Using TMS to elucidate interactions between top-down and bottom-up brain networks in visual discrimination

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Introduction

Single-unit and multiunit recordings in primates have already established that decision making involves at least two general stages of neural processing: representation of evidence from early sensory areas and accumulation of evidence to a decision threshold from decision-related regions.

However, the relay of information from early sensory to decision areas, such that the accumulation process is instigated, is not well understood.

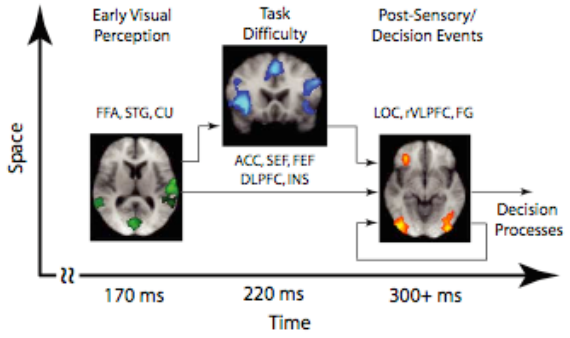
Using EEG, Sajda and colleagues previously reported on temporally specific components related to perceptual decision making (1,2). They used this information to inform the analysis of fMRI data collected for the same behavioral task to ascertain the cortical origins of each of these EEG components (3).

As can be seen in Figure 1, a cascade of events associated with perceptual decision making was revealed which takes place in highly distributed neural networks.

Of particular importance is an activation in the lateral occipital complex (**LOC**) implicating perceptual persistence as a mechanism by which object decision making in the human brain is instigated.

Here, we used paired pulses of TMS at various times in relation to the onset of an object to be discriminated in an attempt to causally demonstrate that the LOC is indeed involved with object decision making. We expected later TMS (at about 400 ms) to interfere with decision making.

Figure 1. Spatiotemporal diagram of the processes involved in perceptual decision making.



References

1. Philiastides and Sajda, Cerebral Cortex 2006, 16: 509-518.
2. Philiastides Ratcliff and Sajda, J Neuroscience, 2006, 26: 8965-8975.
3. Philiastides and Sajda, J Neuroscience, 2007, 27: 13082-13091.

Disclosures

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Methods

Subjects: 14 healthy volunteers: 9 male, all young adult Duke students.

Stimuli: A set of 12 face and 12 car grayscale images (image size, 512 512 pixels; 8 bits/pixel) were used . All images were equated for spatial frequency, luminance, and contrast.

Task: Subjects, seated before a computer monitor, were asked discriminate between grayscale images of faces and cars. Within a block of trials, face and car images over a range of phase coherences were presented in random order (Figure 2).

The levels of phase coherence for both categories were chosen according to psychophysical staircases which converged on a 75% hit rate concurrently for faces and cars.

They made yes/no decisions with hand-held buttons.

Figure 2. Schematic diagram of the face/ car discrimination task

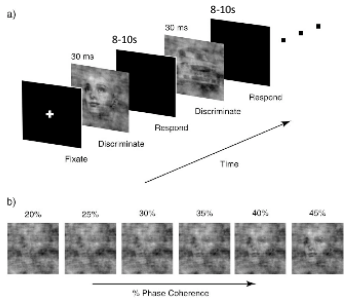


Figure 3. Procedure for each subject

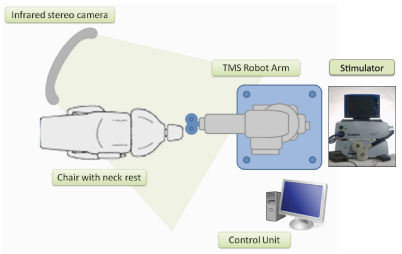
Analysis: 2 x 2 x 5 Repeated measures ANOVAs on RT and % Correct, with factors of Site (left, right), Stimulus type (face, car), and SOA (-200, 200, 400, 450, 500).

TMS: In each trial, two pulses (separated by 50 ms) from a MagVenture MagPro 100 device (100% motor threshold) were randomly time-locked to stimulus onset at 5 different latencies (-200, 200, 400, 450 and 500 ms). In addition, 1/6 of the trials had no TMS.

Latencies are referred to as SOAs: stimulus onset asynchronies

TMS targets were left and right lateral occipital cortex, based on the locations in previous group analyses (Figure 1).

Figure 4. The ANT SmartMove robotic positioning system was used to target the coil, using each individual's structural MRI.



Results

Figure 5. There was a significant effect of SOA on RT ($p < 0.01$). This was due to slowing with the first pulse at 400 ms compared with a no TMS condition, as well as speeding of response at -200 ms (both significant in post hoc analyses).

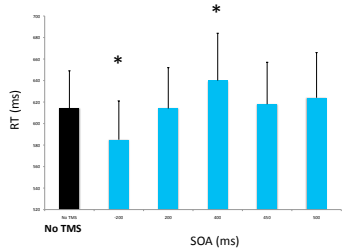


Figure 6. There was also a significant effect of SOA on %Correct ($p < 0.05$). This was due to decreased accuracy at 200 ms, and to increased accuracy at -200 ms.

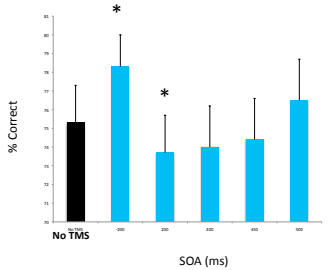
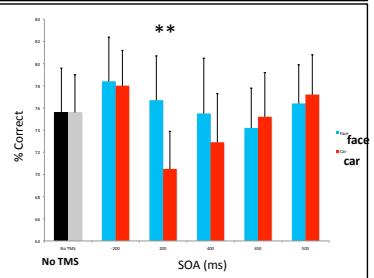


Figure 7. There was also a significant interaction of SOA with stimulus type ($p < 0.02$), due to decreased accuracy in correctly identifying cars at 200 ms.



Conclusions

1. Paired pulses of TMS to LOC slowed RT and lowered accuracy at 400 ms, suggesting that region was indeed involved with perceptual decision making, as previous EEG and fMRI data indicated.
2. An unexpected finding was that TMS prior to the onset of the visual stimulus caused enhanced performance, although that is consistent with prior TMS findings.
3. Decreased accuracy at 200 ms (specifically for the more difficult objects to discriminate, i.e., cars) suggests interference with top-down influence on LOC from the second network (Figure 1), which includes DLPFC and is more active with increasing task difficulty.