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December 27, 2004

Biocomplexity Faculty Search Committee,
c/o Prof. Rob de Ruyter van Steveninck,
Department of Physics,
Indiana University,
Swain Hall West 117,
Bloomington IN, 47405-7105

Dear Committee Members,

I am immensely pleased to have this opportunity to serve as a referee for Dr. Jingzhi Liu in his application for your biocomplexity faculty position. I base this enthusiastic recommendation on his extraordinary ability in science and his outstanding achievements in his field of expertise, which includes fMRI and EEG research on human brain function, biomedical imaging, and the biophysics of the human neuromuscular system.

First, to tell you something about me, I am presently Institute Professor at Case Western Reserve University, and on its physics faculty since 1970, following an MIT Ph.D. I have had visiting appointments at Brookhaven, SUNY at Stony Brook, Fermilab, and Washington University at St. Louis, with membership in the APS (and FIAP) and the Society of Magnetic Resonance. I am an APS Fellow and I have just recently been given the national 2004 AAPT Undergraduate Teaching Award. My applied research has been funded by industry for 20 years, providing industrial apprenticeships, educating industrial physicists (including 8 out of 15 Ph.D.s under my advisory), with more than 60 patents held variously by my former students. The principal areas are MR imaging, EM coil and antenna design, nonlinear dynamics, and electrical sensors. My basic research and student mentorship have also been supported by the NSF and NIH, and led to REU awards for 26 undergraduates, and 12 NSF graduate fellowships. Overall, I have more than 150 papers and abstracts, and I recently co-authored a 900-page imaging textbook as an outgrowth of two decades of industrial MRI work. I have taught 27 different courses, and received a DOE award for educational achievement in 1997. The electronic environment existing in my classes since 1988 has been described in Sheila Tobias' book on new teaching programs, and in periodicals such as *The Chronicle of Higher Education*, and has led to lectures in national and international venues, such as APS conference presentations and a National Inventors Hall of Fame keynote address.

In this letter, I confirm that Dr. Liu is already a recognized expert in the physics of magnetic resonance imaging (MRI) and electroencephalography (EEG) technology and is an outstanding researcher in the design, development and improvement of functional imaging within these technologies and their applications in studying the human brain. The evidence of Dr. Liu's level of skill and achievement is extensive. Dr. Liu has played a critical and

pivotal role in our research programs, which focus on (f)MRI and EEG. He has provided a crucial leadership and liaison between our university research program and the renowned Cleveland Clinic Foundation. During the past eight years, Dr. Liu made original discoveries and contributions of major significance in his field of expertise. He has created new techniques for the study of neural control of muscles and implemented them, he has initiated new ways to study the nervous system with MRI and EEG, and he has published, or is in the process of publishing, more than 70 papers and abstracts in the leading journals of his field as well as at national or international conferences. His publication record together with numerous conference/seminar presentations is excellent for a person this early in his career.

Dr. Liu has designed and developed a new technique for simultaneously recording the fMRI-measured brain activation, hand joint force, and muscle surface electromyography (EMG). This is the first system in the history of this field that had been built with the capability of measuring all three quantities important for correlating the activities of the central nervous system and the peripheral body. It has played a key role in the research on human brain function that has been performed by Dr. Liu and his collaborating investigators. For example, using this technique, Dr. Liu and his colleagues quantified the reproducibility of fMRI data during precisely controlled motor tasks, which is an important question to answer before accurately interpreting any motor control data. This important technique has also been recognized by other scientists in the field of motor control and been reproduced for their studies.

The field of neural control is important for both understanding the basic aspects of brain function and designing new methods of diagnosis and treatment. In this exciting area, Dr. Liu has made significant achievements using his knowledge in fMRI and EEG. An important problem in this field is the human brain function during muscle fatigue. How the brain modulates its activity during the process of muscle fatigue is not well understood. With the data-acquisition technique I just mentioned, this long sought after issue was investigated by Dr. Liu in collaboration with the other researchers in the collaborating research group involving the Cleveland Clinic and Case Western Reserve University. The knowledge acquired from this study is extremely useful for understanding the role of the brain in the control over fatiguing muscles and it may have important clinical applications such as diagnosis and treatment of fatigue-related diseases.

