

Efficient Task Switching Underlies Optimal Multitasking Performance

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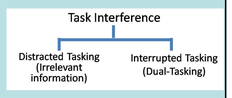
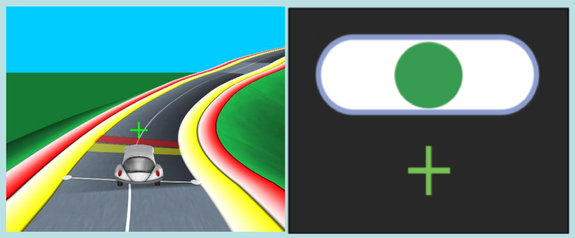
INTRO/METHODS

- **Task interference** has been previously characterized as distraction and interruption, two neurobehaviorally distinct mechanisms (Clapp & Gazzaley, 2010).



- We use *NeuroRacer* (Anguera, et al., 2013), a paradigm previously used to characterize **cognitive control ability** during multitasking interference as well as its neural correlates [specifically, increased midline frontal theta power following practice-based training].
- *NeuroRacer* uses complex continuous tracking task in conjunction with a simple discrimination task (with EEG recording) to determine the neural mechanisms of interruption during dual-tasking.
- Using EEG and a high resolution tracking paradigm *(NeuroRacer)*, we report on the individual differences in multitasking performance.
- Subject's (N=20, 20-29 yrs old) tracking and discrimination ability were thresholded respectively on two tasks: a Tracking and a Discrimination task to put them in their own individualized performance space for each task.



Driving (Tracking)

Discrimination

- Subjects performed mixed blocks of the following conditions:
  - Drive Only
  - Dual-Tasking (tracking and discrimination)
  - Tracking with signs (Drive Only while signs are passively displayed)

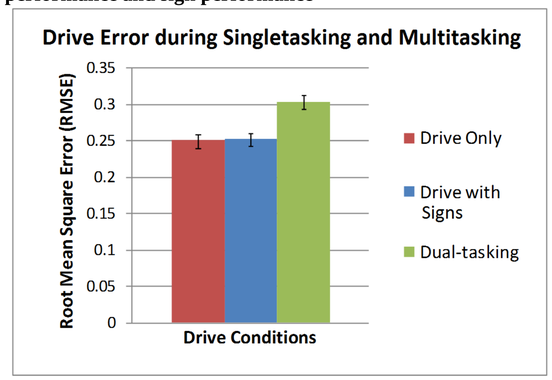
The dual-tasking and Tracking with Signs conditions were perceptually matched.

Sign and road stimuli had intertrial intervals from 2 to 3 seconds. Sign road synchrony was jittered from 0 to 600 milliseconds.

All analysis is time-locked to the onset of the sign events.

BEHAVIORAL RESULTS

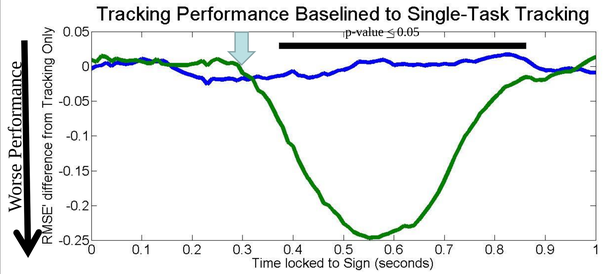
Figure 1 Impact of multitasking interference on tracking performance and sign performance



- Tracking performance measured as Root Mean Square Error (idealized distance from center of road in two dimensions where perfect tracking would be zero).
- Road performance is worse when dual-tasking versus distraction (**p = 2.4e-6**) and worse when dual-tasking versus tracking alone **(p=7.3e-7).**
- Tracking with Signs did not differ in road performance from tracking alone **(p = 0.71)** thus demonstrating this perceptually-matched condition as an appropriate comparison condition.

Figure 2 Timing of Interruption of Tracking Task by Sign Task

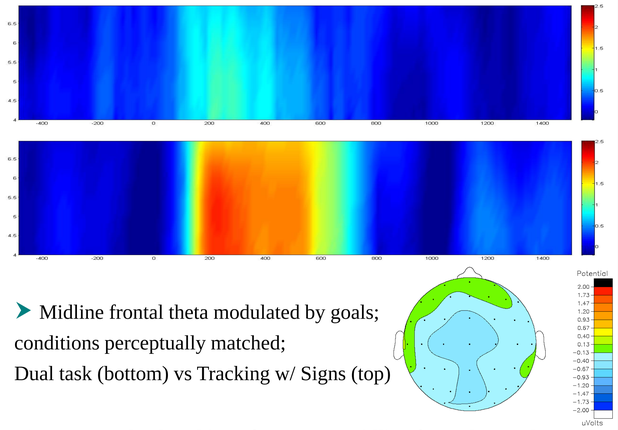
- Dual-Task Tracking (Green) < Tracking with Signs (Blue)
  - Continuous tracking performance was measured as RMSE (root mean square) from the ideal path on the road)
  - RMSE of Distracted Tracking (blue) and Dual-Tasking (green) conditions were baselined against participant's individualized RMSE waveform of their Tracking Only performance



