

Selection of Action: Can transcranial magnetic stimulation influence hand choice in reaching?

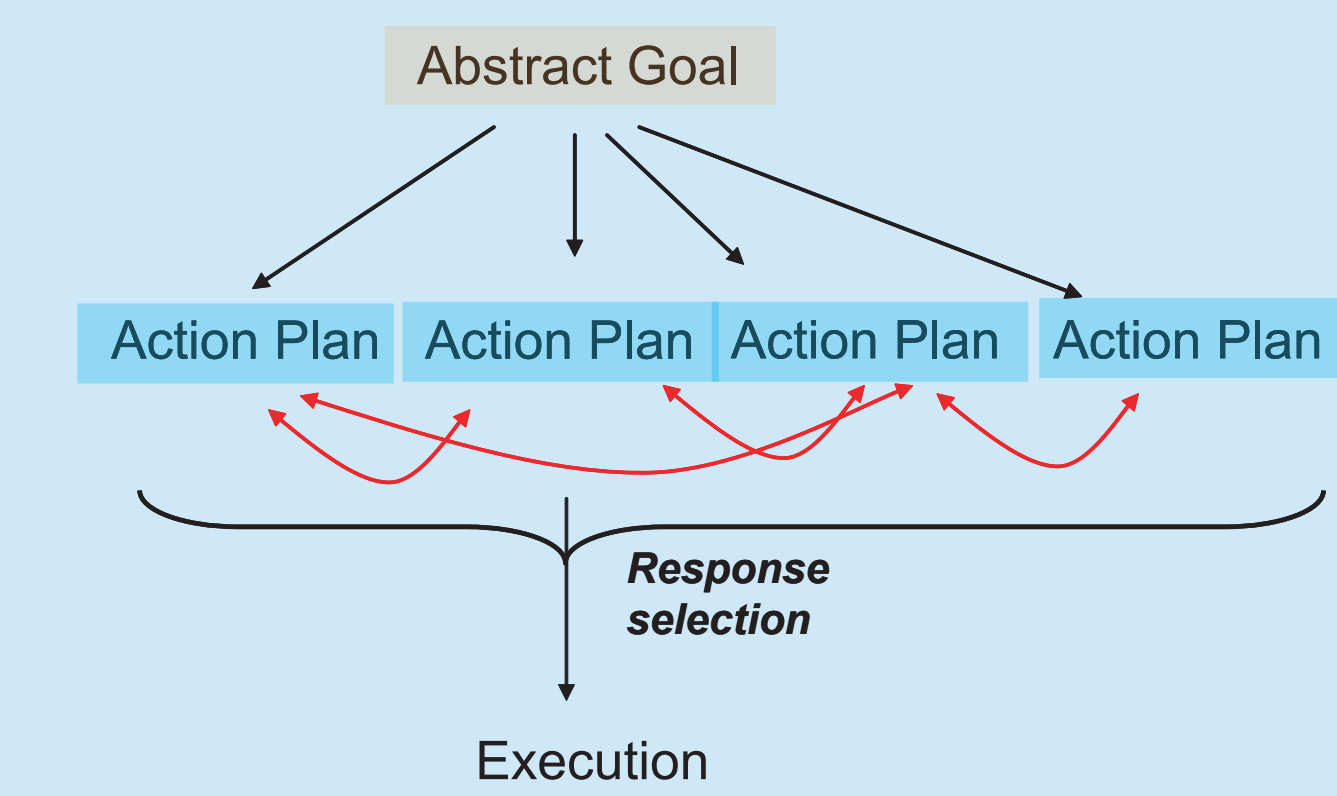
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Introduction

When reaching for something in front of you, which hand do you use?
The closest hand? Dominant hand? Available hand?

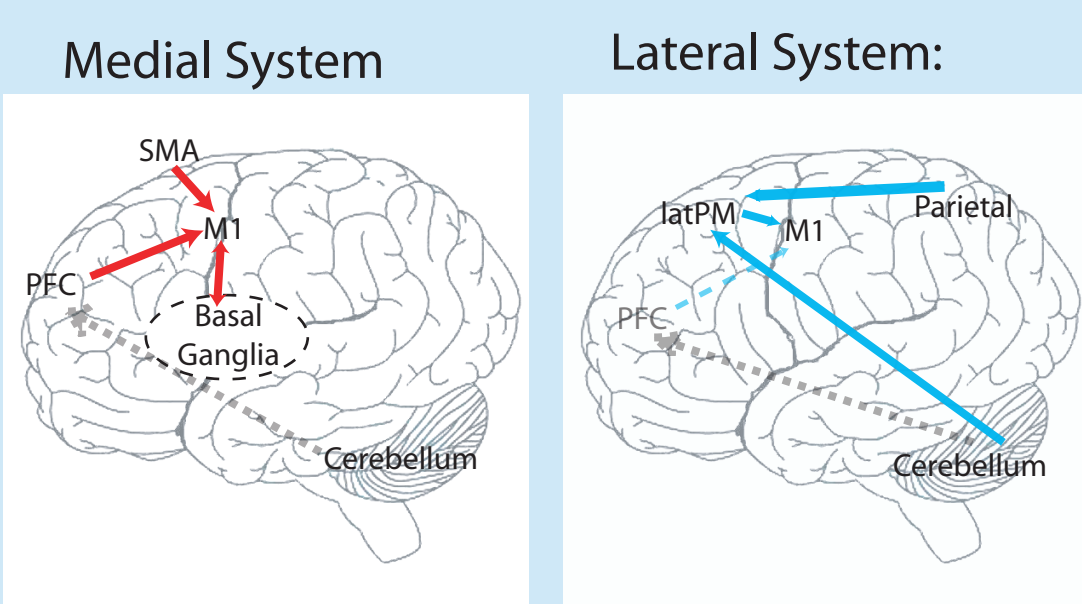


Everyday example: Reaching for a cup of water
- Abstract goal: "drink water"
- Potential actions to achieve goal:
 Reach with right hand
 Reach with left hand
 Bend over and take a sip out of cup

Prediction: RTs will be longer when there is stronger competition and many alternative action plans than when there is lower competition and few alternative action plans.

