International Journal of Psychophysiology 109 (2016) 116–123

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

# The relationship between baseline EEG spectra power and memory performance in older African Americans endorsing cognitive concerns in a community setting

Voyko Kavcic [a,b,*], Bojan Zalar [b,c], Bruno Giordani [d]

[a] Institute of Gerontology, Wayne State University, Detroit, MI, USA
[b] Biomedical Research Institute, Ljubljana, Slovenia
[c] University Psychiatric Clinic, Ljubljana, Slovenia
[d] Departments of Psychiatry, Neurology, and Psychology and School of Nursing, University of Michigan, Ann Arbor, MI, USA

ARTICLE INFO

*Article history:*
Received 18 May 2016
Received in revised form 1 September 2016
Accepted 3 September 2016
Available online 6 September 2016

*Keywords:*
African Americans
Recognition memory
Diffusion model
Resting-state EEG
Delta
Theta

ABSTRACT

The finding that some older individuals report declines in aspects of cognitive functioning is becoming a frequently used criteria to identify elderly at risk for mild cognitive impairment (MCI) and dementia. Once concerns are identified in a community setting, however, effective means are necessary to pinpoint those individuals who should go on to more complex and costly diagnostic evaluations (e.g., functional imaging). We tested 44 African American volunteers endorsing cognitive concerns (37 females, 7 males) age ≥ 65 years with CogState battery subtests and recorded resting-state EEG, with eyes closed. After current source density (CSD) transformations of EEG recordings we obtained spectral power for delta, theta, alpha, and beta frequency bands. We characterized CogState One Card Back Learning (OCL, memory) with diffusion model parameters drift rate, boundary and non-decision time (NDT). Forward regression models showed that lower OCL drift rate, slower accumulation of information needed for decision making was linked to increased absolute and relative delta at occipital region. Lower drift rate was also linked to decrease in OCL theta power at parietal region, with no findings for ONB. Results show that cortical resting, eyes closed EEG rhythms are related to memory in African American seniors endorsing cognitive concerns. This study further supports the use of EEG as an easily accessible, cost-effective, culture-fair, and noninvasive clinical measurement that could provide potentially reliable diagnostic (and perhaps prognostic) information to differentiate at-risk from stable African American seniors.



## 1. Introduction

In the context of the rapid increase in longevity and considerable expansion of the share of elderly in the general population, ubiquitous age- and disease-related cognitive declines have important socioeconomic implications. Thus, identifying those who are at risk for mild cognitive impairment (MCI) and understanding mechanisms leading to these declines are vital for guiding environmental and clinical interventions aimed at cognitive rehabilitation of older adults and early prediction of dementia. Health disparities, however, represent a critical roadblock to early identification of MCI and mitigate the dramatic social, economic, and fiscal benefit that slowing cognitive decline and dementia progression brings, not only to the individual patient and family, but also on the state and federal level. Overall, community dwelling African American seniors access diagnostic services later in their illness and are underrepresented in dementia drug trials. Development of culturally acceptable, reasonable, cost effective, and economically viable methods of early detection of older persons with MCI from underserved populations who are at risk for dementia are thus critical. Also critical is the ability to adapt specialized assessment approaches to a community-based setting, wherein a wider range of participants can be screened effectively, benefitting both early clinical evaluation and outreach for clinical trials in the African American population.

Portable electrophysiological measures (i.e., electroencephalography, EEG, or evoked potentials, ERPs) represent a unique approach for developing community-based outreach that can facilitate very early, enhanced, neurophysiological-based diagnostic accuracy. EEG represents an objective, easily accessible, cost-effective, culture-fair, noninvasive evaluation method. This methodology can detect subtle functional changes that could be used to predict neuro insufficiencies related to cognitive decline in healthy elderly.

This paper presents data from a community- based study of recorded EEG compared to memory performance in a sample of older African American volunteers. Older African Americans were selected on the

* Corresponding author at: Institute of Gerontology, Wayne State University, 87 E. Ferry Street, Detroit, MI 48202, USA.
*E-mail address:* Voykok@gmail.com (V. Kavcic).

http://dx.doi.org/10.1016/j.ijpsycho.2016.09.001
0167-8760/

basis of self-reported change in some cognitive ability over the last year (subjective memory concerns/complaints, SMC), in order to enhance the potential range of memory performance and better evaluate the relationship between baseline, resting-state EEG signal and memory performance.

### 1.1. Resting-state EEG

Brain neuroelectric oscillatory activity is a hallmark of neuronal network function in various brain regions. Modern neurophysiological techniques, including EEG, can accurately index normal and abnormal brain aging to facilitate non-invasive analysis of cortico–cortical connectivity, neuronal synchronization of firing, and coherence of rhythmic oscillations at various frequencies. The brain's spontaneous, intrinsic activity is increasingly being shown to reveal brain function and assist in diagnosing brain disorders.

Brain neuroelectric signals during the so-called 'resting state' (when participants are requested to rest, with eyes closed or eyes open, and without ongoing physical or mental activity), represent intrinsic neural activity. Better understanding of underlying brain coupling dynamics can potentially provide significant insights into the aging process, as well as cognitive decline from neurodegeneration. Numerous studies have explored the association between various EEG cortical frequency bands of delta (1–4 Hz), theta (4–7 Hz), alpha (8–12 Hz),beta (12–28 Hz), and gamma (>30 Hz) oscillations in association with different behavioral and disease states.

