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From motivation to action: action utility better predicts changes in pre-movement beta-band activity than movement speed

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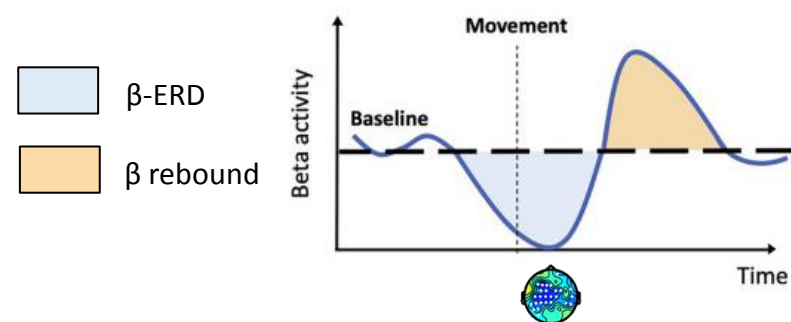
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INTRODUCTION

- Movement planning is associated with a decrease in beta-band activity over sensorimotor cortex, referred to as **beta event-related desynchronization (β-ERD)** ^{1,2}. It can be recorded using **electroencephalography (EEG)**.
- Beta activity constitutes a potent therapeutic target in Parkinson's disease (PD) because its reduction has been shown to result in an acceleration of movements ^{3,4}.



Adapted from Barone & Rossiter (2021).²

BUT...

- Studies in healthy humans have not reported any significant correlation between β-ERD and movement speed ^{1,5}.
- The movement slowness observed in PD might be due to an overestimation of action cost rather than an inability to perform movements faster ⁶.

OBJECTIVE

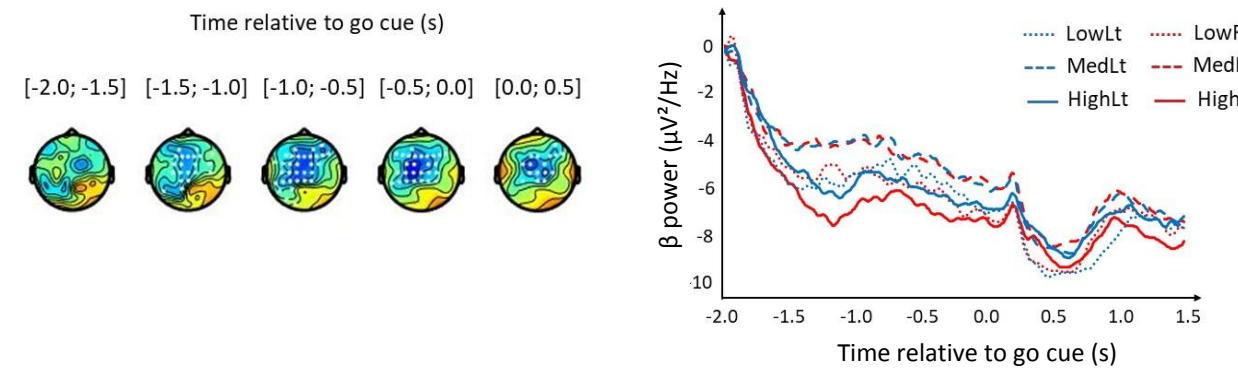
Dissociate movement speed and cost to determine which one best predicts modulations in β-ERD.

RESULTS

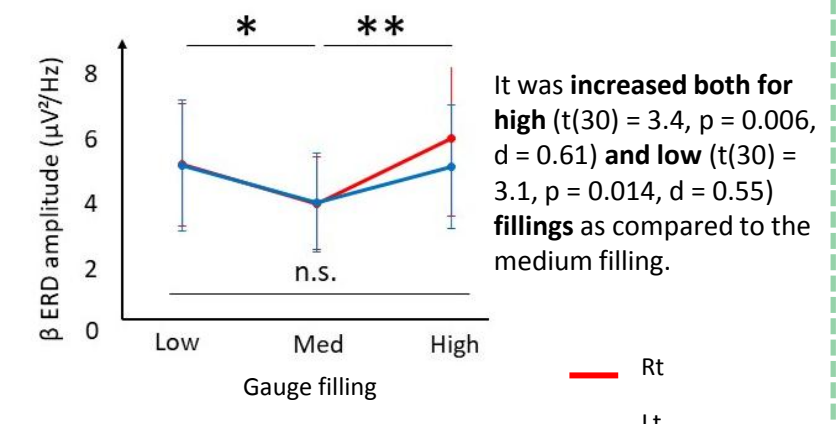
1. Modulations of β-ERD amplitude across speed conditions

Beta activity was reduced over contralateral sensorimotor electrodes during the delay period.

The amplitude of β-ERD appeared differently modulated across conditions.

