a new dataset in which young children (4-8y) watched educational television clips about math and reading while undergoing fMRI. We found category-specific responses in IPS for math clips, in inferior frontal gyrus for reading clips, and in visual word form area for clips displaying text. Naturalistic stimuli are proving to be a practical tool for measuring neural development and provide insight into children's neural processes during unconstrained educational tasks.

1-G-77 Social influences on risk perception across adolescence and adulthood

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[1]University College London

Previous studies have found that adolescents show heightened risk taking behaviour when in the presence of peers, suggesting a relationship between risk taking behaviour and peer influence during adolescence. So far, no study has systematically investigated the relationship between peer influence and risk perception across development. In order to shed light on that question, we designed a study that was conducted in two stages. The first study was a large-scale behavioural study in which we collected data from 650 participants (aged 8 to 60 years) visiting the Science Museum in London. The behavioural study focused on how the perception of risk changes with age, and the degree to which risk ratings are influenced by others' opinion of risk. The subsequent fMRI study in adolescents and adults used the same paradigm and aimed to investigate the neural mechanisms of social influence on risk perception and its development. In both studies, participants were asked to rate the riskiness of different everyday situations. After making a decision about the riskiness of each situation, participants were shown ratings of other people of the same age or different age, and were then asked to rate the same situation again. In a control condition, participants were shown their original rating, and were then asked to rate the situation again. The studies shed light on how the perception of risk changes with age, whether the impact of social influence on risk perception is more pronounced in adolescence, and whether the underlying neural processes develop between adolescence and adulthood.

2-G-78 ""You deceived me... Please be my friend!"" Neurobiological correlates of violation of social expectations in adolescents

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Trust and cooperation are advantageous at all stages of development to forge and maintain social relationships (Lahno, 1995; van den Bos et al., 2011). This is particularly important during adolescence when individuals are navigating an increasingly complex social world. Although numerous studies have examined neural correlates of social processing, our goal was to address neural representations underlying violations of social expectations (deceit). We examined this question using a modified version of the Prisoner's Dilemma game that included deceit trials while participants received a functional magnetic resonance imaging (fMRI) scan. Adolescents and adults played the game with a same age, sex-matched close friend, stranger, and the computer. Violation of social expectations was assessed by examining behavioral and neural responses following trials in which the opponent deceived the target. There was a significant difference in responses to deceit [$F(1,39)= 4.272$, $p < .05$], such that adolescents ($M= 47.04\%$) were less likely than adults ($M= 64.51\%$) to cooperate with their friends. Neurobiologically, we predict that adolescents rely more on striatal circuitry in making emotionally charged decisions than adults. Functional connectivity analyses will be used to assess whether greater coupling between the mPFC and ventral striatum in adults compared to adolescents is associated with greater behavioral regulation in the face of deceit. Together, these data suggest that adolescents may be more behaviorally and neurobiologically sensitive to violation of social expectations.

1-G-79 Peer influence on the receipt of reward during adolescence

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The presence of peers is known to increase risk-taking during adolescence, but the effect of peers on decision-making decreases with age (Gardner & Steinberg, 2005). Recent neuroimaging research has suggested that peers influence decision-making through increased engagement of the reward processing system, specifically the ventral striatum and OFC (Chein et al., 2011). The current study extends these findings by exploring the effects of peers on reward processing outside of the context of risky decision-making. In an fMRI paradigm, we used a simple reward-processing task (a modified version of the High/Low Card Guessing Task; Delgado et al. 2004) to evaluate age- and social context-dependent neural differences during anticipation and receipt of rewards. A sample of adolescents (ages 14-17) and adults (ages 25-35) participated in the study. Social context was manipulated by having participants complete the experimental paradigm alone and in the presence of two same-age, same-sex, peers. Condition order was counterbalanced across participants. Analyses indicate that adolescents, but not adults, show increased striatal recruitment during receipt of reward, compared to non-reward. Furthermore, this effect is dependent on social context, with adolescents demonstrating greater reward-related striatal activation when they completed the task in the presence of peers, compared to when they completed the task alone. This effect was not present in adults. These results extend our understanding of how peers affect the neural circuitry of reward processing in adolescents.

