Mechanisms of recovery in the severely injured brain: Physiological correlates of restoration of the anterior forebrain mesocircuit

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INTRODUCTION

Several observations indicate that common underlying mechanisms of restoration of function can be identified across widely varying patterns of structural brain injury and mechanisms of cellular and circuit dysfunction (Williams et al., 2005; Conte et al., 2010; Drover et al., 2011, 2012; Ferman et al., this meeting). Specifically, the mesocircuit hypothesis proposes that changes in activity across several interconnected structures of the anterior forebrain will index levels of recovery (Stinch 2010). Here we use quantitative electroencephalographic (EEG) measures to identify such changes.

Previous studies identified (1) the presence of low (5-15 Hz) frequency oscillations in the resting EEG of postsubject subjects with severe brain injuries and disorders of consciousness (Drover et al., 2011), (2) reduction of EEG power at these low frequencies and consistent increases in high frequency (15-40Hz) power spatially localized to frontocentral regions in correlation with spontaneous recovery (Conte et al., 2010) and medication-induced improvements in behavioral function (Williams et al., 2009). We now present results of applying hierarchical decomposition (HD; Repucci et al., 2001) to the EEG records of several longitudinally-studied patient subjects. In contrast to principal component or independent component analysis, HD seeks to identify EEG components that drive others. HD components are linear combinations of the original EEG signal for which an autoregressive model demonstrates a simple causal structure. Here we demonstrate that spontaneous recovery, medication-induced behavior facilitation, and transient salient sensory stimuli (Bardos et al., 2011) can all produce similar patterns of changes in local and global EEG dynamics consistent with the mesocircuit hypothesis: reduction in the causal influence of components with low frequency oscillations. These findings further suggest that HD can provide insight into the underlying mechanisms of the recovery process and be developed as a measure for tracking of recovery of brain function in patients with severe structural brain injuries.

REFERENCES


5. Dynamic Isolation of Thalamocortical Dysrhythmia

In a patient subject with spontaneous late recovery from minimally conscious state due to severe traumatic brain injury over an 18-month period, HD reveals increases in ~15-40Hz power in HC1 in right frontocentral regions.

CONCLUSIONS

➢ In healthy subjects, HD shows a characteristic pattern of resting brain dynamics.

➢ In patients, normalization of global EEG dynamics is observed during spontaneous recovery, drug induced recovery, and in the setting of salient natural stimuli. These are paralleled by changes in the spectral content of the most causal EEG component, as identified by HD.

➢ The transitions observed in individual subjects support the mesocircuit hypothesis: recovery is accompanied by reduction in low-frequency oscillations and restoration of higher frequency activity (15-40 Hz) across frontocentral regions.