Aim:
- Can we use transcranial magnetic stimulation (TMS) to influence which action plan is selected? Specifically, can we

What are the candidate brain areas involved in response selection competition?



Internal vs External Guidance of Movement

- Lateral system mediates reaching to cues in the environment, in the presence of sensory feedback

- Premotor single-cell recording studies suggest premotor codes for action plans in an effector-independent way (Cisek 02)

- However, TMS studies over Premotor areas have shown effector-specific delayed reaction times (Schluter 98)

Schluter et al. 1998

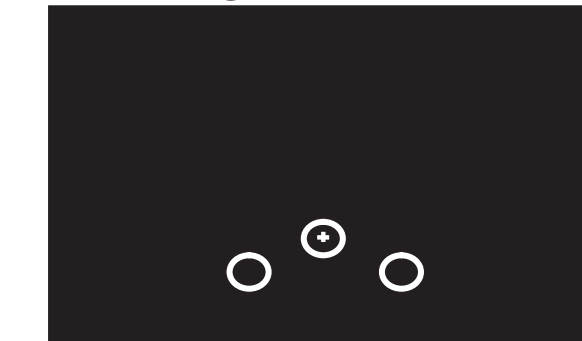
- Subjects make an index-finger or middle-finger response depending on a symbolic cue
- TMS over left Lateral Premotor Cortex at 140ms after stimulus onset delayed RT
- Left PM stimulation delayed right and left hand response; Right PM stimulation delayed left hand response only.

Method

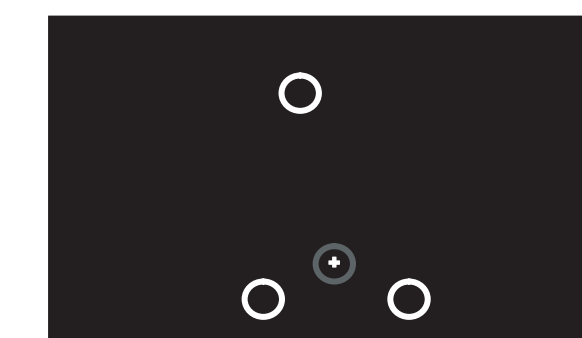
Direct Reaching Task:

1. Fixate at center circle, place both hands in starting circles (hold for 100ms)
2. After variable delay (200ms - 1500ms), a target circle appears
3. Reach to target in a point-to-point ballistic motion. Goal to go as fast as possible. Auditory feedback beep if reach ends in target circle after stopping (no movement for 100ms). Bonus for speed and accuracy
4. Fixation Catch trials (~8 - 17% of trials). When fixation plus '+' changes to an 'x', move hands into the fixation circle. Extra bonus awarded on these trials
5. Bimanual Catch trials (~8 - 17% of trials during choice blocks. Both hands reach simultaneously.

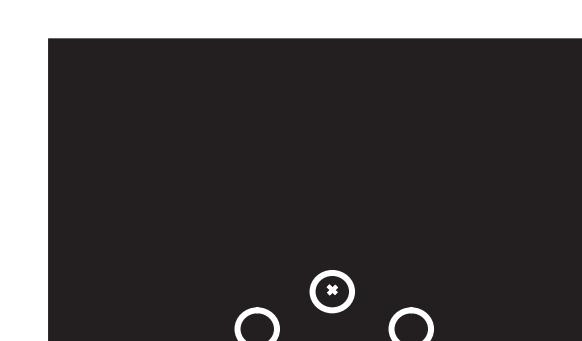
starting position



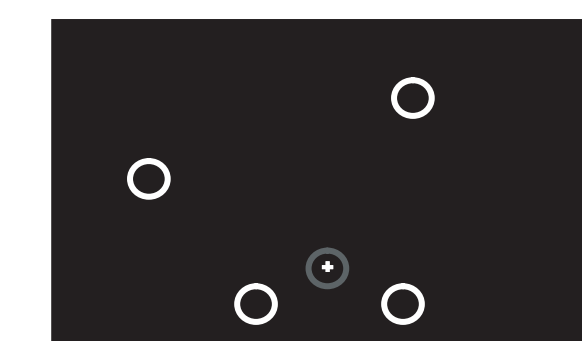
reach



fixation catch trial



bimanual catch trial



TMS experiment design:

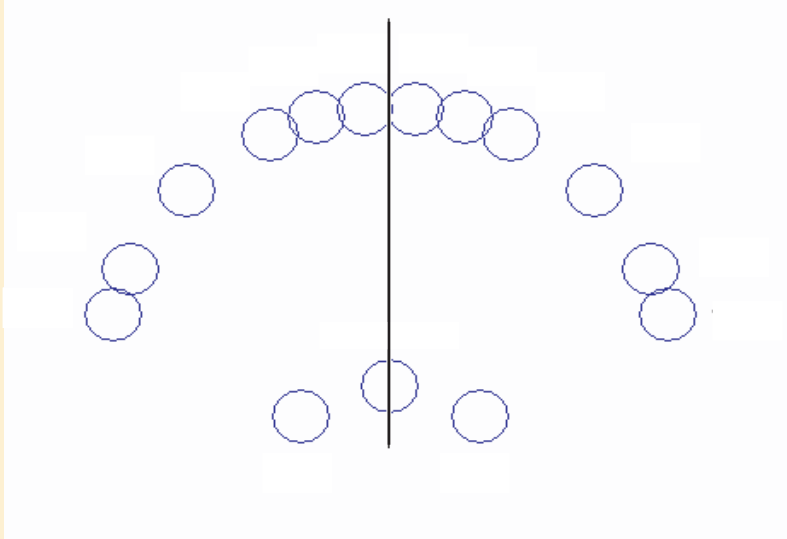
- Each block has 120 reaches
- 60 with TMS, 60 without TMS, pseudo-randomly mixed, satisfying the constraint that no more than 3 TMS trials can happen in a row
- 8 right handed subjects

