Center for Neurodevelopmental and Imaging Research at Kennedy Krieger Institute

Research Update – 2022

Dear Families,

Thank you for taking an interest in the Center of Neurodevelopmental and Imaging Research (CNIR) at Kennedy Krieger Institute. I would like to especially say "thank you" to our families and research participants. Without them, we would be unable to collect pivotal data about neurodevelopmental disorders in order to improve the preliminary work for neurodevelopmental treatments and interventions. With their support, CNIR has been able to remain dedicated to understanding the behaviors and brain circuits that help advance diagnosis and treatment for children with attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), Tourette syndrome (TS), learning disabilities and other neurodevelopmental conditions.

The goal of our work is to better understand the mechanisms that underlie cognitive, emotional and motor challenges in order to improve academic support and clinical interventions. We use a combination of clinical assessments, behavioral measures, neuroimaging techniques and biospecimens to map and evaluate the complex relationship between genetic determination, neural development and environmental risk factors that lead to decreases in symptom severity and positive outcomes. Additionally, with the dedication of our participating families, we have been able to track an increasing number of children into adolescence and even adulthood, providing a crucial opportunity to better understand developmental trajectories contributing to age-related challenges.

Most recently, we expanded our research efforts to children with learning disabilities, such as dyslexia. In collaboration with our newest colleague, Dr. Tzipi Horowitz-Kraus, we are now pursuing studies that assess the effectiveness of an 8-week, web-based reading program and its effect on language development. With the support of community partners like Jemicy School, we have been able to pilot this reading program in a school setting with children diagnosed with ADHD, dyslexia, and speech and language disorders. Our goal is to identify which language processes (e.g., phonemic processing, fluency, comprehension) are negatively impacted in children with neurodevelopmental disorders, and create specialized reading programs to target impaired processes.

Currently, we host ten active research studies for children ages 6–17 years old and three active research studies for adults ages 18–45 years old. We continue to look for new participants, so please feel free to share this newsletter with your family and friends. Adults and children with ADHD, ASD, TS and/or dyslexia are encouraged to join.

We are excited to share our most recent projects and findings with you, as this progress would not be possible without our families and participants. We greatly appreciate all of their efforts and support in helping us better understand how we can apply science to improving the lives of children with neurodevelopmental differences.

Sincerely,

Stewart Mostofsky, MD

Director of the Center for Neurodevelopmental and Imaging Research

Batza Family Foundation Research Chair

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Kennedy Krieger Institute

CENTER FOR NEURODEVELOPMENTAL AND IMAGING RESEARCH

Autism Research

Imitation in Autistic Children

Imitation may be the sincerest form of flattery, but it is also a critical learning tool throughout the lifespan. Many practical skills, such as brushing our teeth, are picked up through observation. Social behaviors, like waving hello or nodding our heads, are also learned from those around us.

Studies show that ASD children tend to have a harder time with learning through imitation than their neurotypical peers. This difficulty could affect how these children acquire social and practical skills.

Here at CNIR, we are interested in investigating motor imitation in ASD children through fun dance movements. Using cutting-edge, motion-capture technology, our team, in collaboration with our colleagues at the Center for Imaging Science at The Johns Hopkins University, created and tested a Computerized Assessment of Motor Imitation (CAMI). This method automatically measures a child's ability to imitate the actions of a model on a computer screen.

In two recently published studies* we applied this technology and discovered that autistic children have a harder time accurately imitating these dance movements, and that we can predict an ASD diagnosis with up to 90% accuracy using our CAMI method. Further, we saw that poorer imitation was associated with more severe ASD symptoms among these children, so we can say that CAMI performance is predictive of ASD severity.

These are promising results that reveal the potential of this task to identify ASD-associated difficulties with motor imitation. We are currently enrolling ASD children and adults (as young as 6 years old and as old as 40 years), as well as children and adults without ASD. To further expand our understanding, we are developing different versions of the dance task, like one focusing on just the upper body and another designed specifically for children aged 3–5 years old. We are also in the process of looking at what parts of the brain might correlate with imitation performance. In the future, we hope that the CAMI method can be used as a tool to inform diagnosis of ASD.

