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Seeing Isn't Always Believing: The Realities of Imaging Technology and Neuroscience

On July 23rd, the Potomac Institute for Policy Studies hosted a seminar to address the various ways in which neuroimaging technology has advanced, and how these new developments can be used to achieve the goals of the BRAIN Initiative. Dr. Marvin Chun of Yale University spoke about the progression of neuroimaging in the last 25 years. He primarily uses fMRI (functional Magnetic Resonance Imaging) to build the capacity to predict attention-related behavior. Imaging research has encountered three phases: mapping (1990s), decoding (2000s), and predicting (present). Mapping provides an overview of the structures and functions of different parts of the brain. Decoding combines math and neuroscience to create computational models that can be used to visually recreate what people are thinking. Prediction is then the ability to analyze and quantify individual differences in behavior. Dr. Chun emphasized that using brain imaging for prediction is now feasible and could have huge implications, introducing the capability to diagnose disease and predict characteristics like intelligence, attention, academic aptitude, etc. In addition, Dr. Chun identified imaging as a way to detect brain activity in patients suffering from a persistent vegetative state. While these people have normal sleep-wake cycles, there is no physical indication that higher mental function is occurring. Using fMRI, scientists can now detect brain activity by asking these patients to think of specific actions; the fMRI has been shown to pick up this activity, proving that higher brain function is occurring. While this is rare, it can play an important factor in making decisions about the fate of such questions, though it also raises ethical concerns. This application of fMRI indicates its potential to serve as a diagnostic tool for neurological diseases. Currently, the BRAIN Initiative places a lot of emphasis on mapping; Dr. Chun stated that while mapping is an important part of understanding the brain, it is not enough. Focus on decoding and prediction is imperative to ensure that neuroimaging capabilities can be applied to the population.

Dr. Vaska discussed new approaches in multi-dimensional neuroimaging, detailing both the benefits of combining temporal and spatial imaging techniques, but emphasizing the extreme difficulty and financial cost associated with such projects. By combining structural imaging techniques, such as CT or MRI, with functional techniques such as PET, fMRI, SPECT, and EEG, researchers can measure multiple functions at once, and achieve a greater understanding of the biology behind human behavior. Much of Dr. Vaska's work revolves around Positron Emission Tomography (PET) scans, which he described as non-invasive, translatable from animal to human subjects, and quantitative, meaning that they can acquire physiological parameters such as metabolic rate, or receptor availability. Using PET, researchers can target numerous neurotransmitter systems via the injection of radiotracers. Dr Vaska stated that the scarcity of combinatory imaging techniques results from technological difficulties, in that current imaging technologies are severely limited. Dr. Vaska explained these limitations, saying that present techniques offer poor resolution, are inconvenient for subjects (who must remain absolutely still in the claustrophobic scanners), and limit the types of stimuli that can be presented. According to Dr. Vaska, animal subjects are even worse because their brains are smaller, and it is difficult to control them in the scanner. Therefore, the majority of animal imaging studies can only be accomplished on anesthetized subjects. Dr. Vaska has worked with a combination of PET and CT imaging techniques to achieve both spatial and temporal resolution amongst his subjects. He focuses on associating physical brain characteristics with behavioral, and his attempts at such behavioral neuroimaging led to a novel technology called the RatCap. RatCap is a brain scanner that attaches to the rat's head, removing the need for anesthetization, and allowing for functional images to be related to behavioral changes. The project took a total of 10 years to develop, and required an extreme re-working of existing imaging techniques. In the future, Dr. Vaska hopes to bring such wearable brain scanners to human subjects, which would allow researchers to examine spontaneous behavioral event such as concussions, or other traumatic brain injuries. Dr. Vaska anticipates future technologies that will eventually permit the combination of all current imaging techniques.

Following the speakers' remarks, the panel discussed how to identify when imaging technologies are ready for application, the accuracy and precision of current imaging technologies, and the need for more funding to allow current research projects to reach their full potential.