Stimulation Parameters

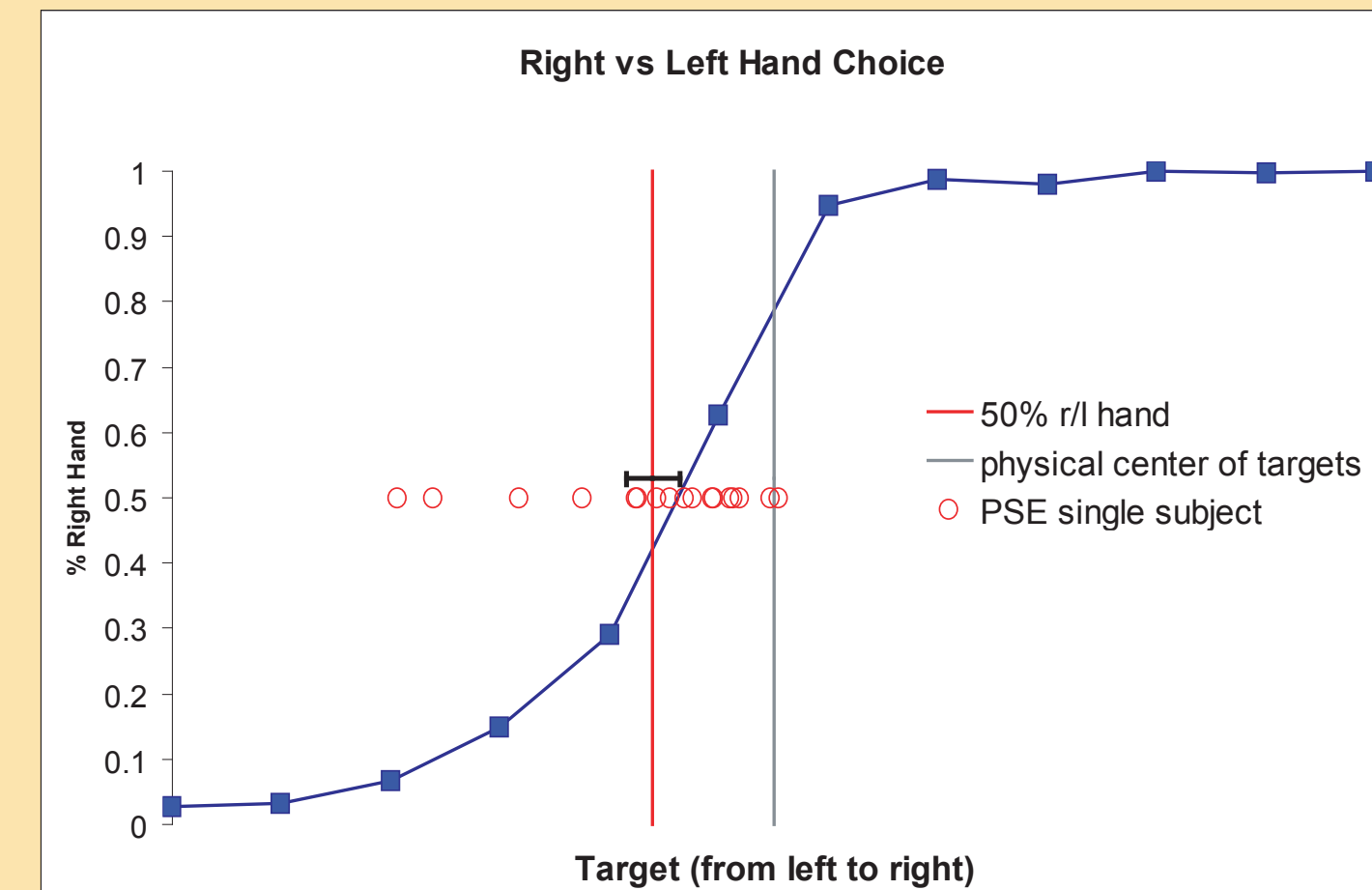
- Left and right Lateral Premotor Cortex
- Measure 1 cm medial x 1.5 cm anterior to motor hand notch
- Max (115% of active left motor threshold, 60% MSO)
- 140 ms after stimulus onset

Results: Behavioral

How does higher competition between the hands for central reaches affect reaction time?