*Automated and Scalable Computerized Assessment of Motor Imitation (CAMI) in children with Autism Spectrum Disorder using a single 2D camera: A pilot study

Computerized Assessment of Motor Imitation as a Scalable Method for Distinguishing Children With Autism

Atypical Processing of Dynamic Visual Information in ASD Children

The difficulties that children with autism spectrum disorder (ASD) have in imitating others' actions can have profound impact on their ability to learn new skills and engage in social interaction. That is why it is important to understand what contributes to imitation difficulties in autistic people, and then use that knowledge to guide the development of interventions to help individuals learn new skills.

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One promising explanation is that ASD children have difficulty perceiving and tracking rapidly changing visual stimuli—a skill that is important for imitating others. To figure out if this is the case, we developed a video game–like task that requires the children to squeeze a bar with their hand while tracking a target on a computer screen. The target is either stationary (static) or moving up and down the screen (dynamic). We found that while ASD children had no difficulty controlling their hand movements to maintain the static target, they had a lot of difficulty controlling the hand movements needed to track the dynamic target moving up and down the screen.

To follow up on this work, we are now examining whether slowing down the speed of visual feedback helps children improve their ability to track the moving target. The findings from this work can help inform new therapeutic approaches, specifically regarding whether slowing the speed of visual information may be an effective way to teach ASD children new skills, including learning through imitation. We look forward to updating you on these findings soon!

Now It's Your Turn: Social Imitation and Storytelling

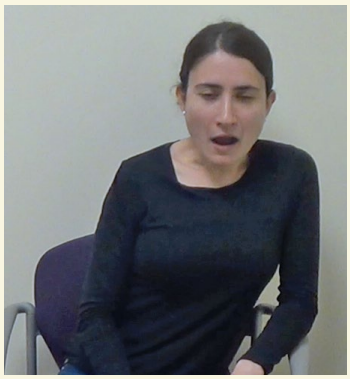
Most of us have the tendency to automatically copy or mirror other people's actions: we often yawn when we see someone else yawn, or want to scratch an itch when we see someone else itching. It is possible that this helps us socialize and communicate better with others.

We know that a primary characteristic of autism spectrum disorder (ASD) is a decreased ability to communicate effectively and engage socially with others. This may involve a decreased tendency to copy and imitate others. To explore this further, we investigated how children with and without ASD differ in their tendency to automatically mimic the gestures and movements of a social partner.

For this investigation, we collected data on more than 60 children with and without ASD. Each child watched a video of a narrator who told them an engaging 10-minute story while also doing things such as yawning, scratching an arm and gesturing for emphasis. Each child was then asked to repeat the story to the best of their memory. We examined whether each child, in retelling the story, was spontaneously imitating the actions and movements they had seen the narrator making. We also analyzed each child's version of the story, looking at, for example, how many details they remembered and how often they used first-person dialogue.

Our next steps include integrating these findings with data from behavioral studies, such as our study of dance imitation, and with neuroimaging data, including data showing differences in the mirror neuron system among study participants. These findings could broaden our understanding of social engagement and communication in children with and without ASD, and could help develop therapies that focus on improving social communication.

Please contact Natalie Alessi at **CNIR@KennedyKrieger.org** for more information on how to participate in one of our ASD studies.



Images to the right, from top to bottom: The actor is yawning. The actor is scratching her arm. The actor is explaining "zooming under the bed" with her hand gesture.

