Neuroimaging in Child Clinical Populations: Considerations for a Successful Research Program

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As a growing body of translational research continues to cut across the boundaries of traditional disciplines in all domains of scientific study, the field of child psychiatry has become increasingly collaborative in its goal of understanding the etiology of child psychopathology and developing treatment strategies. One notable area of increasing collaboration is in the field of neuroscience, where magnetic resonance imaging (MRI) is used to probe the neural structure or function underlying psychological deficits. In 2011 alone, 13 of the 121 articles (11%) published in the *Journal* used MRI to examine the impairment of a specific neural circuitry, representing approximately one article per monthly issue. In comparison, just one neuroimaging article (1%) was published in 2006. One can assume that that number will increase in the years ahead. Advances in this state-of-the-art technology show potential for the discovery of biomarkers specific to symptom presentation, which can inform the development of therapeutic or pharmacologic interventions or, possibly, identify those at risk for the maturation of future disorders. Taking a single example from the field of autism research, functional MRI has helped to identify dysfunction in neural circuitry related to deficits in eye contact.[1] Similar findings have been uncovered in siblings of patients with autism who are at genetic risk for the disorder.[2] The sum of this growing body of literature has led researchers to conclude that therapeutic interventions, aimed at this impairment, might improve social behavior through altered neural functioning.[3]

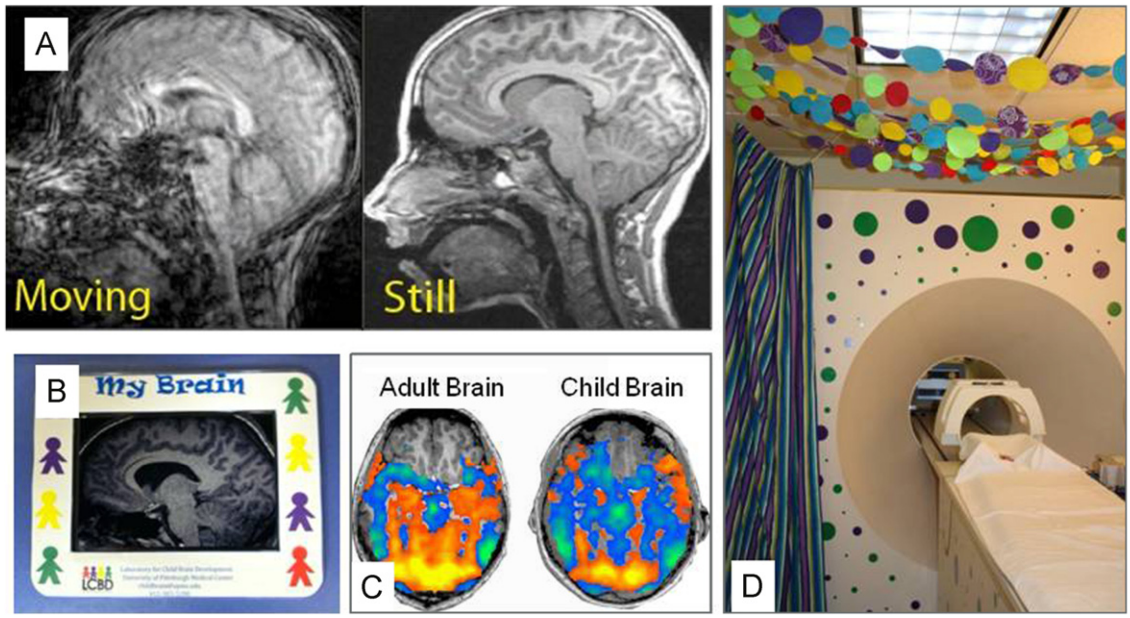
The synergy between the neuroscientific and psychiatric disciplines is of great benefit to the field. However, successful neuroimaging in pediatric populations is not without its challenges. MRI is a constricting, isolating, and often intimidating environment for children and the need to remain motionless for an extended period often leads to data loss. One could argue that an 80% success rate, considered highly successful in a pediatric patient group, indicates that the most impaired children are not providing useful data. Thus, low success rates in data collection come not only at a high financial cost, but also may dilute the effect sizes in scientific findings or fail to uncover the neural circuitry that may be deficient in only the most severe cases. The following paragraphs present brief considerations aimed at delineating strategies for successful neuroimaging in pediatric clinical populations for those who wish to begin a program of developmental neuroimaging or to improve success rates in their current work.

CONSIDERATIONS FOR IMPROVING THE SCANNING ENVIRONMENT

An educational approach to data collection in young subjects can greatly improve the quality of imaging data. Children who view study participation as an opportunity to learn about the brain and "do a science project" will become personally invested in the outcome of the study and, thus, motivated to remain attentive and motionless during scanning. Beginning with the initial contact with the subjects, it is important to provide opportunities for learning that are appropriate to these subjects (Figure 1C). In addition, consider the added benefit of exposing children to a university setting, scientific research, and an elementary lesson in neuroscience.

