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# Measuring Partial Motor Programs

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## Introduction

All three dominant theories about the organization of serial behavior [7] assume a centralist view and that there is some kind of motor program [6]. However, the neural mechanisms involved in motor programs are as yet unknown. Most experiments require subjects to choose between a few well-learned sequences [8], but how are motor programs first constructed and what brain activity is related to the construction of a new and partial motor program? What EEG-measures are useful for studying partial motor programs? In another task we found that time domain measures were more related to execution preparation and frequency domain measures were more related to program construction [2].

## Method

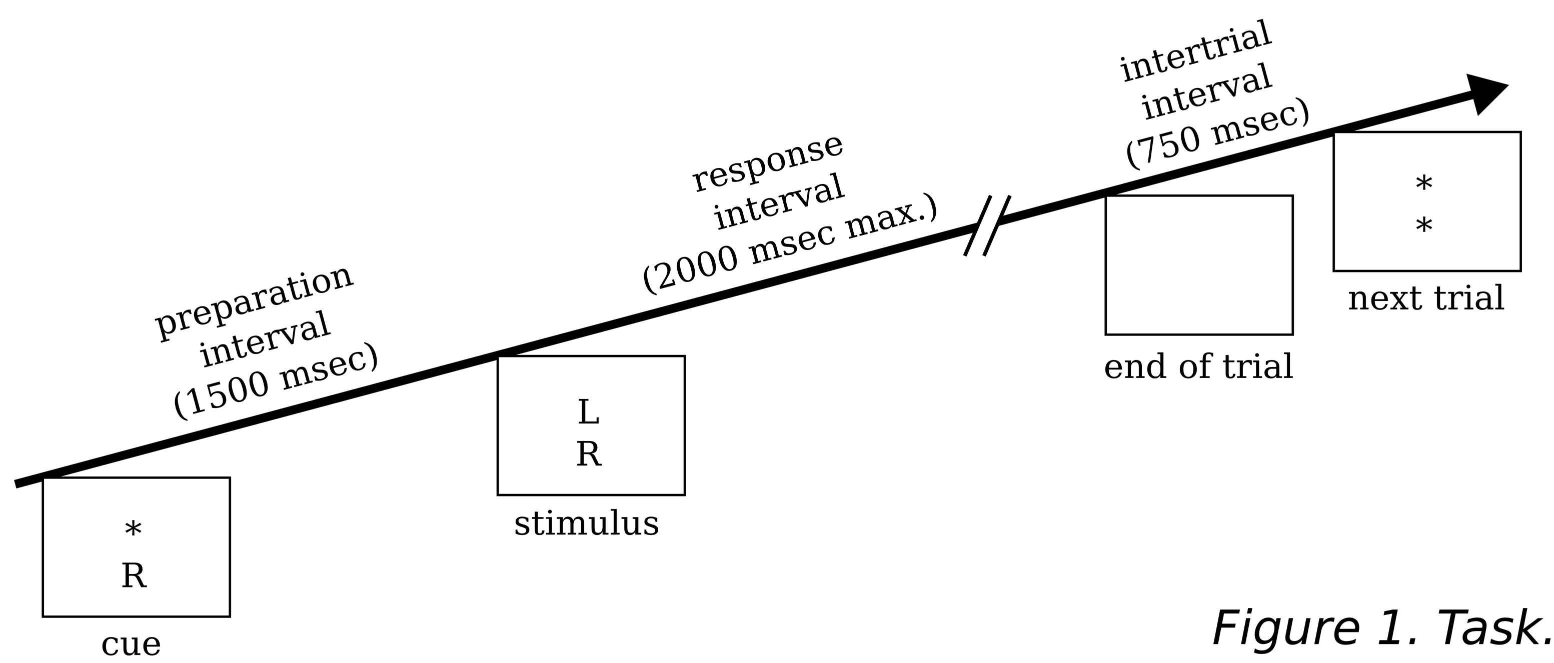


*Figure 1. Task.*

To investigate the preparation of motor sequences we used a two-movement, two-response task with full, partial and non-informative (neutral) cues [4]. Subjects (N = 16) received cues in the form of two letters: ‘R’ and ‘L’ for the right and left index finger. The upper letter indicated the first and the lower letter the second response (fig. 1). For uncued movements the letter was replaced by an asterisk. A 1.5 second preparation interval preceded the stimulus that provided full information. Partial cues were intended to have subjects prepare a partial motor program.

Measures reported here are the Contingent Negative Variation (CNV) and two lateralization measures: the Lateralized Readiness Potential (LRP) and the Motor Related Amplitude Asymmetry in the beta band (beta MRAA). The formula for LRP was (similar for beta MRAA):

$$LRP = (C3-C4)_{\text{left hand responses}} - (C3-C4)_{\text{right hand responses}}$$

Lateralization was calculated over the second half of the preparation interval using the first cued response or the first actual response for neutral cues.