ADHD Research

Adolescent Outcomes for Girls and Boys With ADHD

Over the past seven years, we have invited adolescents ages 12–17, who participated in research at our center when they were 8–12 years old, to return and participate in follow-up studies with us. At the same time, we are also inviting adolescents who have not previously visited our center to participate in research. With this approach, we continue to make important discoveries building on our previously published work showing that girls and boys with attention-deficit/hyperactivity disorder (ADHD) show different developmental patterns of cognitive control compared to same-sex typically developing peers. Importantly, we found increasing impairments in cognitive control from childhood to adolescence among girls with ADHD relative to typically developing girls and boys with ADHD. More recently, we have submitted a manuscript being considered for publication showing that girls with ADHD show more persistent increases in emotional symptoms (e.g., irritability, anxiety and depression) from childhood through adolescence, compared to boys with ADHD.

In addition to these longitudinal findings, we have also collected sufficient data on adolescent clinical and functional outcomes that we have begun to examine childhood brain and behavioral predictors of adolescent clinical and functional outcomes. For example, we have shown that weaker cognitive control and heightened delay discounting (e.g., preference for smaller, immediate rewards over larger, delayed rewards) in childhood predicts greater substance use and anxiety and self-harm, respectively, in adolescents with ADHD. These findings were presented at an international conference earlier this year and will soon be submitted for publication. Information obtained from neuroimaging data, specifically diffusion weighted imaging, collected in childhood has also been shown to predict progression of ADHD symptoms from childhood to adolescence. Specifically, children with ADHD with better white matter integrity in the corticospinal tract show a greater improvement in ADHD symptoms of hyperactivity and impulsivity from childhood to adolescence.

Related to this project, Dr. Keri Shiels Rosch is completing a two-year grant from the National Institute of Mental Health (NIMH) for a project titled "Examination of developmental trajectories of cognitive, motor, and emotional control in relation to sex differences in psychopathology". In this project, Dr. Rosch has combined cross-sectional and longitudinal data from multiple studies conducted at Kennedy Krieger involving children with ADHD from preschool age through adolescence. She is examining how individual differences in motor, cognitive and emotional control—and in associated brain development—relate to sex differences in internalizing disorders, such as anxiety and depression, and externalizing disorders, such as ADHD, among a sample of children 4–17 years old. For this project, the research team at CNIR has been developing new methods for characterizing white matter integrity in neural circuity connecting frontal "control" regions and subcortical regions involved in reward and emotional responding, critical for self-regulation. These studies will help us continue to improve our understanding of the development course of ADHD from childhood through adolescence and beyond, including how these trajectories are different for girls and boys with ADHD.

Dr. Rosch is nearing the completion of the **Goldstein Innovation and Collaboration Grant**, a two-year internal grant from Kennedy Krieger, for her project titled "*Characterizing heterogeneity in decision-making in adolescents with ADHD: Considerations of effort, delay, and risk*". This project examines how, in adolescents with and without ADHD, different forms of decision-making—involving delayed reward, risk-taking and effort—impact behavior and mental health. This important work will allow us to better identify the specific challenges that children with ADHD struggle with, and better target interventions (medication and behavioral) that can address those specific challenges.

Understanding the Co-occurrence of ADHD and Obesity in Childhood

Drs. Rosch and Mostofsky, in collaboration with Dr. Susan Carnell, an associate professor in the Department of Psychiatry and Behavioral Sciences at Johns Hopkins University, are investigating the shared and distinct brain and behavioral basis for ADHD and obesity in childhood. We have collected height and weight data from children and adolescents enrolled in our studies at CNIR to examine associations between behavioral measures of cognitive control and delay discounting (e.g., preference for smaller, immediate rewards over larger, delayed rewards) and body weight, including comparisons of children with ADHD with and without overweight/obesity.

We recently submitted our findings for publication showing typically developing children without a diagnosis of ADHD who are classified as being overweight/obese show a similarly heightened level of preference for smaller, immediate rewards over larger, delayed rewards as children with ADHD, regardless of body weight. In contrast, body weight was not related to cognitive control more generally, suggesting that self-control in the context of reward may be similarly implicated in childhood ADHD and obesity.