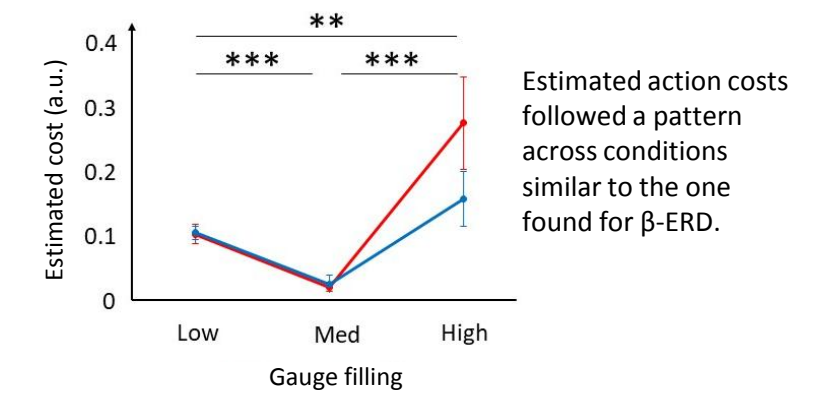
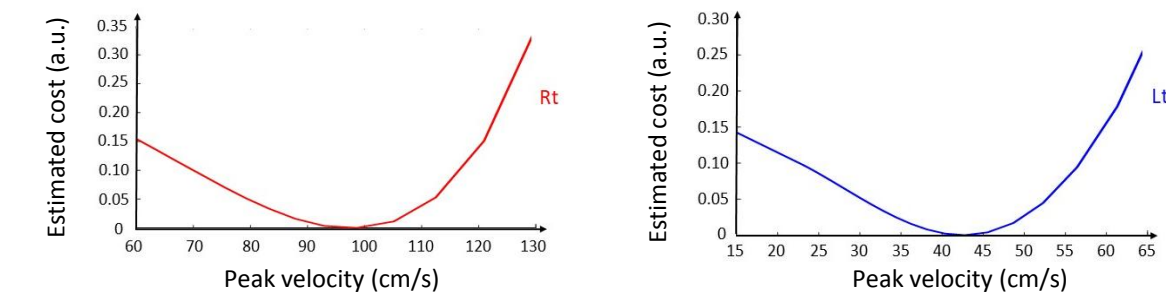


The amplitude of β-ERD was significantly modulated by **gauge filling** ($F(2,60) = 7.7$, $p = 0.001$, $\eta^2 p = 0.20$) but not by **target position** ($F(1,30) = 0.8$, $p = 0.368$, $\eta^2 p = 0.03$).



2. Modeling of action costs

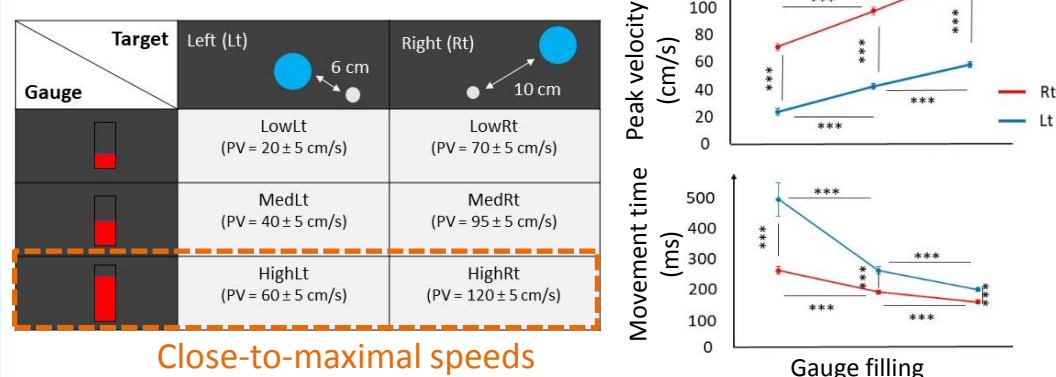
Action cost was modeled as a function of peak velocity ⁷ for the two target positions separately.



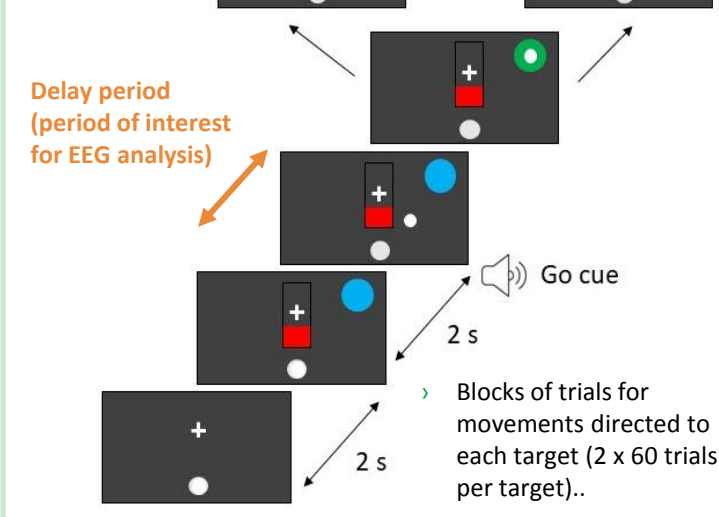
METHODS

31 right-handed participants (15 females, 16 males ; 23 ± 3 years old) performed a reaching task while an EEG was recorded.