- **Interruption of tracking** occurs ~300 ms after sign onset (as an onset of a negative slope in baselined RMSE, 5% above baseline).
- Correction occurs after sign response (495 ms ± 10 ms) as an onset of positive slope occuring around ~550 ms.
- Tracking RMSE returns to baseline (is equivalent to distracted tracking) by ~850 ms.

NEURAL RESULTS

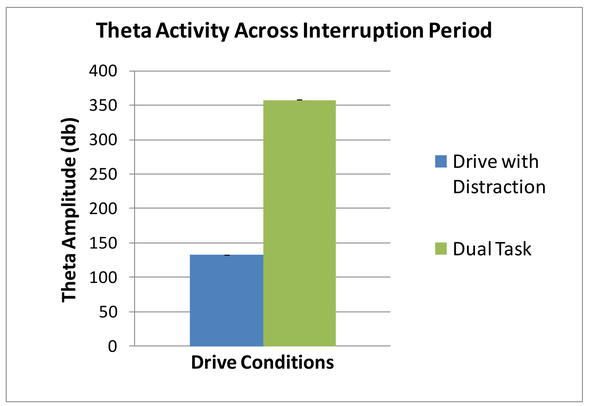
Figure 3 Peak Midline Frontal Theta Activity by Goal



- Midline frontal theta modulated by goals; conditions perceptually matched; Dual task (bottom) vs Tracking w/ Signs (top)

Figure 4 Goal-related interference on midline frontal neural activity

- **$t_{(1,19)}$= 3.82; p = 0.001**
- Dual-Task Tracking and Discrimination vs Tracking with Signs



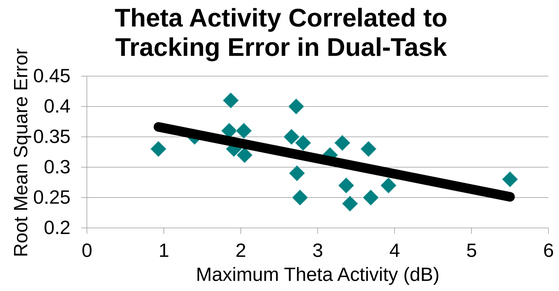
- Peak midline frontal theta activity to signs during sign response (windowed from 200 to 600 ms after sign presentation) is increased by an active tracking task (dual-tasking) when compared to the perceptually-matched distraction condition.

- **Frontal theta power is increased in the dual-task condition when compared to a perceptually matched condition that also contains active tracking.**

CORRELATIONAL RESULTS

Fig, 7 Peak Midline Frontal Activity Correlates to Users That Interrupt Tracking Quicker

- Dual-Task: r = -.546, **p = 0.013**

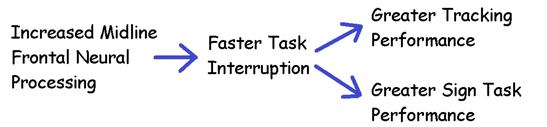


- Midline frontal theta burst profile correlates with tracking performance profile (during Dual-tasking) with a 310 ms lag (as determined by a time-series cross-correlation).
  - Neural activity predicts measured behavioral task interruption (and presumed task switch) by 310 ms.

Additional Behavioral-behavioral Correlations:

- Tracking Error (RMSE) to Sign Accuracy: r = -0.45, **p = 0.046**
  - Less error during tracking correlated with increased accuracy on the sign task when dual-tasking. This also provides counter-evidence against a performance trade-off argument.
- Time of Road Error (350 ms ± 150 ms) correlates to Sign Accuracy: r = -0.563, **p = 0.01**
  - Earlier interruption to tracking attention (as measured by the which maximum tracking error occurs) correlated with increased sign accuracy when dual-tasking.
- **Faster interruption of the tracking task when dual-tasking correlates with improved accuracy of both tasks.**

CONCLUSIONS



Participants with **increased midline frontal theta** activity showed **earlier task interruption**, which resulted in overall **increased multitasking performance** on **both tasks**.