We are currently examining structural brain data to determine whether school-age children with and without ADHD and overweight/obesity show similar differences in brain morphology in frontal cortical regions involved in control functions and subcortical regions involved in reward, motor and emotional responding. We are also preparing a proposal to obtain grant funding to continue to support this important work. Improving our understanding of the brain and behavioral processes that contribute to these prevalent and chronic physical and mental health conditions is important for guiding prevention and intervention efforts.

Motor and Behavioral Control in Children With ADHD

Children with ADHD are at a substantially increased risk for long-term difficulties into adulthood, in their schooling, jobs and relationships with other people. What is not well understood is how to best identify which children might actually be at risk. One promising approach could be to rely on assessment of motor coordination, which can provide highly reliable tools for pinpointing difficulties with controlling responses.

It has long been recognized that many children with ADHD show difficulties with controlling motor responses that parallel their difficulties with controlling behavioral responses. Recognizing this, over the past decade, we have worked on identifying highly reliable motor measures that could be used to help better guide ADHD diagnosis and treatment. Our efforts, which were most recently published in the journal *Neurology*, have led to the discovery of two brain-based measures that are abnormal in children with ADHD and, importantly predict the severity of ADHD behaviors.

Based on these promising findings, we received funding from the National Institutes of Health to take crucial steps to determine whether these two brain-based measures, performed with brief and safe transcranial magnetic stimulation (TMS), are reliable and meaningful enough to be used to help improve the precision of individually targeted and effective ADHD treatments. We are currently enrolling children 8–12 years old in this study, including children with or without ADHD.

Frustration Tolerance in Children With ADHD

One prominent impairment in children with attention-deficit/hyperactivity disorder (ADHD) is emotion dysregulation. Emotion regulation has been defined as an individual's ability to modify an emotional state so as to promote adaptive, goal-oriented behaviors. Prior research suggests that as many as half of children with ADHD demonstrate difficulties with dysregulated emotion. In the long term, emotion dysregulation in children with ADHD is associated with increased severity of core ADHD symptoms (e.g., inattention and hyperactivity/impulsivity), elevated rates of comorbid conditions (e.g., anxiety, depression, oppositional defiant behavior, etc.) and greater social impairment.

At CNIR, we are interested in better understanding the behavioral and neural basis of emotion dysregulation in children with ADHD. In particular, we have focused on two prominent types of emotion dysregulation: frustration and irritability. Our research uses behavioral tasks designed to elicit frustration both in and out of the MRI scanner, as well as questionnaires about children's regulation of emotions such as mood and irritability.

Recent findings from our research suggest the importance of sex differences in frustration and irritability in children with ADHD. Using a novel behavioral task developed at the CNIR, we have found that when frustration is added to a task, girls with ADHD show a significant decrease in their ability to inhibit responses compared to typically developing (TD) girls. In fact, for girls with ADHD, their response inhibition error rate increases by 120% when frustration is added to the task. These results indicate that frustration may not affect all participants equally, and may have implications for who is at the greatest risk for negative outcomes due to poor emotion regulation.

Additionally, our research has shown that across adolescence, girls with ADHD show a very different developmental trajectory of irritability than do boys with ADHD or their TD peers. Specifically, while early in development boys and girls with ADHD show modestly elevated levels of irritability, boys with ADHD show reduced levels of irritability as they progress through adolescence, while girls with ADHD show continued, if not increasing, levels of irritability as they progress through adolescence.

These findings highlight the importance of considering the impact of emotional regulation, particularly irritability and frustration tolerance, on children with ADHD. Next, we plan to continue to examine how emotional dysregulation impacts children with ADHD, both in the short term and in the long term. We also plan to examine how interventions could help children with ADHD better respond to frustrating situations.

Mindful Movement in Children With ADHD

In prior research conducted at CNIR, we found that an eight-week tai chi mindful movement intervention was associated with significant improvements in behavior, including in the inattentive and hyperactive/impulsive behaviors that are core to ADHD and oppositional defiant disorder (ODD). We also found that the tai chi intervention was associated with significant improvements in motor control and coordination. Finally, we found a significant association between these two findings: The children who showed the most substantial improvements in motor control also showed the most substantial improvements in ADHD behavior.