2-G-80 Default Distrust? An fMRI investigation of the neural development of trust and cooperation

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The tendency to trust and to cooperate increases from adolescence to adulthood. This social development has been associated with improved mentalizing and age-related changes in brain function. Thus far, there is limited imaging data investigating these associations. We used two trust games with a trustworthy and an unfair partner to explore the brain mechanisms underlying trust and cooperation in subjects ranging from adolescence to mid-adulthood. Increasing age was associated with higher trust at the onset of social interactions, increased levels of trust during interactions with a trustworthy partner and a stronger decline in trust during interactions with an unfair partner. Our findings demonstrate a behavioural shift towards higher trust and an age-related increase in the sensitivity to others negative social signals. Increased brain activation in mentalizing regions, i.e. temporo-parietal junction, posterior cingulate and precuneus, supported the behavioural change. Additionally, age was associated with reduced activation in the reward-related orbitofrontal cortex and caudate nucleus during interactions with a trustworthy partner, possibly reflecting stronger expectations of trustworthiness. During unfair interactions, age-related increases in anterior cingulate activation, an area implicated in conflict monitoring, may mirror the necessity to inhibit pro-social tendencies in the face of the partner s actual levels of cooperation.

1-G-81 Successful in secondary education: a vulnerable balance between friends and homework

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In most children, the cognitive control system and the socio-emotional system get into balance during adolescence. Great differences in this 'balancing process' between children however exist. The present research focuses on these differences, and their underlying factors - in relation to school performance. The results of the first wave of a longitudinal project will be presented. This project includes two behavioral data waves and one fMRI experiment. N= 550 young adolescents (age range 11-14 years) from the last year of primary education, and the first and second years of secondary education performed on experimental neuropsychological tasks to measure cognitive flexibility, working memory capacity, inhibition, and risk taking. In addition, we indexed school performance, and collected survey data on e.g., pubertal status, need for arousal, substance use, social networks, and media use. Graph theoretical modeling was applied to examine individual differences in the network of connections between these variables. The most prominent result indicated that 'need for arousal' was the central node in all participants, but even more central in the network of the particpants who were delayed at school. The results will be discussed in vis-à-vis the notion of adolescence reflecting a period of social-affective engagement and goal flexibility (e.g., Dahl & Crone, 2012).

2-G-82 Being rejected and taking revenge: Neural correlates of punishing initiators of social exclusion during adolescence

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Adolescence is a developmental period characterized by heightened sensitivity to peer rejection. Research has shown that victims of exclusion modify their behavior in response to social exclusion, but the neural mechanisms associated with these reactions have received less attention. The current fMRI study examined the neural correlates of social exclusion and subsequent decisions about fairness toward initiators of social exclusion in a sample of adolescents (n=46; age 12-15). Participants were first included in a virtual ball-tossing game (Cyberball) by two unknown peers (the includers) and were then excluded by two novel peers (the excluders). Subsequently, they played a modified Dictator Game where they divided money between themselves and the includers and excluders. After being excluded in Cyberball, participants reported increased distress and social exclusion was associated with heightened activity in anterior insula, ventral anterior cingulate cortex, medial prefrontal cortex, and ventrolateral prefrontal cortex; regions associated with negative affect and emotion regulation. Participants punished the excluders in the Dictator Game, even when this yielded no monetary gains for themselves. Fairness-related decisions towards excluders were associated with increased activation in ventral striatum, anterior insula, and dorsolateral prefrontal cortex; regions important for reward-processing, negative affect, and cognitive control, respectively. Current findings will be related to individual differences in pubertal development and real-life experienced peer rejection.

1-G-83 Theory of mind and social functioning in typically developing children: An fMRI investigation with a novel movie-based task

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Theory of mind, the ability to think about others' thoughts and feelings, is a critical social cognitive skill for effective social development. The aim of this study is to use fMRI to identify the neurobiological mechanisms that underlie social cognitive processes like theory of mind and investigate their role in social functioning. This study uses a novel, ecologically valid theory of mind task to further explore the neurobiology of social cognition in elementary and middle school-aged children, a less well-studied age-group. In this task, children were asked to watch movie clips of social interactions and then were asked to predict future mental states. Results from this task show that typically developing 8-13 year olds recruit bilateral temporal parietal junction (TPJ), the superior temporal sulcus, and superior temporal gyrus when thinking about mental states. Additionally, this study looks at the relationship between brain activity during this theory of mind task and social functioning variables as assessed using self-report, interview, and performance based measures.

