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MAGNUS 3.0T advances neuroscience discovery at Waisman Center

Advancing knowledge of human development, developmental disabilities and neurodegenerative diseases is the core mission of the Waisman Center at the University of Wisconsin, Madison. The University has a deep history in this area of research, beginning as one of the first two sites selected by the National Institute of Child Health and Human Development in 1965 for construction of a multidisciplinary center devoted to the study of human development and intellectual and developmental disorders. Recently, the University of Wisconsin School of Medicine and Public Health was awarded a $150 million grant from the National Institutes of Health (NIH) to examine the neurobiology of Alzheimer's disease and related dementia and establish a standardized brain imaging and blood plasma test protocol to analyze levels and types of amyloid and tau proteins.

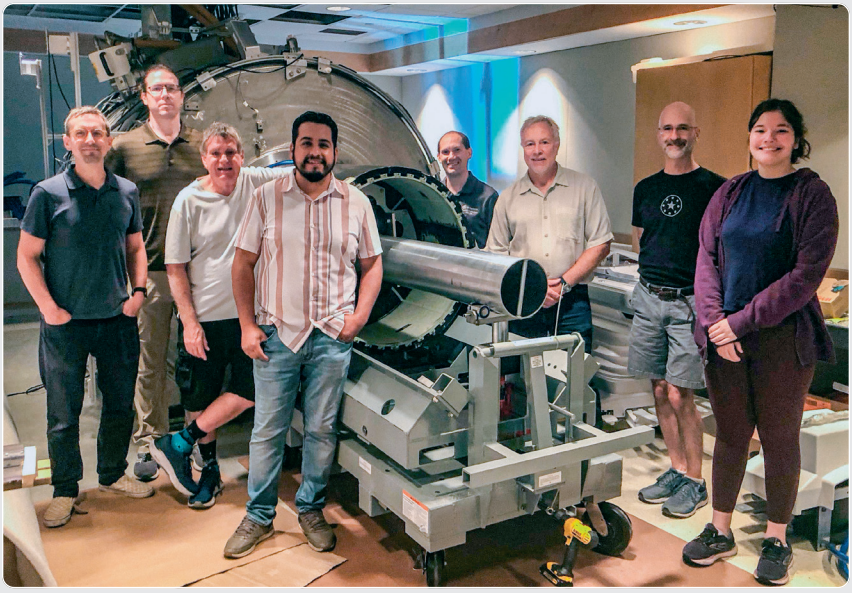

Figure 1. Waisman Center, Brain Imaging Core team. From left to right: Michael Anderle, Steve Kecskemeti, Greg Kirk, Jose Guerrero-Gonzalez, Justin Ricci, Andy Alexander, Ron Fisher, Lisette LeMerise.

Named for Harry A. Waisman, MD, PhD, a biochemist, pediatrician and pioneer in intellectual and developmental disabilities research, the multidisciplinary research center employs nearly 700 people. Within the Waisman Center is the Brain Imaging Core, which supports behavioral and biological research at the Waisman Center, often encompassing up to 40 different projects at any given time. According to Michael Anderle, manager of the Brain Imaging Core, these research projects include early brain development, cerebral palsy, autism, Fragile X syndrome, Down syndrome and more. As a core campus resource, the Brain Imaging Core supports investigators across campus, including