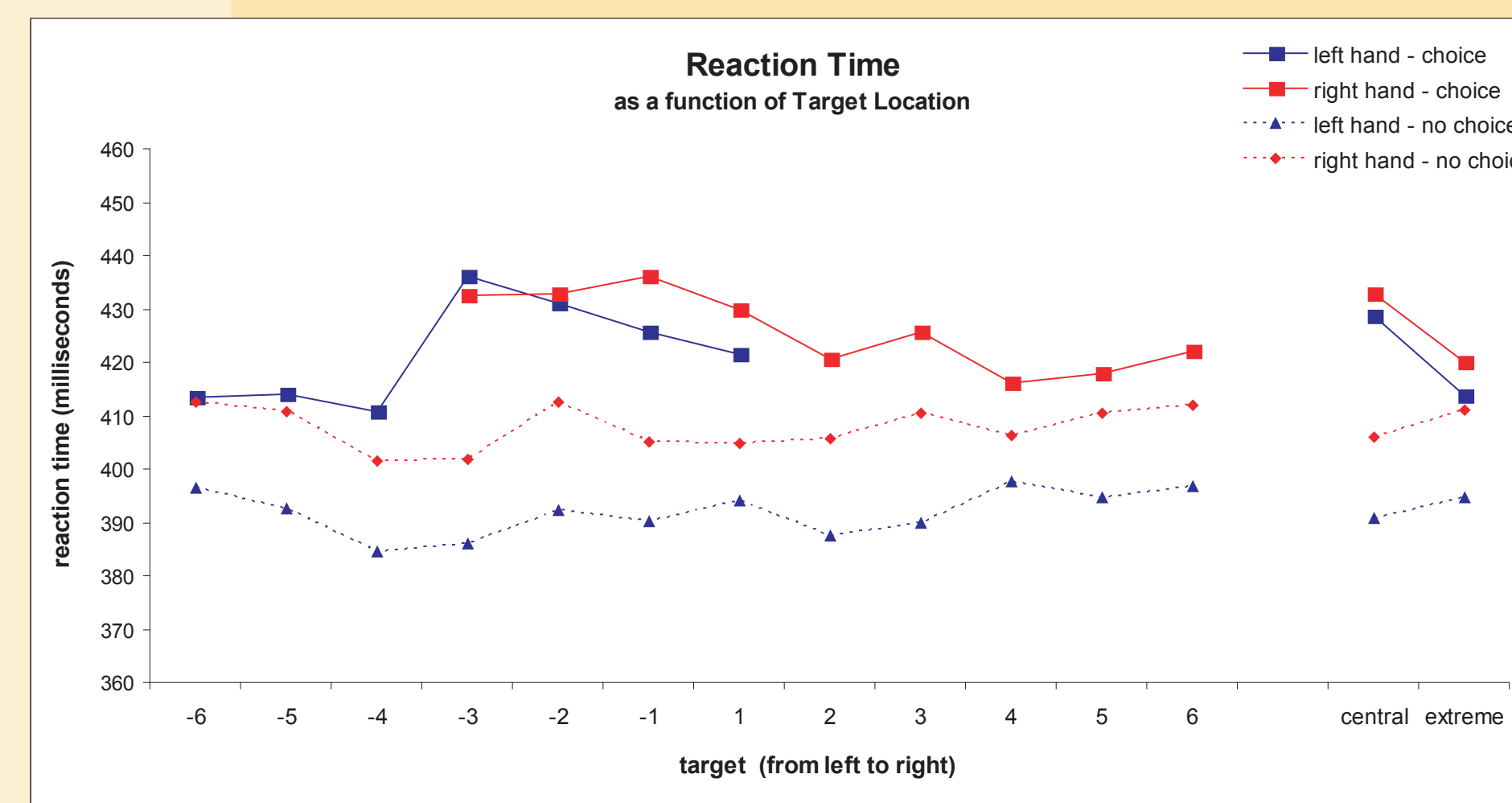


- 17 right-handed subjects
- 4 blocks left, 4 blocks right, 8 choice
- 8 or 16 reaches/target/condition



Hand Choice Curve:

Subjects used closest hand for the extreme left and extreme right targets, with a soft-decision boundary between these extremes



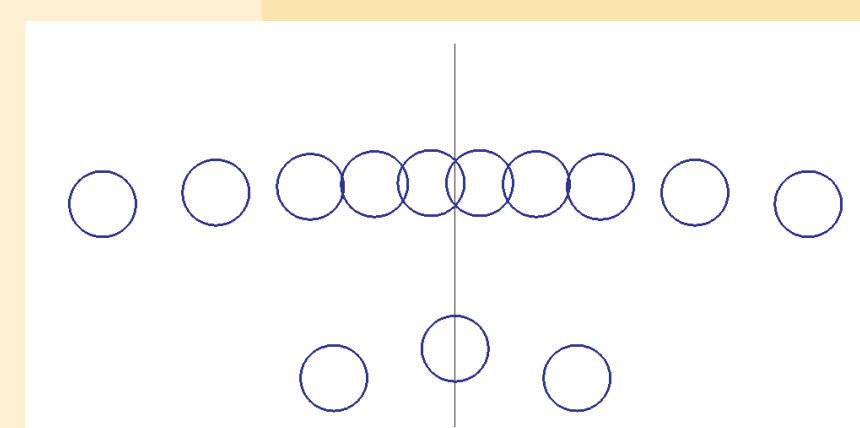
for any point, S.E.M. ~ 6-12 ms

Reaction Time :