Prior research suggests that mindfulness and embodied practices such as yoga and tai chi cultivate sustained attention and the inhibition of distractions and task-irrelevant behaviors—factors that are definitional to the diagnosis of ADHD. Given this information and prior data, our center has collaborated with a local charter school in Baltimore City to further examine the beneficial effects of a mindful movement program. Students in second and third grade at City Neighbors Charter School have been completing a program that introduces them to the mindful movement practices of tai chi. Through the program, children can learn how to identify their emotions and are taught mindful skills that can help them to regulate their emotions and related motor control. The mindful movement training is focused on tai chi but also incorporates exercises from other embodied practices, such as yoga, walking and seated meditations.

The program is facilitated regularly twice a week with students at their school throughout the school year. In addition, students complete assessments at three separate points of time throughout the school year to examine their cognitive and motor control. Parent and teacher rating scales are also collected, to explore changes in observed behavioral control

across contexts. Our goal is to understand how these interventions can help students improve their abilities to focus and better regulate their emotions and behavior, something that is increasingly challenging for children, particularly since the onset of the COVID-19 pandemic.

Our findings from our last cohort that completed the program during the 2021–22 school year reveal participants exhibited improved bilateral motor control as measured by a motor assessment. In addition, students demonstrated improved performance, fewer total errors and a decrease in mean response time as measured by cognitive behavioral tests evaluating executive functions like attentional switching, response speed and response inhibition. Together, these results suggest that the program may be beneficial in enhancing cognitive and motor control.

We are currently building toward expanding the program to include a parent-child, at-home program. The expansion of the mindful movement intervention program to include parent mentors will allow us to assess the impact of the parental mentor involvement, and the benefit of overall community engagement. We plan in the future to also include a control condition to ensure that the positive impacts observed thus far are specific to the mindful movement program.

Please contact Jenny Fotang at **CNIR@KennedyKrieger.org** for more information on how to support this program.

ADHD and Autism Research

Sleep Disturbances in Autistic Children and Children With ADHD

Difficulty with sleep is a common experience for children, and can have detrimental effects on school performance, mental health and social functioning. Sleep disturbances are particularly prevalent among children with neurodevelopmental disorders such as ADHD and ASD. Despite accumulating evidence supporting the prevalence of sleep disturbances and their detrimental effects among children with neurodevelopmental disorders, there remains much that we do not yet understand.

We have begun to use wearable technology in the form of a simple wristband to get a more accurate, real-time measure of sleep quality and sleep-wake cycles in children. Using both parent ratings and state-of-the-art wearable wristbands to evaluate sleep, our goal is to better understand how sleep is affected in children with neurodevelopmental disorders and how it impacts their ability to function academically, behaviorally and socially.

We are also interested in better understanding the relationship between sleep disturbances and brain development in children with ADHD and autistic children. In a recent analysis, researchers at CNIR observed that anomalous connectivity in brain networks relevant to attention and self-reflection was associated with greater parent-reported sleep disturbance in autistic children. We plan to follow up on these findings using the more accurate wristbands to evaluate sleep quality in children.

We are currently enrolling children 8–12 years old with or without ADHD and ASD for brain imaging (MRI), with the goal of examining associations between measures of brain structure and function and measures of sleep quality, with measures assessing the core features associated with ADHD and ASD. We hope to gain insight into the nature of sleep quality in children with ADHD and ASD and how sleep is associated with brain development, as well as the impact of these relationships on behavior and academic functioning. Our work could lead to advances in the identification of sleep disturbances and sleep-based interventions, with the potential to reduce the negative impact of sleep disturbances on children's behavioral and social functioning.

Please contact Alyssa DeRonda or Natalie Alessi at **CNIR@KennedyKrieger.org** for more information on how to participate in one of our ADHD or ASD studies.

