Using EEG to Study Alzheimer's Disease and Aging

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Alzheimer's is one of the most feared diseases of later life. The early and middle stages of the disease are associated with progressive declines in memory and other basic cognitive functions. These cognitive declines are accompanied in some cases by difficulties with language function, disturbing changes in personality, and by newly developed inappropriate behaviors. Later stages of the disease are characterized by the inability to perform normal activities of daily living, inability to recognize family members, profound losses of memory for one's personal history, and eventually, by progression to a vegetative state (Cohler, Groves, Borden, & Lazarus, 1990).

The onset and worsening of symptoms represent a dramatic challenge to the coping abilities of both the person with the disease and to family members who take responsibility for their care. For example, the stress-related effects of providing care for a person with Alzheimer's disease have been well-documented. Caregivers are at significantly greater risk of developing hypertension, ulcers, and migraine headaches (George & Gwyther, 1986) and the weakened immune function of caregivers puts them at increased risk for flues and other communicable diseases (Kiecolt-Glaser, Dura, Speicher, Trask, & Glaser, 1991). Descriptions of the devastating effects of Alzheimer's disease takes on added significance when placed alongside the fact that Alzheimer's disease affects approximately 4 million adults in the United States.

Although current Alzheimer's research is focused mainly on biomedical questions regarding genetic and neurochemical links to the disease, psychology has an important role to play in a number of areas. Clinicians will increasingly be asked to work with caregivers who are experiencing a constellation of presenting symptoms and issues that include severe depression, physical markers of stress, and the need to work through the complicated issue of grieving for a family member they're losing a little bit at a time. Experimental psychologists will also be asked to make significant contributions to the study of Alzheimer's disease. For example, development of a new generation of cognitive tasks will help to more clearly define aspects of cognitive function that discriminate between Alzheimer's and other causes of dementia such as Pick's disease and Huntington's disease. Research on perceptual changes in Alzheimer's will help in the design of better living environments.

Our lab in the Center for Brain Research and Informational Sciences at Radford University has begun a study attempting to identify patterns of EEG activity that yield a more accurate and earlier diagnosis of Alzheimer's disease. In collaboration with faculty members Karl Pribram and Jeffrey Chase and graduate students Derk Replogle, Sean Kelly, Chris Minter, Todd Watson, Jane York, and Christin Daniels, we are particularly interested in differentiating between early-stage dementia and depression.

Distinguishing between dementia and depression can present a difficult problem for mental health professionals. Persons with Alzheimer's disease often report feelings of depression and depression-related symptoms, such as changes in sleep patterns. On the other hand, clinical depression can also be accompanied by reduced levels of cognitive functioning. Given the potentially severe consequences of failing to treat depression in older adults and the fact that current Alzheimer's drugs are most effective when administered early in the course of the disease, correct early diagnosis becomes an important task for behavioral science.

One reason to consider EEG for diagnostic purposes is that it provides a different type of information about brain function than do imaging techniques such as Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI). A PET scan for example, provides highly detailed information about the anatomical locations in the brain that are particularly active during performance of a cognitive task. However, these images represent a composite of brain activity averaged over a period of no less than 30 seconds, and usually several minutes. Moreover, even if it were possible to generate a perfect representation of the cortical areas involved in a specific cognitive activity, this would still not address the question of <u>how</u> the brain is dealing with the information at hand. EEG can complement work with PET technology by providing information about patterns of change in brain activity over time scales ranging from minutes to less than a second. It is possible that, in very early stages of the disease, Alzheimer's patients will be most easily distinguished from comparison groups (e.g., depressed or healthy older adults) on the basis of differences in the <u>type</u> of activity recorded at a particular cortical location, rather than on differences in the cortical <u>locations</u> that are most active. In other words, the same parts of the brain may be active during cognitive performance in Alzheimer's disease and normal aging, but the patterns of activity among these same regions may be different. Currently, only EEG can provide non-invasive information about the pattern of activity at a given location.