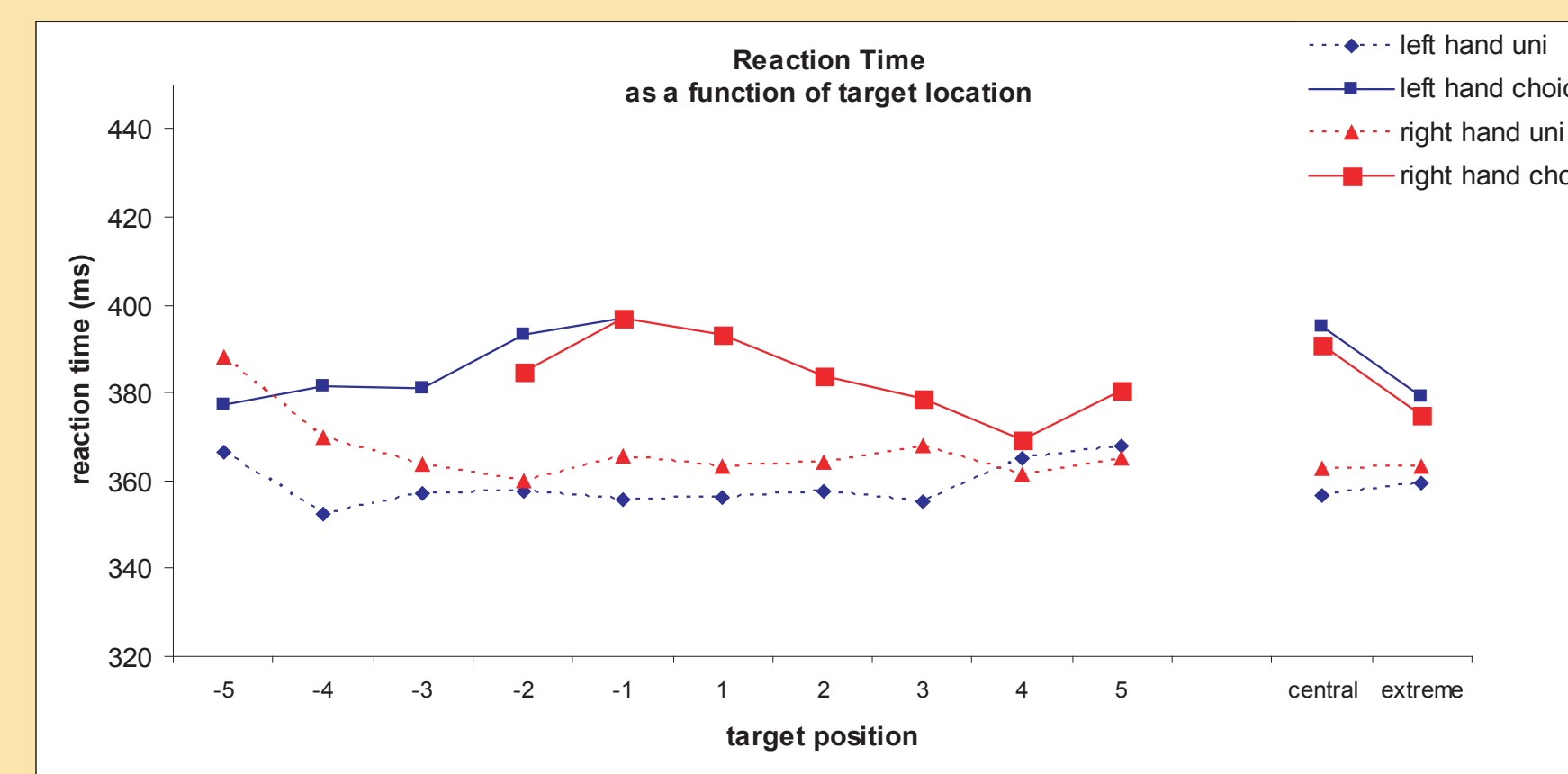
- Unimanual conditions (dotted lines) show consistent reaction times across target locations

- During the choice condition, elevated reaction times are seen for the central targets. Average RTs for the central targets {-2 -1 1 2} and extreme targets {-6, -6, 5, 6} are collapsed and shown on the right

Is there still an central-extreme RT cost when distance isn't a confound?



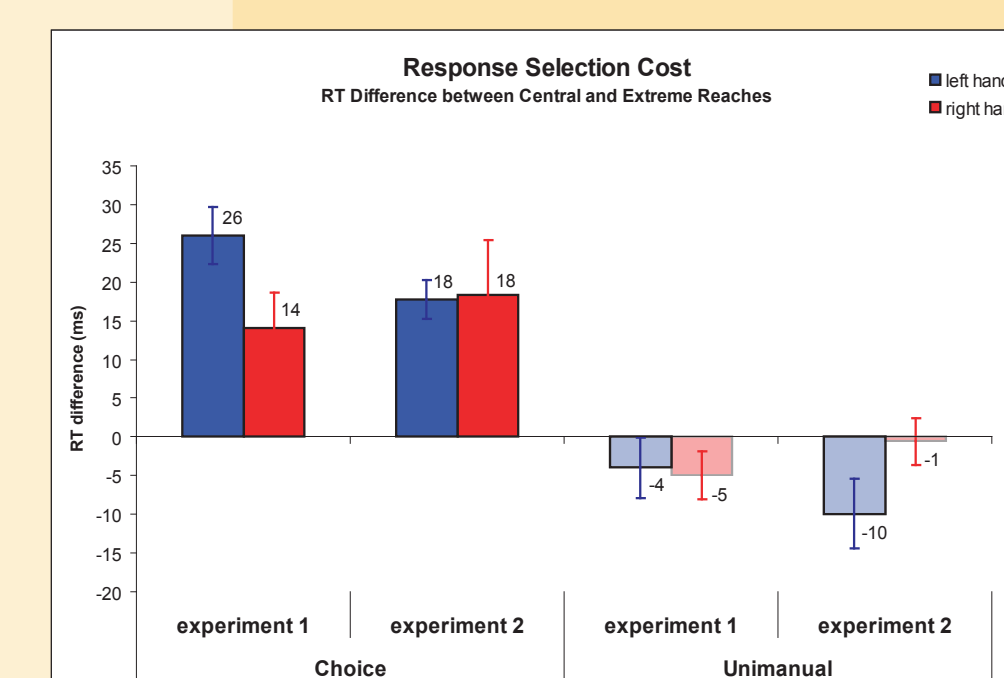
- 8 subjects
- 3 blocks left only, blocks right only, 3 blocks choice reaching
- 15 reaches/target/condition
- Fixation catch trials (with added distractor reaching target)



for any point, S.E.M. ~ 15-20 ms

Comparison of Response Selection costs from behavioral experiments:

- Response selection cost is similar (~20 ms) for both experiments

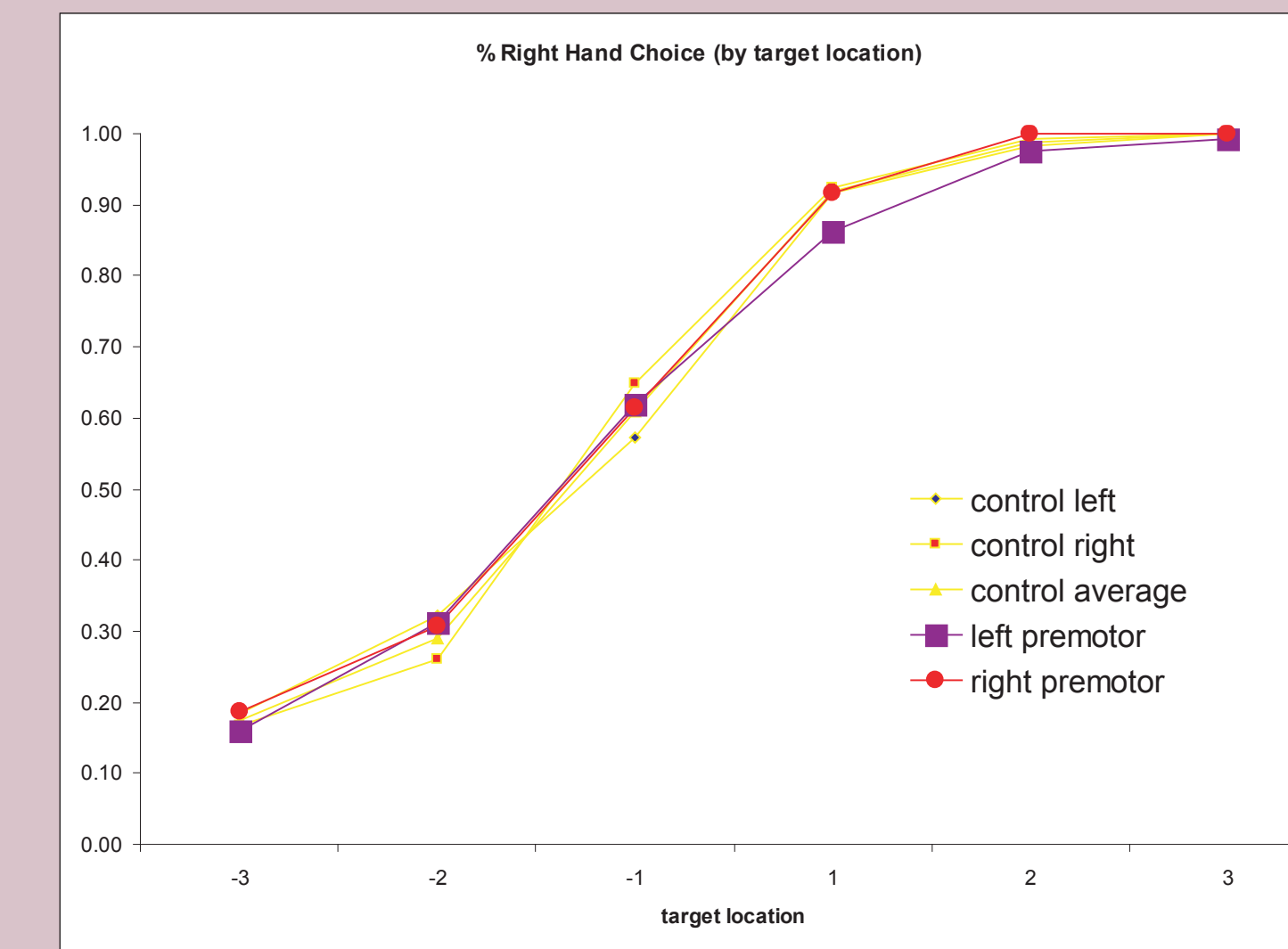


RTs are slower to central targets

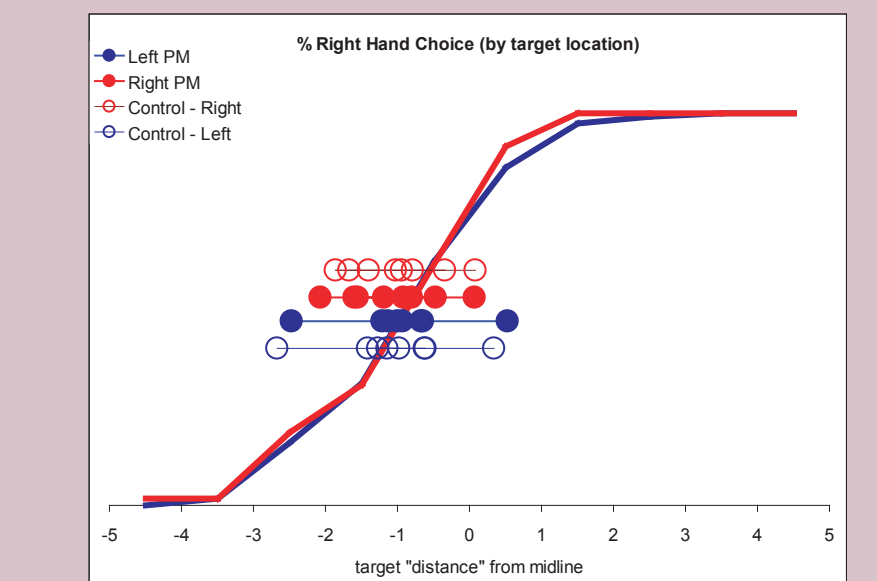
RTs are slower to peripheral targets

Results: TMS

Hand Choice Curves:



- 6 of the 10 targets in the central region plotted (left)
- No difference in hand choice curves across conditions

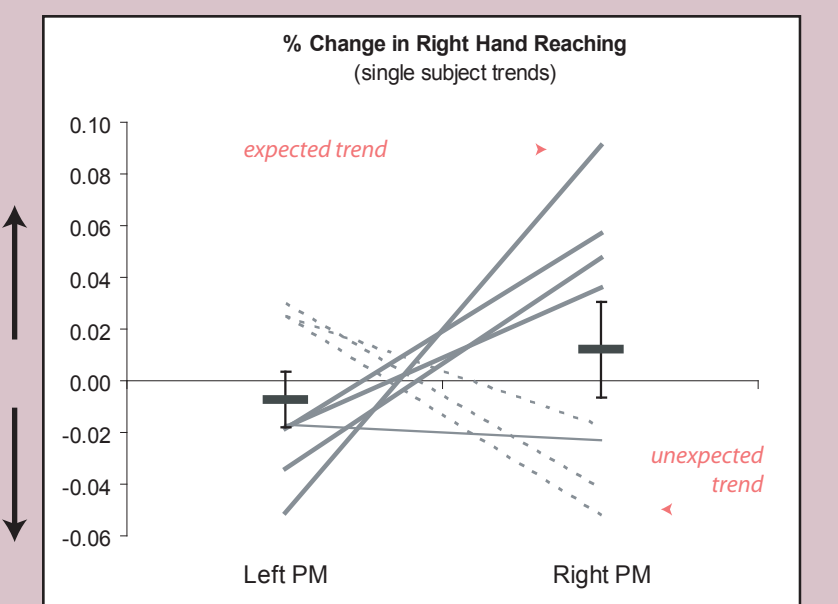


- Single subject 50% Hand Choice points for each condition, plotted on the group average hand choice curve.

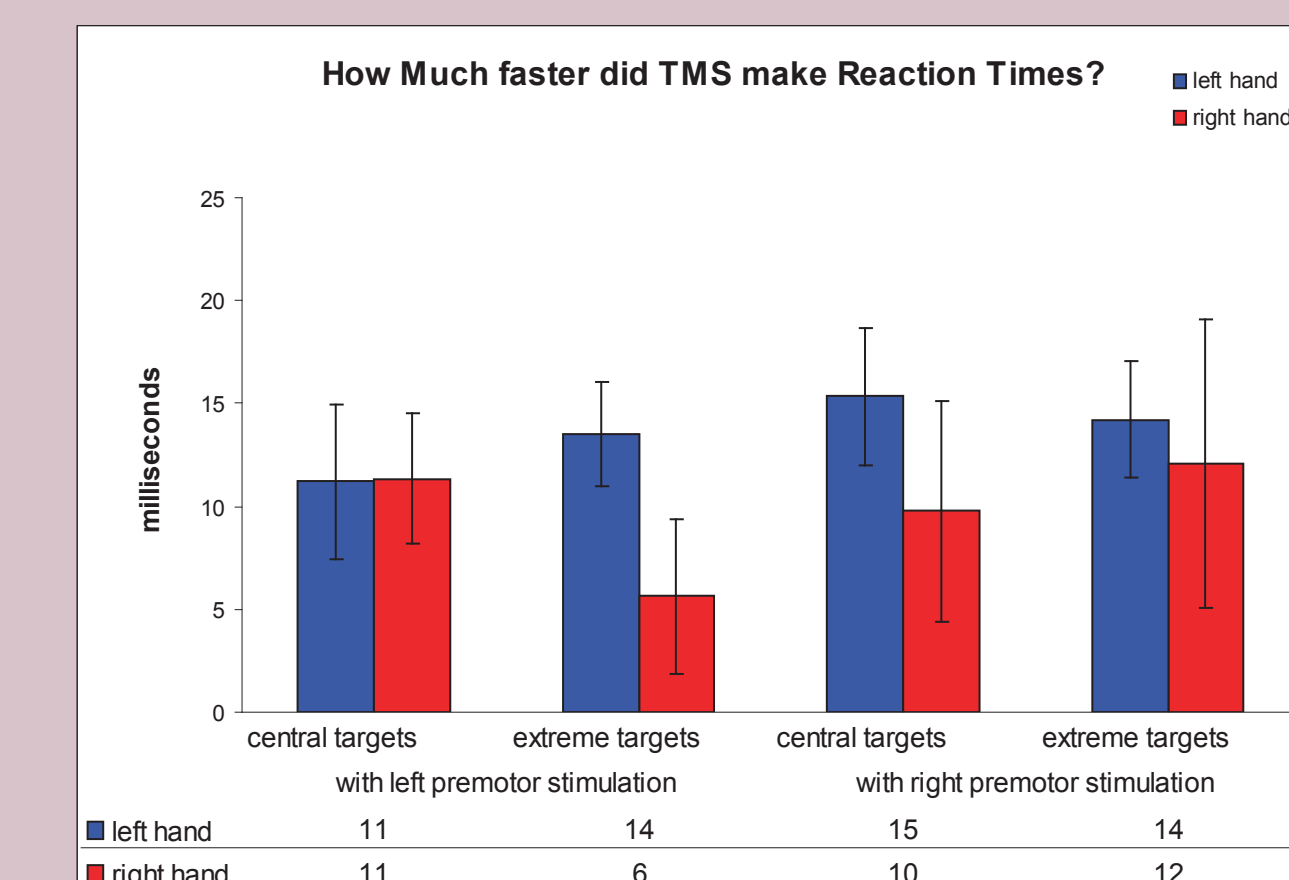
How much more did people reach with their right hand during TMS?