Tourette Syndrome Research

Sensory and Sensitivity in Individuals With Tourette Syndrome

It has long been recognized that people with Tourette syndrome (TS) often report that a sensory "urge," such as an itchy throat, contributes to the need to complete a tic, such as throat clearing. Relatedly, children with TS also may often experience more generalized difficulty ignoring faint, repetitive tactile stimuli. An example of this may be a child being bothered by a tag in their shirt or by seams in their socks.

Recognizing this, we initiated a study to evaluate and compare tactile sensitivity in children with TS to that of typically developing children, to determine whether impaired tactile sensitivity is associated with the severity of tics and sensory urges, and to look into brain mechanisms that contribute to impaired tactile sensitivity and sensory urges in TS.

So far, our findings reveal that, compared to typically developing children, children with TS do show increased tactile sensitivity, with reduced ability to adapt to tactile stimuli. Furthermore, among children with TS, both reduced adaptation and more severe sensory urges are associated with a greater number of tics.

To examine underlying brain mechanisms, we have employed both brain imaging (MRI) and brain stimulation (transcranial magnetic stimulation, or TMS) methods to examine the function of a key inhibitory brain signal called GABA (short for gamma-aminobutyric acid). Last year we reported that among children with TS, reduced GABA-based inhibition in the brain's supplementary motor area (SMA), which is important for selecting and guiding motor responses, is associated with both increased severity of TS symptoms (urges and tics) as well as a reduced ability to actively suppress (i.e., withhold) tics. Over the past year we have since discovered, using TMS, that reduced motor cortex correlates with greater tic severity.

We are currently enrolling children with and without TS, 8–17 years old, with the goal of using brain imaging and brain stimulation to confirm whether GABA-based inhibition is reduced in the brain's SMA of children with TS, and to better identify how this is associated with tic severity. The findings will provide a basis for helping children with TS reduce tics and sensory urges by targeting GABA and related brain signaling.

Please contact Beatrice Ojuri at **CNIR@KennedyKrieger.org** for more information on how to participate in one of our TS studies.

Reading Disabilities Research

Reading Fluency in Children With Dyslexia

Dyslexia is a neurodevelopmental learning disorder characterized by reading difficulties (RD), including slow and inaccurate reading that continues into adulthood. The neurological reasons for RD are yet to be discovered, although several differences in how the brain processes written materials have been suggested in previous studies. Individuals with RD may also experience deficits in other cognitive domains. For example, they may struggle with executive functions, an umbrella term used to categorize certain brain processes (e.g., attention, processing speed, working memory, inhibition, etc.) that monitor and optimize our performances when completing tasks. Prior research suggests that individuals with RD can improve their reading skills to some degree if an intervention is provided at an early age. Most reading interventions developed in the past focus on phonological processing and demonstrate an improvement in reading accuracy among individuals with RD. They do not, however, demonstrate much improvement in the reading fluency domain.

At the CNIR, we are enrolling children with and without RD in a research study to examine the effects of a computerized reading intervention program that is fluency-based. This program was developed by Dr. Horowitz-Kraus, a faculty member at the Technion – Israel Institute of Technology who is also a new faculty member at Kennedy Krieger Institute, to enhance children's reading fluency skills while building reading speed and developing executive functions. The program improves children's reading by controlling the presentation rate of letters in a sentence that a child reads on a screen. It also examines comprehension skills through questions about the content of the sentence following the removal of the sentence from the screen.

Prior preliminary data has revealed that this program increased reading fluency, reading accuracy and comprehension in children with RD across several age groups. Our study seeks to further examine the effects of this program on reading performance, including reading fluency. We are currently investigating how demonstrated changes in reading performance following completion of this training correlates to changes in the neural circuitry that supports reading and executive functions.

Our study also introduces an executive function "warm-up" prior to starting the reading training. For the warm-up, children complete a program that trains underlying factors of reading processes, such as working memory, inhibition, visual attention and processing speed. With the introduction of this warm-up combined with the reading program, we can assess alterations in neural circuitry supporting reading in the brain and compare it to alterations in circuitry demonstrated by the reading-only intervention group.