2-H-84 Evidence for neurophysiological change in the adolescent striatum revealed using multivariate pattern analysis of time-averaged fMRI activation

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Most common fMRI data analyses look at changes in BOLD activation over time or between experimental conditions. However, previous research has shown that time-averaged MRI activation (i.e. time-averaged T2*-weighted images) may be useful for investigating differences amongst individuals. The present study investigates the relationship between this measure and adolescent development using a multivariate pattern analysis (MVPA) approach. Specifically, we use MVPA of striatal time-averaged T2*-weighted signal in a large cross-sectional dataset to predict the age of adolescents and young adults, using both task-related and resting-state data. To create the time-averaged T2* weighted image, each subject's fMRI scans were motion corrected, non-linearly transformed to standard space, normalized, and averaged across time, resulting in one time-averaged volume per subject. Patterns of striatal time-averaged T2*-weighted signal generated highly significant predictions and accounted for over 65 percent of variance in subject ages. Voxels in the ventral striatum were identified as having the largest relative contribution to the age prediction and results were replicated using resting-state data. Our ability to predict age with a high degree of accuracy from both time-averaged task-related and resting-state taT2* signal indicates that this measure reflects a physiological state. As such, these results suggest that there is continued physiological maturation through adolescence in the striatum, which may underlie known developmental changes in motivation and learning through adolescence.

1-H-85 Resting-state functional connectivity MRI reveals a developmental change in basal ganglia functional organization from childhood to adulthood

Deanna Greene[1], **Timothy Laumann**[1], **Joseph Dubis**[1], **S. Katie Ihnen**[1], **Maital Neta**[1], **Jonathan Power**[1], **John Pruett Jr.**[1], **Kevin Black**[1], **Bradley Schlaggar**[1]

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The basal ganglia (BG) comprise a set of subcortical nuclei with sensorimotor, cognitive, and limbic subdivisions, indicative of functional organization. Several developmental disorders, including Tourette syndrome, ADHD, and OCD, have been associated with BG dysfunction, suggesting the importance of BG maturation. However, there is little work on the development of BG functional organization. Here, we used resting-state functional connectivity (RSFC) MRI to compare BG functional organization in children and adults by interrogating functional relationships between the BG and RSFC-derived cortical systems. Volume censoring and preprocessing procedures were used to control for motion-related effects. Results demonstrated functional organization in the adult BG consistent with subdivisions previously identified. Group comparisons revealed a specific developmental shift in a bilateral posterior putamen/pallidum cluster from preferential FC with the "face" somato-motor (SM) system in children to preferential FC with control/attention systems in adults. FC of this cluster with the face SM system was stronger in children than adults, while FC with control/attention systems did not differ between groups. Further, within the child group, FC with the face SM system decreased with increasing age. Thus, we showed decreasing FC with the face SM system during development, giving way to dominant FC with control/attention systems in adulthood. Our results are generally consistent with the prominent view of a developmental shift from stimulus-driven to goal-directed processing in the brain.

2-H-86 Sex Steroid Receptor Gene Expression Correlates with Expression of Neurodevelopmental Genes and Modulates Gray Matter Volume in the Human Brain

Tuong-Vi Nguyen[1], **Peter Schmidt**[1], **Jonathan Kippenhan**[1], **Melanie Sottile**[1], **Jeffrey Bloch**[1], **Victor Ekuta**[1], **Joel Kleinman**[2], **Barbara Lipska**[1], **Bhaskar Kolachana**[1], **Venkata Mattay**[1], **Daniel Weinberger**[1], **Karen Berman**[1]

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Animal models have documented organizational effects of sex steroid receptor (SSR) gene expression on the brain, and human studies have linked single nucleotide polymorphisms (SNPs) in the genes for estrogen receptor alpha (ESR1), estrogen receptor beta (ESR2) and the progesterone receptor (PGR) to the development of psychiatric disorders. Here we characterized neurodevelopmental markers of SSR gene expression in the human brain using a two-pronged approach: (1) in a sample of 269 post-mortem brains ranging from fetal age 14 weeks to 80 years old, we examined expression of SSR genes across the lifespan and correlated their expression levels with those of genes related to neuronal migration, dendritic remodeling, and glial proliferation; and (2) in structural MRIs of 289 healthy living adults 18-55 years old, we examined associations between gray matter volumes (GMV) and SSR genotypes. We found that ESR2 expression levels were higher prenatally than postnatally, and that ESR2 expression correlated

with that of genes involved in neuronal migration/dendritic remodeling such as LIM-domain kinase 2; in contrast, ESR1/PGR expression levels were higher postnatally and correlated with those of genes associated with glial proliferation, such as glial fibrillary acidic protein. In adults studied in vivo, genetic variation in these same SSR genes modulated cortical (ESR1/PGR) and subcortical (ESR2) GMV. Thus developmental trajectories of SSR gene expression across the lifespan appear to translate into organizational characteristics in the adult brain.

1-H-87 What are we measuring in developmental structural MRI?