A library of basic materials can be prepared and presented to subjects before their session and throughout their participation. For children with access to a computer, a website, including pictures of the scanning process, facts about the brain, or even simple games involving brain regions, can help prepare the child to feel more comfortable

FIGURE 1 (A) An illustration of an image of head movement can help children understand the need to remain still during magnetic resonance image scanning. (B) A framed picture of a pediatric subject's own brain can serve as the motivation to remain motionless. (C) Presenting children with educational information encourages interest in the study outcome. (D) Child-friendly decor helps children feel at ease in a clinical environment.



about research participation. A simple page of instructions for practicing lying motionless, including games such as "freeze tag," can make the preparation fun. Instructions on what to wear for testing and directions to an easily located access point where subjects will meet study staff should also be included. A short video can be produced and included on a website or sent home on a disk. This video should introduce some basic facts about brain imaging, show the scanner facilities, include methods for practicing stillness during scanning, and even follow a young child actor through the scanning procedures. Most importantly, children should be told that if they are able to remain motionless and participate to the point at which an image can be acquired, they will receive a picture of their brain (Figure 1B). Consider collecting structural sequences before functional sequences so that children who end participation during functional scanning can still receive a brain picture. This serves to provide children with a visual goal of a clear brain picture (they can be shown a "blurry" brain picture to illustrate the effects of movement [Figure 1A] and to add to the educational objectives outlined earlier). Note that researchers should receive guidance from their institutional review board regarding the relevant procedures for providing brain pictures to subjects.

The decor of the imaging center or hospital should be taken into account. Family-friendly decoration, which should be bright, colorful, and even themed (e.g., a submarine or a spaceship), can make the youngest of child participants feel at ease (Figure 1D). Consider that many children will associate medical settings with visits to the doctor, which may include memories of immunizations or other painful procedures. This, combined with minimal exposure to fear-provoking hospital wards and/or medical equipment, will help children feel more comfortable with the scanning procedures. All lights should be turned on in the scanning room and the laboratory personnel should be encouraged to dress casually and in bright colors. It should be made clear to the children during the consent process that all participation is voluntary and that "no one will be angry with them" if they choose to stop at any time.

CONSIDERATIONS FOR THE MINIMIZATION OF MOVEMENT

Participant movement is the single largest contributor to data loss in pediatric neuroimaging studies. However, ample preparation through scanning simulation can greatly improve the rates of success. A mock scanning facility, including a head coil, projection screen, and scanner sounds, should be built to acclimate young children to the scanning environment. A head-tracking device can train children to remain still by beeping or pausing a video when a movement occurs. Children should always practice the testing paradigms in which they will participate inside the mock scanner. The simulation protocol should be flexible and modified based on the needs of each clinical population. For example, children with anxiety disorders may be apprehensive of the large equipment and, thus, might need extra time to acclimate to the mock scanner. Children with attention-deficit/hyperactivity disorder may find remaining still a challenge and might need extra practice controlling their head movements. Consider adding additional games where they are given visual feedback of their movement (e.g., keep their head at the bull's eye of a target). Children with autism may be very excited by the technology but sensitive to the noise. An explanation of how the scanner works and a tour of the control room can motivate this population.

During MRI scanning, it is important to use additional strategies for the minimization of movement. Children should wear ear plugs or noise-minimizing headphones and have sufficient padding around their heads to keep them comfortable and still. Surgical tape (adhesive away from the skin) across the forehead and under the chin can provide sensory feedback when the child is moving. The child should be given a blanket to stay warm in the chilly scan room and be allowed to wear their own non-metallic clothing (pajamas) rather than a hospital gown. Most importantly, a study staff member should accompany the child into the scan room and stand by the child's side. This person reminds the child that his/her movement is being monitored. The staff member can gently tap the child's foot if movement is observed or alert the staff in the control room to remind the child to remain still through the microphone.

A final method for the minimization of movement comes at the analysis stage. Because of the lengthy debate in the field over the best practices for minimizing movement,[4] a thorough discussion of these techniques is considered outside the scope of this piece.

CONSIDERATIONS FOR OPTIMIZATION OF DATA COLLECTION

The more enjoyable the experience for the child, the less likely the child is to move excessively. Boredom in the scanner will likely result in fidgeting movements, face scratching, and trips to the bathroom. Consider making functional tasks child-friendly by including colorful graphics and sound effects and using a graspable/child-sized response device. For example, a simple go/no-go task can be made more engaging to children by substituting standard letters and numbers with popular cartoon characters.[5] Children can watch a favorite video during structural imaging. Also consider keeping the duration inside the magnet to a minimum (30 minutes in preschool and elementary-school children). A staff member can speak to the subject, by microphone, between tasks with enthusiastic words of encouragement.

With these considerations in mind, it is always best to ensure that all children end the study participation on a positive note. Regardless of whether successful data collection was accomplished, children as young as 4 years old, and their families, will surely value this exciting learning experience. &

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