In addition, the CNIR has branched out into the community to collaborate with schools in the area that serve student populations with language and/or learning disabilities to provide a school-based intervention approach. Through our collaborations, schools have provided their students with the computerized reading program and incorporated it into their school curriculum so students can complete the intervention as part of their routine school schedule. Our school collaborations have also highlighted the high comorbidity rate of ADHD and dyslexia, which is estimated to be somewhere between 25–40%. Understanding the huge overlap between these two prevalent developmental disorders is key to elucidating their underpinning neural circuitry. Thus, we have recently expanded our study to include children with RD who also have an ADHD diagnosis. We plan to examine how the computerized reading intervention may be most beneficial for children with both ADHD and RD in enhancing their reading performance and executive functioning skills.

Opportunities for Participation in CNIR Studies

Interested in Participating?

CNIR is currently enrolling children and adults (ages 6 to 40) to participate in several of the studies. Research participants have the opportunity to complete an IQ assessment and an MRI scan, along with a variety of motor movement games and sensory tasks. Eligible participants will receive monetary compensation for their participation, an IQ report and a picture of their brain! There are minimal risks, such as boredom and fatigue, associated with participation. Please contact a study coordinator at **CNIR@KennedyKrieger.org** if you are interested in participating in our research studies. For additional information about our studies, please see our active studies below.

Autism Studies

Computerized Assessments of Motor Imitation (CAMI): Advancing the Validity, Scalability and Neurophysiology of a Promising Phenotypic Biomarker for Autism Spectrum Disorder

- To assess the ability of children with and without ASD to imitate social and motor movements and to train a novel diagnostic algorithm

Dysfunction of Sensory Inhibition of Autism

- To investigate the neurobehavioral basis of abnormal sensory processing in autistic children

High-Resolution Imaging of Cerebellum in Children With Autism and ADHD

- To gather high-resolution data on the cerebellum in order to determine function subsections responsible for executive function, motor production and social imitation

Measuring Altered Glutathione in Children With Autism Spectrum Disorder

- To investigate how levels of the antioxidant glutathione relate to the behaviors associated with ASD

Attention-Deficit Hyperactivity Disorder Studies

Adolescent Changes in Brain and Behavior in Boys and Girls With ADHD

- To learn more about the development of executive functioning, emotional symptoms and behavioral outcomes like substance use, risk taking and mood disorders in adolescents with and without ADHD

Anomalous Motor Systems Physiology in ADHD: Biomarker Validation and Modeling Domains of Functions

- To learn more about the effect of stimulant medication on the motor integration system in children with and without ADHD

Tourette Syndrome Study

Tactile Adaptation in Tourette Syndrome: Probing GABA-Mediated Neuroplasticity

- To assess the effect of a neurotransmitter, GABA, on the motor and sensory system in children with and without TS

Reading Disabilities Study

The Role of Executive Functions in Reading and Reading Remediation

- To investigate the effectiveness of a reading intervention on literacy and reading-related brain activity of children with reading difficulty compared to typical readers

Research Articles

If you are interested in reading more about our ADHD, ASD, TS and learning disabilities findings, please visit us at **https://bit.ly/3M5UybC** to browse through our extensive collection of lab-published articles.

Parent Partnership Program

We are excited to introduce our Parent Partnership Program, a community-based program that enlists the support of families to spread the word about research opportunities at CNIR. For each referral, you will be emailed a $10 Amazon gift card. If you are interested and would like more information, please email Kaala Harrilal at **CNIR@KennedyKrieger.org**. If you would like to enroll, please sign up at **https://bit.ly/3yktzTX**.

Interested in Supporting Our Work?

All the research listed in this newsletter is funded in part by support from donors and friends of CNIR. If you would like to learn how you can help support our work, please visit us online at **KennedyKrieger.org/CNIRFund** or contact Jen Doyle in the Office of Philanthropy at **DoyleJ@KennedyKrieger.org** or **443-923-4324**.

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