Prediction:
More right hand reaches with Right PM stimulation and less during left PM stimulation

- 4 of 8 of the subjects showed the expected trend
- 3 showed the opposite trend

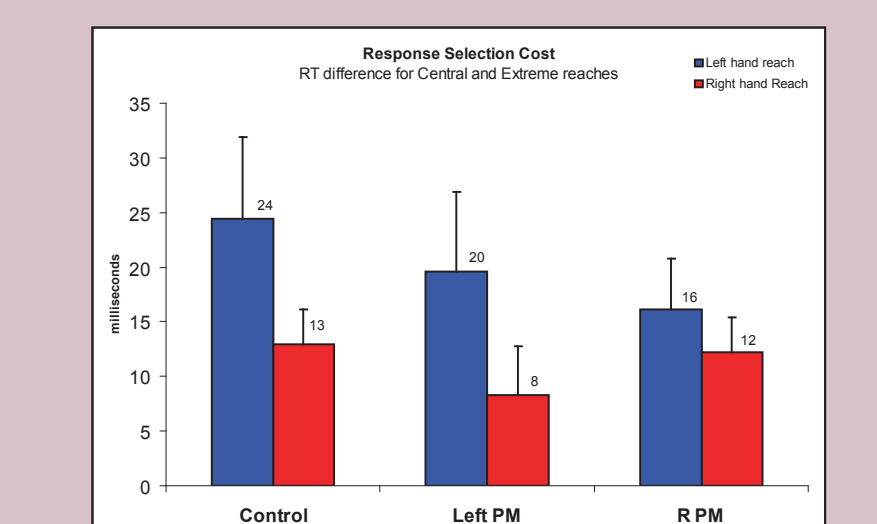


More Right hand Reaches
Fewer Right hand Reaches



Reaction time:

-TMS sped reaction times for both central and extreme targets during both left and right premotor TMS

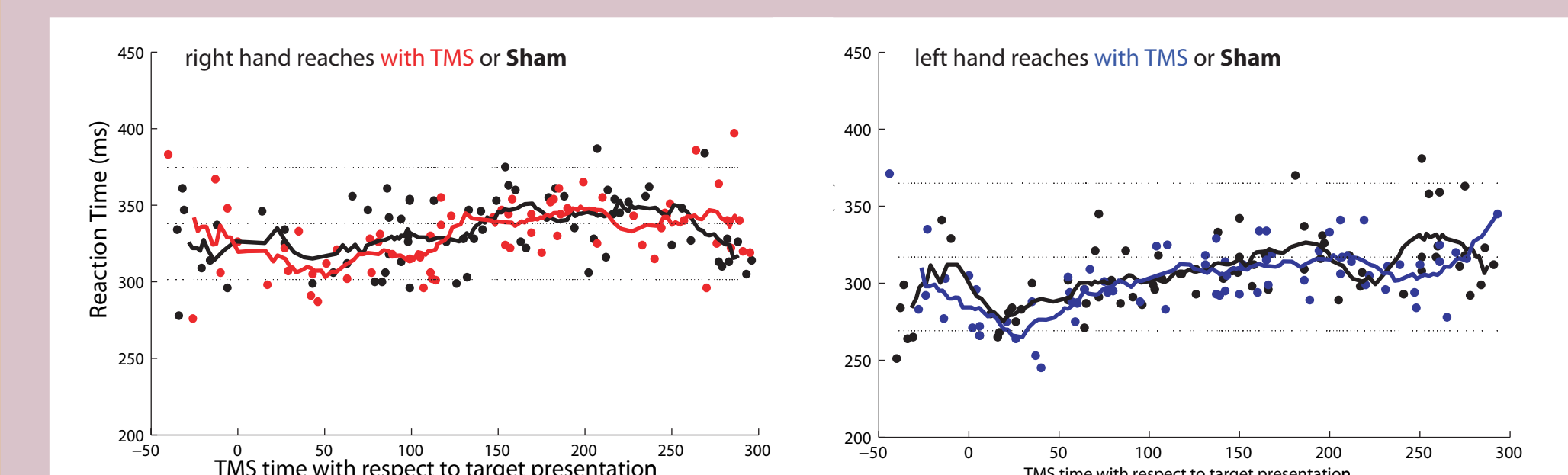


- Response selection cost is unaffected by TMS

Is there any time that TMS over lateral PM will delay a direct reaching movement?

- Pilot studies with two reaching locations
- Left premotor stimulation or sham stimulation, 70% MSO
- TMS delivered uniformly between [-50 300]ms of target onset

Reaction time as a function of time of stimulation over **Left PM** (single subject):



- Reaction time is speeded for TMS between 0 and 150 ms after target onset

- No clear window of stimulation that leads to a delayed RT

Summary

Behavioral:

- Reaction time is ~ 20 ms greater for reaches to central targets than to extreme targets when either hand can be used to perform the reach. This does not change when central targets are closer to both hands than extreme targets. This paradigm provides a consistent behavioral measure for **response selection** cost.

- When people had the option of using both hands, reaction times were ~ 20 ms slower than when the reaching hand was specified in advance. This is evidence for a **bimanual preparation** cost.

TMS:

- TMS over left and right premotor cortex at 140 ms **speeds reaction times** independent of stimulation site and reaching hand. This likely reflects the general arousal effect of the TMS pulse click.

- Stimulation of Left premotor at 70% MSO delivered in anywhere between -50 ms and 300 ms before or after target presentation also fails to delay reaction time of a direct reaching movement.

Conclusion:

- We were unable to influence hand choice with premotor TMS. Future work will explore the effects of TMS over parietal cortex and SMA.