Another important basic problem in neural control is how the brain activities relate to the muscle activation levels. Dr. Liu and other investigators determined the relationships between fMRI/EEG-measured brain activation and muscle force/EMG. The relationships are critical in interpreting the acquired data and understanding the brain control mechanisms. Before this work, there were only very limited data available to indicate such relationships. With these fundamental relationships available, more advanced investigation of the neural control mechanisms and quantification of the brain functional activity is possible.

Dr. Liu has an excellent ability in applying his extensive knowledge in physics, mathematics and engineering to biomedical research. For example, Dr. Liu's development of a dynamical model on muscle activation, fatigue, and recovery is a striking achievement. This model establishes a theoretical framework to explain and describe the mechanisms of how muscles

get activated, fatigued, and recovered. It also creates possibilities of applications in clinic and engineering fields. The parameters introduced by this model can serve as good indicators of the physical state of different people with different conditions. This would be extremely useful for quantitative diagnosis of certain diseases related to muscle, especially symptoms of fatigue. More recently, Dr. Liu applied the fractal concept to his investigation of brain structure. Based on observation of the similarity between human white matter structure and tree-like fractals, he developed a way to quantify the fractal dimension of the cerebellum white matter. This direction of research has potential applications in quantitatively characterizing dynamical progresses in neural development, aging, diseases as well as evolution. Dr. Liu is also probing other nonlinear characteristics residing in neural activities, such as chaos in the EEG signals, which may have even more power to capture brain dynamics. More fundamentally, Dr. Liu has a lot of very interesting and exciting ideas; any one of them may have huge impact on our view of the world and life. He thinks very deeply and I have been greatly impressed by his keen insight in identifying important problems and proposing possible solutions.

In recognition of Dr. Liu's significant research contributions, he is frequently invited to make presentations and showcases at important international conferences in different countries, including most important academic conferences in the United States. These national and international conferences are the most influential conferences in the field of fMRI/MRI, EEG, biomedical imaging, and neurosciences.

Dr. Liu's outstanding educational background and his exceptional prior working experience certainly play a significant role in his success. In 1996-1997, Jingzhi worked as a research assistant in the collaborating research program involving the Physics Department, Case Western Reserve University and Philips Medical Systems, Inc. (formerly Picker International, Inc.), which is a world leader in MRI, MEG and other medical techniques. Since 1997, Dr. Liu has been working in the collaborating research program involving the Physics Department, Case Western Reserve University and the Biomedical Engineering Department, Cleveland Clinic Foundation, first as a research assistant, then as a research engineer. Cleveland Clinic is a national leading medical facility and its Biomedical Engineering Department is the largest hospital-based BME departments in this country. His work in this program had been so successful that he received an offer to join the Project Staff (equivalent to a research assistant professor) directly at the Cleveland Clinic Foundation even before officially getting his Ph.D. degree. Meanwhile he also holds an adjunct appointment as assistant professor in the Physics Department, Case Western Reserve University. This is a noteworthy achievement for a young researcher at this early stage in his career.

Finally, I must state something however obvious it may be to you. We need only survey a couple of days of newspapers, magazines, television news, or other media to see further evidence of just how important a role that functional MRI is playing in neuroscience today. Every time I read an article that announces a new discovery about what part of our brain is involved in some motor or cognitive skill, or about how the brain changes as we mature, or about how some new medical procedure has been developed based on online imaging guidance, I know fMRI is behind it. Studies of tumors, strokes, autism, alcoholism, language, learning, maturing, dyslexia, epilepsy, etc. etc. have been revolutionized. Dr. Jingzhi Liu is perfectly poised to bring this excitement with him wherever he goes, not even to mention his combined strength with the EEG modality. I believe that a person like

Jingzhi who has in-depth expertise in both the technical and the application aspects is extremely desired in the highly competitive intelligence market at this time as well as in the foreseeable future.

If I have not conveyed to you the description of a person who will provide leadership in functional MRI, EEG, biomedical imaging, biophysical study of human brain function, and even more exciting and fundamental directions, I have failed in doing what is right and needed. Dr. Liu has the rare skills and experience necessary for the advancement of science and engineering in these fields. I would like to give you the strongest recommendation I can in the hopes that you will give serious consideration of his candidacy. If you have additional questions about this matter, please feel absolutely free to contact me further.

Sincerely,

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