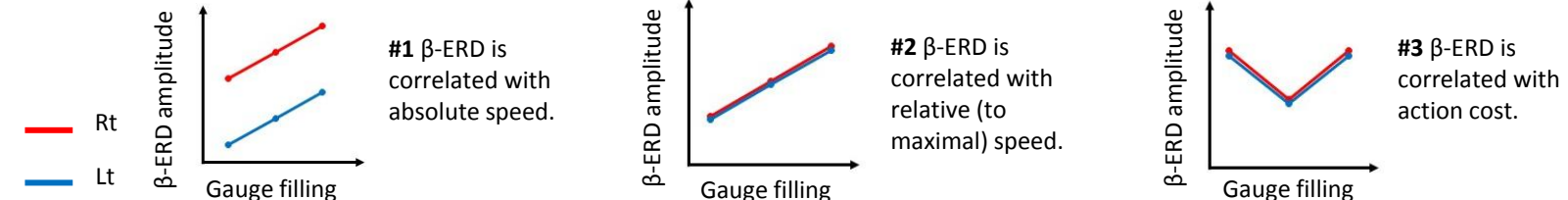
Experimental conditions



Trial timeline

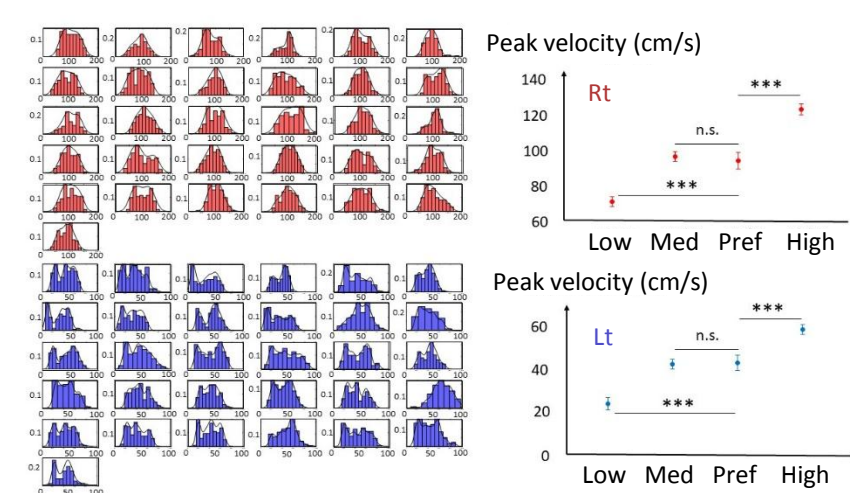


EXPECTED RESULTS

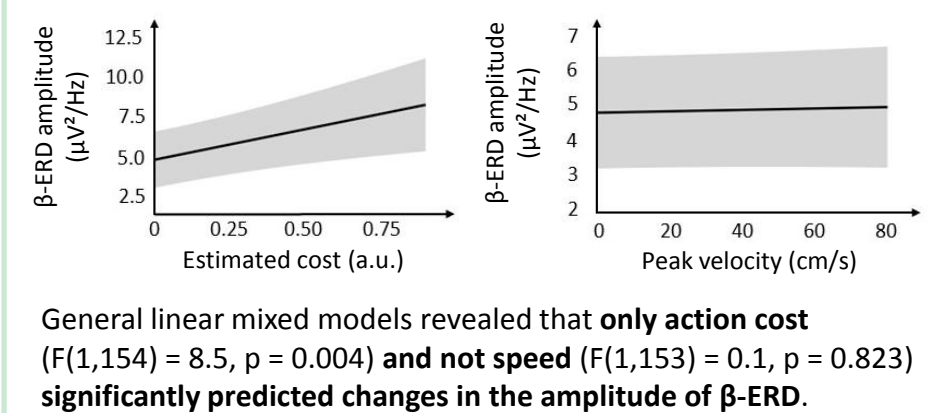


Estimation of preferred speeds

- Preferred speeds were estimated based on maximal values of kernel probability density functions.
- The average preferred speed was not significantly different from the medium speed.



3. Comparison of the effects of movement speed and cost on β-ERD amplitude



General linear mixed models revealed that **only action cost** ($F(1,154) = 8.5$, $p = 0.004$) and **not speed** ($F(1,153) = 0.1$, $p = 0.823$) significantly predicted changes in the amplitude of β-ERD.

DISCUSSION

Changes in the amplitude of β-ERD were significantly explained by expected action cost rather than movement speed.

How would β-ERD be related to action cost?

- The amplitude of β-ERD might reflect the amount of neural resources that are allocated for motor planning ⁸, which would depend on the expected motor cost.

Why would action cost increase both when accelerating and slowing movements?

- Performing habitual actions requires less cortical activation than in habitual ones ⁹. Medium-speed movements could have been preferred because they are performed more often and thus may need less neural resources ¹⁰.

PERSPECTIVES

- Is β-ERD amplitude reflective of movement preferences in free choices (i.e., without speed instructions)?
- Could action cost be best represented as neural effort (cerebral energetic cost) rather than motor effort (muscular energetic cost)?
- Could reducing β activity result in facilitating flexible motor control rather than merely speeding up movements?

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