## Results

Response Times (RT) on the first segment were most sensitive to the manipulations. RT was lower when cues were more informative. There was an interaction-effect of cueing the first response, cueing the second response and sequence type on first RT (fig. 2; $F(1, 15) = 21$, $p = .000$).

An interaction effect between electrode (Fpz, Fz, Cz and Pz) and cue type (neutral, second, first, full-different, full-equal) on CNV during the second half of the preparation interval was found ($F(12, 180) = 2.2$, $p = .047$). This could be due to a division between full-different and both partial cues and the full-same and neutral cues at Cz (fig. 3A).

The LRP (fig. 3B) only developed for full cues and sequences with two different responses ($t(15) = 3.8$, $p = 0.002$). There also was a significant effect of cue type on beta MRAA (fig. 3C; $F(4, 60) = 9.4$, $p < .0005$). Pairwise comparisons showed that this was due to differences between full cues with equal responses and the three non-full cues. Note the double dissociation between the LRP and beta MRAA for full cues.

## Discussion

Ulrich et al [9] posed the question: Is it possible to prepare the second component of a movement sequence before the first one? Their answer is no, suggesting that motor programs can not be partially constructed. This is in contrast with the widely held view that motor programs can be flexibly parametrized [8]. The results found on CNV here indicate that partial program information is at least processed in some way.