Age-related cognitive decline can be in part characterized by the progressive loss of functional connectivity within cortical areas resulting in dedifferentiation and reduced cortical activity (Baltes and Lindenberger, 1997; Li et al., 2001; Park et al., 2010; Reuter-Lorenz and Park, 2010). EEG provides a tool to investigate these early alterations of neural networks, providing a potential biomarker for various neurological and psychiatric disorders (Fox and Greicius, 2010). In this way, EEG could provide an early predictive model of MCI development among elderly with progressive cognitive decline.

Several EEG research groups have shown that resting state, gradual modifications in the spectral power profile, so called global "slowing" of the intrinsic EEG, occurs with aging. This is reflected by pronounced increases in power in the slower delta (2–4 Hz) and theta (4–8 Hz) frequency ranges localized at centro-temporal and parieto-occipital sites (for review see Klass and Brenner, 1995; Klimesch, 1999; Rossini et al., 2007) and decrease of alpha (8–13 Hz) rhythm (Babiloni et al., 2006; Muller and Lindenberger, 2012; Reichert et al., 2016). In contrast to the findings above with delta activity, a study by Widagdo et al. (1996) did not find differences in resting delta activity. In support of Widagdo study (1996) several additional research groups have reported decreased delta activity in older, as compared to younger, participants (Cummins and Finnigan, 2007; Leirer et al., 2011; Reichert et al., 2016; Vlahou et al., 2014).

Further, "slowing" of EEG has been reported as healthy older individuals progress to MCI and probable Alzheimer's disease (AD) (for review see Vecchio et al., 2013). AD patients, as compared to healthy older adults, demonstrate further increased power in delta and theta rhythms and decrease power in posterior alpha (8–12 Hz) and beta (12–30 Hz) frequency (Babiloni et al., 2011, Babiloni et al., 2014; Baker et al., 2008; Jeong, 2004; Prichep et al., 2005). Research in resting state EEG with MCI patients, the prodromal stage of AD, has shown intermediate EEG changes, as compared to healthy older adults and diagnosed AD patients. Specifically, intermediate increase in power of delta and theta frequency (Kwak, 2006) and intermediate decrease in alpha rhythms in the parietal and occipital regions (Coben et al., 1985; Babiloni et al., 2006; Luckhaus et al., 2008; Moretti et al., 2011) has been found.

Few studies have investigated the ability of resting state EEG to predict the conversion from MCI to AD (Antila et al., 2013; Jelic et al., 2000; Poil et al., 2013; Prichep et al., 2005). In two studies, the EEG markers of MCI to AD progression included a power increase of theta rhythms in temporal and occipital regions, as well as a power decrease of beta rhythms in the temporal and occipital regions (Jelic et al., 2000; Poil et al., 2013). Prichep et al. (2006) reported that when seniors with SMC were followed for up to nine years, there was a significant increase in theta power among those who converted to MCI. On the other hand, Poil et al. (2013) showed that following 86 patients initially diagnosed with MCI for two years, during which 25 patients converted to AD, mainly changes in the power in beta-frequency range (13–30 Hz) predicted conversion from MCI to AD.

Age-related resting EEG spectral changes in theta (approx. 4–8 Hz) and alpha (approx. 8–12 Hz) frequencies also have been linked to age-related memory declines, though reports have not always been consistent. For example, Klimesch (1999) reported that older adults with lower resting state theta rhythms performed better on memory tests than those with higher rhythms. In contrast, Finnigan and Robertson (2011) found that those with higher resting-state theta power actually performed better with cognitive performance (i.e., immediate and delayed recall, executive function, attention). Reports about the relationship between alpha power and cognition are consistently showing that higher resting-state alpha power is associated with better performance in memory tasks (Klimesch et al., 1999; Lopez Zunini et al., 2013; Vogt et al., 1998). More recently, Reichert et al. (2016) reported that subjects in eyes-open state with higher theta power at fronto–central locations perform better on verbal memory test while subjects with higher alpha II (10–12 Hz) power in eyes-closed state at parietal locations performed better on visuospatial memory test.

### 1.2. Diffusion model

Relationships between brain activity and memory recognition processes have been historically based on separate analyses of response latencies and/or accuracy measures. The Diffusion Model approach for analyzing recognition data, however, represents a new approach, combining both response time and accuracy to provide additional insight into information processing. According to the diffusion model, following stimulus onset in a two-alternative, forced-choice memory recognition task (e.g., new-old), as used in this study, the decision process can be characterized by initially random, noisy processing moving toward one of 2 decision boundaries (i.e., "new" or "old" recognition response; Fig. 1). Evidence for one of these two possible responses randomly varies until the person starts to accumulate information toward one decision or the "boundary". This process is labeled "drift rate" (i.e., the rate at which information is accumulated). Once this accumulation process passes a boundary for one of the possible responses, that response is initiated. Performance is, therefore, a function of the rate of information accumulation (*drift rate*), the distance to the boundary for the correct response from the starting location of the diffusion process (*boundary separation*), and the perceptual and response factors that are combined in the model into what is labeled as non-decision time (*NDT*). Drift rate indicates the speed and quality of information buildup toward the correct response, while boundary reflects response caution or the amount of evidence a person needs before executing the response.

The diffusion model has been applied to differentiating persons at risk for cognitive impairment from healthy controls. Aschenbrenner et al. (2016) reported that individuals with a family history of AD exhibited lower recognition accuracy, represented in the diffusion model as decreased drift rate that could not be explained by APOE status, differences in response caution, or other diffusion model parameters. These authors suggested that drift rate could be considered as a novel cognitive marker of preclinical AD.

In summary, it is hypothesized that spontaneous brain activity measured at rest may provide information about normal and/or pathological aging processes and may predict the level of proficiency in explicit cognitive tasks using more sophisticated measures of memory performance. The aim of the present study was to investigate the degree to which spectral power of resting-state EEG frequencies relate to memory