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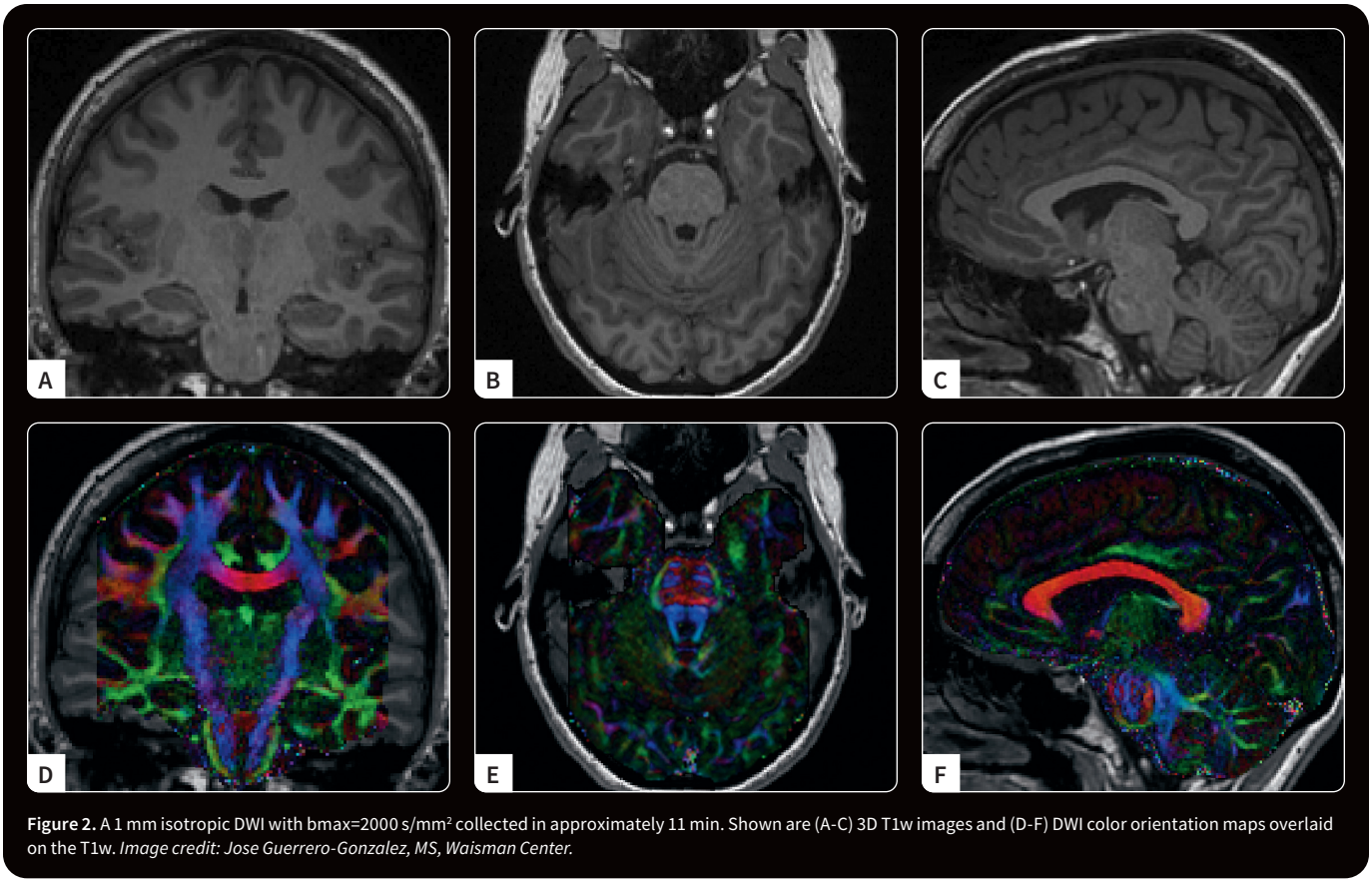

Figure 2. A 1 mm isotropic DWI with bmax=2000 s/mm^2 collected in approximately 11 min. Shown are (A-C) 3D T1w images and (D-F) DWI color orientation maps overlaid on the T1w. *Image credit: Jose Guerrero-Gonzalez, MS, Waisman Center.*

those from the departments of psychology, psychiatry, pediatrics, medical physics, kinesiology and journalism, as well as the UW-Madison's Alzheimer's Disease Research Centers.

The Brain Imaging Core within the Waisman Center is the latest site to acquire GE HealthCare's investigational MAGNUS[‡], an ultra-high performance 3.0T head-only MR system with peak gradient amplitude of 300mT/m and maximum gradient slew rate of 750 T/m/s. MAGNUS was designed to improve diffusion imaging at high b-values without incurring SNR loss or the constraints of peripheral nerve stimulation. The MAGNUS gradient system delivers greater efficiency, resulting in higher maximum gradient amplitude and slew rate for shorter TEs, delivering increased SNR and decreased distortion.

In January 2023, Andrew Alexander, PhD, professor of medical physics and psychiatry, and Steve Kecskemeti, PhD, scientist, were part of a team of Waisman Center researchers who were awarded a $2.5 million grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development at the NIH. The grant is to improve brain imaging techniques for infants and build a quantitative atlas of typical early brain development.

"This is one area where we think MAGNUS will be beneficial for faster, quieter scanning of the infants during sleep and without sedation," says Dr. Kecskemeti.

With high SNR and reduced distortion, Dr. Alexander anticipates MAGNUS will be helpful in another study that is focused on mapping out different structures within the brainstem, specifically the microstructure of the fine white matter tracks and gray matter nuclei using diffusion.

"Because the MAGNUS gradients are both faster and stronger, it helps reduce the amount of distortion that we get in the brainstem, which is typically a big problem. With the high spatial resolution provided by MAGNUS, we can better resolve these finer structures and that will hopefully provide better specificity of our microstructural measurements."

Dr. Andrew Alexander

In the Alzheimer's disease research at UW-Madison, Dr. Kecskemeti and Dr. Alexander have developed a brainstem DTI protocol with MAGNUS that is acquiring 1 mm isotropic imaging data at b-values up to 2,000 s/mm^2. They have also pushed multi-shell diffusion beyond