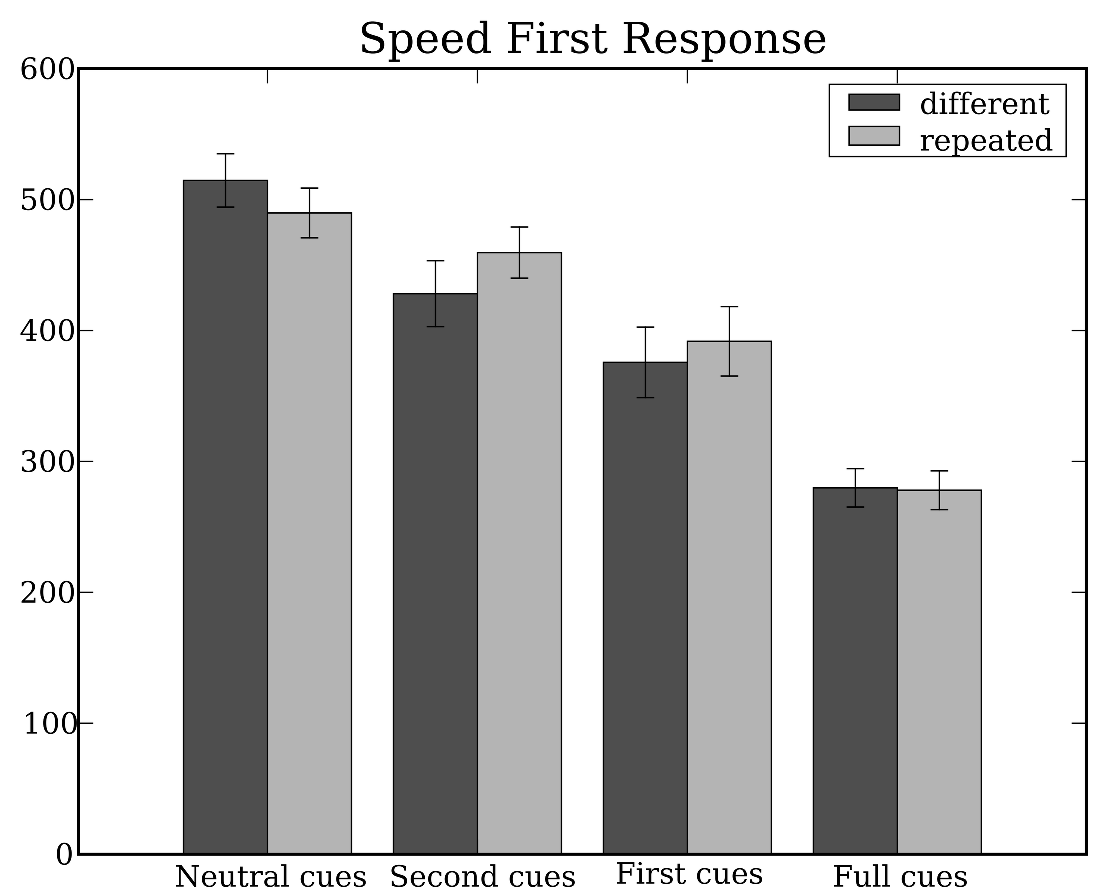


*Figure 2. RT of first segment and standard deviations.*

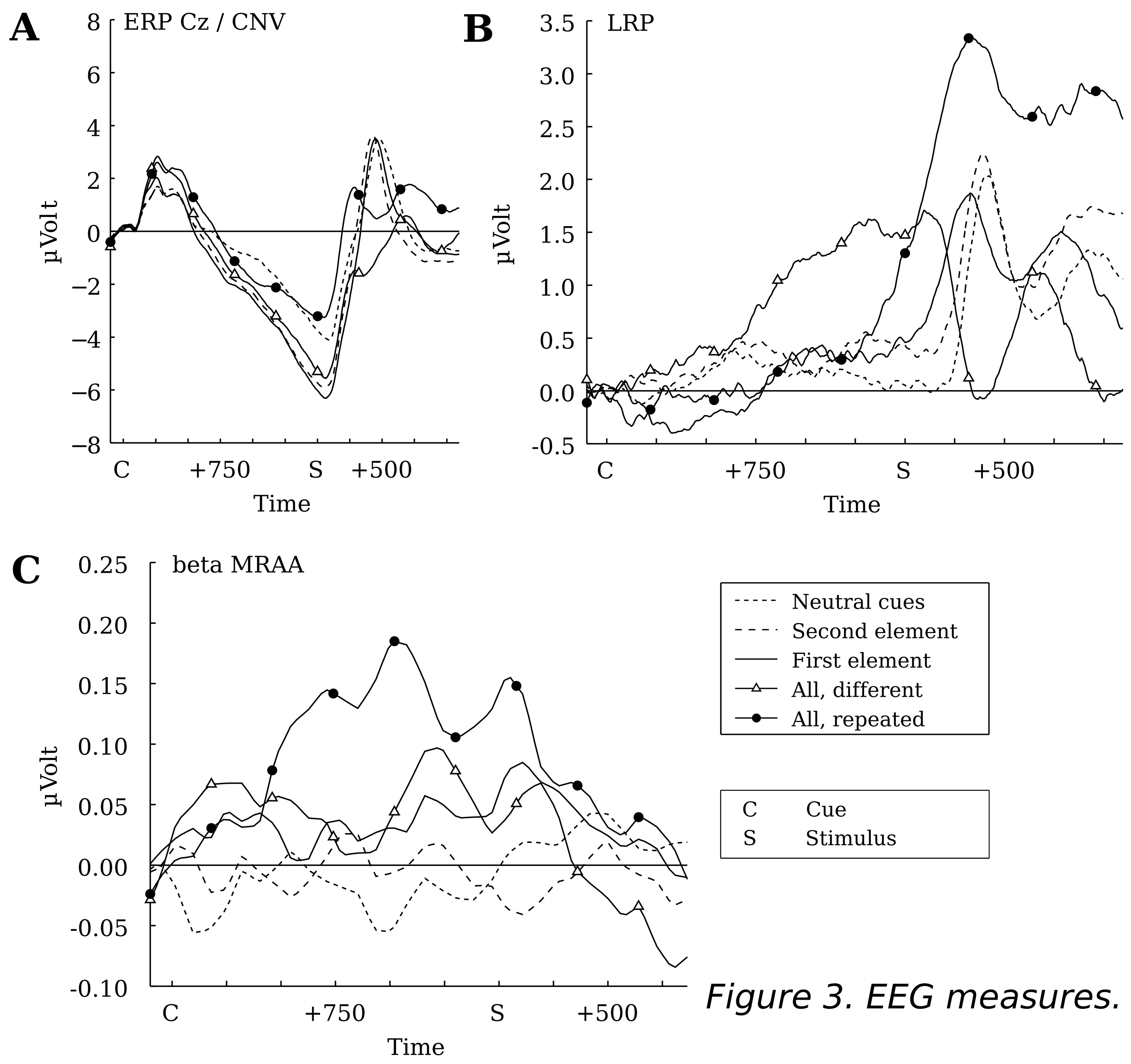


*Figure 3. EEG measures.*

Behavioral data showed that all information was in some way beneficient for performance, but the different EEG measures were sensitive to different aspects of the task. This suggests that in complex motor planning different aspects of motor preparation are handled differently, involving neural activity with different temporal characteristics, as we observed before in other tasks [2]. The lateralization measures only show an effect for fully cued sequences, suggesting they are not useful for studying partial (more complex) motor planning. Other researchers have suggested that complex motor tasks require more or different brain regions [3]. Specifically the pre-supplementary motor area is reported to be involved in complex motor planning [1] and is also a cortical source of CNV [5], which can explain the effect found here on Cz for cue types requiring planning.

## References

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