Through support from the Waldron family and the St. Alban's Foundation we have obtained a 128 electrode EEG system from Electrical Geodesics Inc. This system digitally samples voltages at each location 500 times per second. We record one minute segments of running EEG (a) during two pre-task baseline conditions (eyes open and eyes closed), (b) during performance of a 13 minute continuous performance task (Intermediate Visual and Auditory task developed by psychologist Joseph Sanford, Ph.D. of Richmond, VA), and (c) during post-task eyes-open and eyes-closed baseline conditions. We then derive a number of quantitative measures of EEG activity in each of these seven task conditions. These include the percentages of activity in the standard delta, theta, alpha, beta, and gamma frequency bands through use of a Fast Fourier Transform algorithm.

We are also comparing Alzheimer's volunteers to healthy younger adults and healthy older adults on several descriptive measures developed in our own lab. Electrical engineers have developed mathematically rigorous techniques for describing patterns of change over time. Because the EEG is an electrical signal that is changing constantly, our general approach is to try to describe the EEG the way an electrical engineer would. With the help of a Ph.D. candidate in electrical engineering from Virginia Tech, Pei Jun Shan, we are applying these signal processing strategies to our data. Among the EEG measures we collect are (a) the number of changes per second & in

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laborate for the benefit of our patients as well as providers, health care organizations and the need to deliver services in a responsible manner.

Trigon has reversed its policies concerning setting non-physicians as gatekeepers deciding whether patients will see their eye doctors, and requiring pre-certification for all hospital admissions, even on nights and weekends and for emergency-room care. An editorial in the Richmond Times Dispatch (Saturday July 25, 1998) raises the question, "Why does Trigon invoke such policies in the first place - policies indicating it is warring against doctors?"

Trigon is willing to seek a joint solution to the issues raised in this article with the creation of a new multidisciplinary Task Force. Dr. Weissman has invited one of the authors (AE) to serve on this Task Force. While Trigon has the obligation to look at quality care, provider profiling as proposed is not the mechanism to yield such data. Efficiency and effectiveness studies of psychotherapy should not be confused.

According to the data, managed care companies should be encouraging therapists to retain patients in treatment and increase the mean length of treatment, thereby providing more effective mental health treatment. This would facilitate medical offset costs by lowering costs for psychologically associated medical treatments, reduced need for lengthy and costly inpatient hospitalization, promote workplace efficiency resulting in fewer days lost from work and more productive workers, and enhance the general mental health of consumers and their families.

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highest squared voltage among the 128 electrode sites changes location (Pribram, King, Pierce, & Warren, 1996), (b) a mathematical measure of the complexity of the path of the highest squared voltage across the surface of the scalp (algorithmic complexity, see Rapp, Zimmerman, Vining, Cohen, Albano, & Jimenez-Montano, 1994), (c) the number of times per second that the dominant frequency in the EEG changes, and (d) the factor structure of voltages from the 128 electrode locations.

While we have tested approximately 60 people thus far, only 10 have had a diagnosis of Alzheimer's disease. Consequently, it will be about six more months before we have obtained a sample size large enough to provide useful information about Alzheimer's disease. In the meantime, our comparisons of healthy younger and healthy older adults suggest that younger adults display EEGs with lower frequencies during performance of the IVA Continuous Performance Task than do older adults. Behaviorally, older adults perform only slightly less well than younger adults on measures of vigilance, but perform significantly better than younger adults on measures of how consistent their performance remains over the entire 13 minutes of the task.

Understanding the relationship between brain function and behavior represents a significant challenge for cognitive neuroscience. Hopefully, our lab will contribute measures of EEG activity that can be applied by medical professionals to the problem of differential diagnosis of Alzheimer's disease and other pathophysiological conditions of later life.

For more information about the study, please contact Dr. Tom Pierce, Box 6946, Radford University, Radford, VA 24142; (540) 831-5444; tpierce@runet.edu.

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