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Structural magnetic resonance imaging (MRI) has given us the unprecedented capability to measure the developing human brain. This technique has paved the way for longitudinal studies exploring brain development across the entire life span. Results from these studies have given us a glimpse of the remarkably extended development of our brain, converging with evidence from anatomical and histological studies. But what are we measuring in developmental structural MRI studies? In this presentation, we attempt to unpack how developmental changes in brain structure during childhood and adolescence relate to co-occurring physical changes, and explore possible explanations for what these measurements represent in terms of cellular processes and organization. We utilize longitudinal structural MRI data to describe the developmental changes in brain structure as they relate to other physical measures such as height, weight, and pubertal stage, and consider the impact of accounting for regional brain volumes or total intracranial volume. In addition, we review and discuss the possible cellular and organizational changes that could be reflected in developmental structural MRI studies.

2-H-88 A longitudinal MRI study: puberty specific cortical and subcortical maturation in adolescence

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While cross-sectional data has shown puberty to be related to neuromaturation in a sex-dependent fashion, specific neuromaturational effects are better characterized using within-subject longitudinal designs. We examined the influence of pubertal maturation on cortical and subcortical brain development in 120 youth, ages 10 to 14, with an average of 2 years between assessments. Tanner Stage, testosterone (T), estradiol (E2), and T1-weighted structural MRI images were collected. FreeSurfer's longitudinal pipeline was used to examine whole-brain cortical thickness, and a priori subcortical volumes of the hippocampus, amygdala, caudate and thalamus. Using multilevel mixed models, the independent variables of puberty (controlling for age), sex, and pubertal-by-sex interactions predicted brain development. In both sexes, more pubertal maturation during study interval related to reduced thinning in the left lateral orbitofrontal and right superior frontal cortex. Tanner-by-sex interactions were found, with larger pubertal development changes related to greater inferior frontal thinning in boys. Greater annualized increases in E2 predicted greater right superior temporal, right

lateral occipital, left middle temporal, and left superior parietal thinning in girls, but none in boys. Subcortical analyses revealed Tanner-by-sex interactions for the left hippocampus, amygdala, and caudate, with greater changes in pubertal maturation leading to volume increases only in girls. These analyses confirm that puberty influences within-subject neurodevelopment in a sex-dependent manner.

1-H-89 The relationship between socioeconomic variables and brain development

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Brain development is the output of many variables. Literature suggests that socioeconomic factors may affect healthy brain development. Further, evidence indicates that socioeconomic factors may interact with demographic variables, including genetic background. We investigated if cortical area differences could be observed across SES while controlling for genetic ancestry. Typical children were recruited as part of the PING initiative (http://pingstudy.ucsd.edu). Participants were screened for medical disorders. DNA was extracted from each participant's saliva sample. A standardized imaging protocol was performed. Relationships between regional cortical area, parental education and household income were explored, and we examined the association between total cortical area and SES. Positive associations were observed between socioeconomic variables and cortical area, bilaterally ($p=.000$; FDR $<.05$). Parental education was associated with more surface area in right parietal, temporal, supramarginal, orbito-frontal and lateral occipital cortex, and in left temporal and frontal regions. Bilateral differences were observed in the fusiform and anterior cingulate cortices. Household income was associated with more surface area for most cortical regions. Results were not explained by age, scanner device, gender, or genetic ancestry. Here, we show that SES differences SES may account for differences in cortical surface area. Likely mechanisms include differences in the childhood environment. Understanding these effects will aid in identifying more precise targets for intervention.

2-H-90 Human Superior Temporal Sulcus Subserves Both Concrete and Abstract Social Cognition in Typical Development

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Developmental studies of disorders that include social cognitive dysfunction, such as autism, fragile X syndrome and schizophrenia have identified deficits in a distributed network of cortical and subcortical pathways associated with *concrete* (e.g., explicit emotion processing), as well as *abstract* (e.g., processing of point light displays of people or moving geometric shapes symbolizing social interactions) social cognition. Although examining *concrete* aspects of social cognition is relevant for understanding how the brain mediates more complex social cognitive skills such as predicting other people's mental states and intentions and adapting accordingly during social interactions, a neural basis for the

relationship between *concrete* and *abstract* social cognitive abilities remains largely unknown. Here, we showed 18 typically developing children (ages 5-17 years) highly *concrete* (videos of pleasant and disgusting gustatory experiences) and *abstract* (moving geometric shapes symbolizing social interactions) social cues during functional magnetic resonance imaging (fMRI) and demonstrated that the degree of right posterior superior temporal sulcus (pSTS) response to *concrete* social cues strongly predicts an anatomically convergent pSTS and a distributed cortical and limbic response to *abstract* social cues. These results demonstrate a developmentally relevant convergent pSTS pathway involvement in normal social cognition and may guide future experimental diagnostic approaches in the search for clinically relevant biomarkers for a range of social cognitive dysfunctions.