Dissolution of Phase Amplitude Coupling with Concurrent Increases in Local Phase Coherence During Visuomotor Responses

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***Abstract*—In this study we compared how brain rhythms interacted with one another via coupling and coherence during a visuomotor response task. Our brief analysis has shown that coupling between the mu phase and high gamma amplitude in the motor region are dissolved during the response while simultaneously the mu phase throughout the motor region becomes coherent. The relationship between this observation and currently existing theories is discussed.**

I. Introduction

Suppression of unwanted stimuli and execution of an intended motor task requires a complex orchestration of information within the brain. Many studies have suggested that information within the brain is processed or transmitted via mechanisms such as coupling and coherence [1-4]. Low-frequency phase to high-frequency amplitude coupling has gained greater theoretical importance given recent findings that low-frequency brain rhythms are often entrained by external sensory and motor events [1]. Additionally, recent research has provided evidence that coherence among neuronal groups within motor regions may be entrained by thalamocortical rhythms [2]. In this ongoing study, we investigate the ties between phase amplitude coupling (PAC) and local phase coherence (PC), using electrocorticographic (ECoG) signals that were recorded in human subjects who performed a spatial attention task. Analysis of PAC, PC and their relationship may give deeper insight into the functionality of brain rhythms, the information they contain, and their relevance to behavioral performance (i.e., motor response).

II. Materials and Methods

We recorded ECoG signals from five subjects while they performed a modified Posner task. The subjects were instructed to orient their attention to the cued portion of the screen and respond to a change in contrast by pressing a button. Attentional engagement was verified with sham trials. We investigated coherence and coupling within 1 second windows of "rest", "attention", "contrast change" and "motor response". PAC was determined using the Modulation Index method described in [1]. PC was determined by comparing phase locking value before and after the onset of events.

III. Discussion

In our preliminary analyses, we observed decreased PAC (calculated for mu phase and high gamma amplitude) throughout the "contrast change" and "motor response" periods when compared to rest within distinct locations over the precentral gyrus and posterior parietal cortex. Additionally we observed an increase in PC during the "contrast change" and "motor response" period when compared to rest in the same regions. These two observations, which occurred within multiple channels, suggest a nontrivial link between PAC and PC.

There are two existing hypotheses on how cortical areas communicate involving phase information of underlying neural activity. The first hypothesis, *communication through coherence* (CTC) [3], states that communication between neural groups is dependent on the availability of excitation, that is, there are only windows of opportunity for communication and they must be temporally optimized to ensure that a neuronal group can be accessed when needed. The second, binding by synchronization (BBS) [4], hypothesis states that the phase locking of brain rhythms may act as a program or object selection mechanism for executing functions. It is suggested that PAC acts as the preparation or windowing mechanism that is described in the CTC hypothesis. The resulting increase in PC is thought to be the increased synchrony that indicates program selection via the BBS hypothesis. PC then decreases after the motor task has been completed.

IV. Conclusion

In summary, our ongoing work is beginning to provide evidence for a relationship between PC, PAC, and the motor response. With further verification in additional subjects, this study could contribute to the understanding of the information processing mechanisms that underlie brain rhythms and how the BBS and CTC hypotheses are connected. In our future work we will investigate amplitude coherence to determine if it also plays a roll in the dissolving of PAC. Future work will also investigate PC between channels over the visual and motor cortices.

References

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