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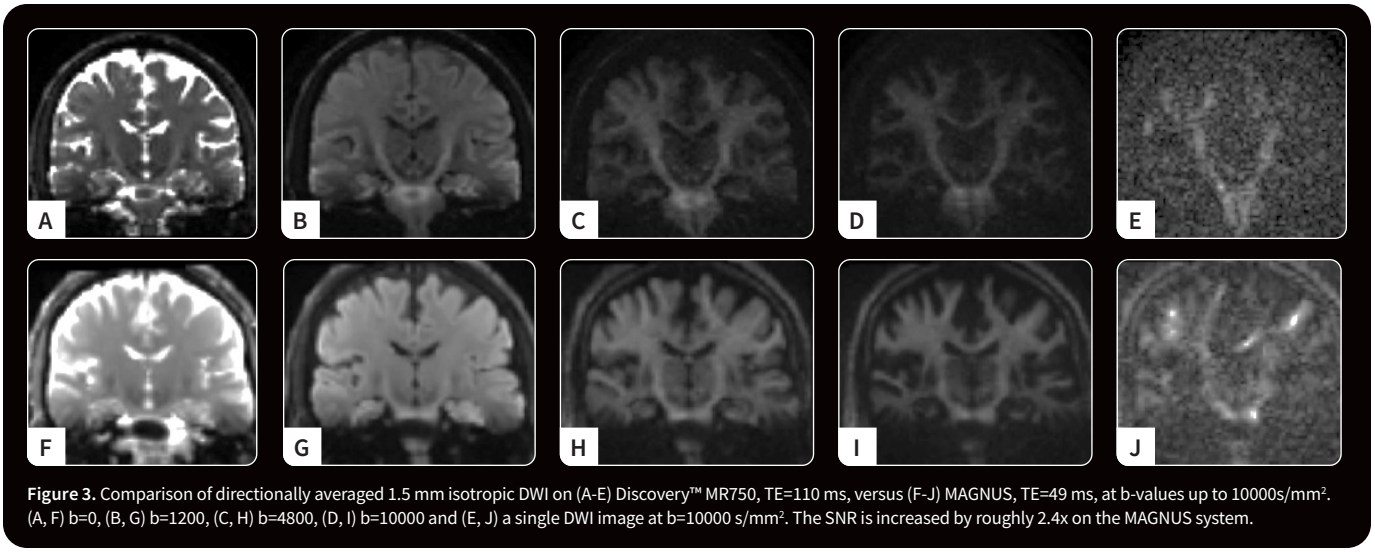

Figure 3. Comparison of directionally averaged 1.5 mm isotropic DWI on (A-E) Discovery™ MR750, TE=110 ms, versus (F-J) MAGNUS, TE=49 ms, at b-values up to 10000s/mm^2. (A, F) b=0, (B, G) b=1200, (C, H) b=4800, (D, I) b=10000 and (E, J) a single DWI image at b=10000 s/mm^2. The SNR is increased by roughly 2.4x on the MAGNUS system.

what was previously attainable with 2.5 mm isotropic, maximum b-value = 10800 s/mm^2 and SNR ~2.4x higher than the Discovery™ MR750 3.0T.

"With higher performance diffusion imaging, we'll have data that is more sensitive to smaller microstructural features in the tissue and more restricted diffusion components," adds Dr. Alexander. "That is an exciting area of research where MAGNUS is really well designed to enable these discoveries."

Adds Dr. Kecskemeti, "…and, because the TRs were so much shorter, which reduced the scan time, we could add an entire extra shell of higher b-values without having to drop a different scan in that study." He says it's like getting to add the additional higher b-values "for free."

"The speed at which we can collect the data is going to revolutionize both the acquisition speed and image quality," Dr. Alexander continues. He explains that in certain sequences such as Cartesian-based EPI or spiral imaging, the readout times are much shorter, leading to less distortion or image blurring. In fMRI, he anticipates the team will collect twice as many echoes in roughly the same amount of scanning time using MAGNUS compared to the prior whole-body scanner. This multi-echo fMRI should result in reduced sensitivity to participant motion that can then provide more specific measurements of functional activation and functional connectivity.

Acquisition speed also impacts the quantity and type of information that can be obtained in one hour of scanning time for research subjects. Dr. Kecskemeti explains that on average, using the optimized MAGNUS gradient parameters currently reduces a one-hour protocol by approximately 20%. So, researchers can now use that time to add an additional sequence that they previously didn't have time to include. Dr. Alexander notes this time could also be used to combine different yet complementary types of imaging data in one study, such as adding the 1 mm isotropic diffusion imaging acquisition.

The fast scan times can also help with the reliability of the data by reducing motion artifacts or distortions, particularly when imaging patients who have difficultly remaining still for the scan, such as pediatric participants or those with intellectual disabilities.

Subjects who have been scanned on a conventional 3.0T and MAGNUS seem to prefer the latter, adds Anderle. "Participants in some of our longitudinal studies have mentioned to our techs they prefer MAGNUS because there is more space around the shoulder and the scanning time is shorter."

Even though the Brain Imaging Core team is focused on research, they can appreciate the need for an FDA-cleared, head-only MR scanner for clinical use,[‡] particularly for sites that perform both research and clinical imaging studies. Dr. Alexander reports that both the T1-weighted and T2-weighted sequences – commonly used clinical structural imaging sequences – are faster with higher image quality and improved spatial resolution. This capability could benefit neuroradiologists and neurologists who are focused on neurodegenerative diseases such as multiple sclerosis, Alzheimer's disease and more.

"MAGNUS is a very solid imaging platform that allows us to acquire the highest quality imaging of the head and brain that we have been able to achieve to date," says Dr. Alexander. "Hats off to the GE HealthCare GRC/HTIC team for designing a system with these imaging capabilities that does not take a large amount of power to operate."

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