Importance of recurrent processing in V1 to scene-based object recognition (#25408)

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1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
We have the ability to recognize objects within a split-second, regardless of the location, visual angle, or whether an object is partially occluded. Even in a blurred image, contextual cues from the surrounding scene help us to identify an object (Oliva & Torralba, 2007). Interestingly, some studies have provided evidence that early visual cortex V1 may be of relevance for conscious high-order object recognition. Specifically, Camprodon et al. (2010) showed that during the categorization of noise-degraded objects in briefly presented natural scenes, disruption of V1 with TMS led to a decrease in performance at: 1) an early time point (~100 ms), which corresponds to the first arrival of visual information in V1; and 2) a later time point (~200 ms), which the authors suggested represents recurrent activity induced by object-selective cortex.

In the present study we will test whether this recurrent processing is particularly important for recognizing degraded objects in scenes, in which a feedforward transformation of local features may not suffice for the task. To this end, we will compare the effect of TMS over V1 at different time points for recognizing intact objects without scene context and degraded objects presented within scene context (Brandman & Peelen, 2017). The scenes will also be presented without the object in order to observe how predictive the scene itself is to the object category (no specific predictions are made for this condition). Relative to the onset of these stimuli, disruptive double-pulse transcranial magnetic stimulation (TMS) will be applied over V1 at an early (60-100 ms after stimulus onset), middle (160-200 ms after stimulus onset), and late time point (260-300 ms after stimulus onset). We will test the following two hypotheses: 1) early TMS should disrupt initial processing of visual information in V1 and hence object recognition performance should be affected both for intact objects as well as degraded objects within scenes relative to late TMS. 2) middle TMS should disrupt recurrent information processing of V1 and hence should primarily affect object recognition performance for degraded objects within scenes, relative to late TMS.

Previous studies have indicated that the efficacy of TMS is subject to inter-individual variation and is limited by depth of this area within the brain, skull thickness and orientation of axons within an area. Additionally, TMS parameters, such as intensity, coil shape, coil orientation and pulse waveform, can determine whether TMS will be effective or not. Therefore, phosphene threshold will be determined before the beginning of the study. Only participants who report perceiving phosphenes will be included in the main study. During the main experiment TMS intensity will be set to 85% of phosphene threshold.

3) Describe the key dependent variable(s) specifying how they will be measured.
Participants will be asked to indicate which out of eight objects was represented in the picture (object in scene or object alone). If a scene alone was shown, participants have to indicate which object was removed from the picture. The aim is to answer with the correct object category. The main dependent variable is the percentage of correct trials in object alone, object in scene, and scene alone conditions. A secondary variable is reaction time.

4) How many and which conditions will participants be assigned to?
The experiment adopts a 3x3 repeated-measures design. The first factor, TMS timing, has 3 conditions: early, middle and late. The second factor, stimulus type, has 3 conditions: (intact) object alone, scene alone, and (degraded) object in scene. All conditions have an equal number of trials and are presented in random order.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
We will conduct a 3x2 repeated-measures ANOVA with TMS timing (early, middle, late) and stimulus type (intact objects, degraded objects in scene) as within-subject factors. Accuracy and reaction time will serve as dependent variables in separate ANOVAs. We predict a significant interaction, with TMS timing differentially affecting the two stimulus types. For intact objects, a planned pairwise t-test is predicted to show better performance for TMS late than TMS early. For degraded objects in scenes, two planned pairwise t-tests are predicted to show better performance for TMS late than both TMS middle and TMS early.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
Participants will be excluded who do not complete the experimental procedure. Furthermore, participants whose accuracy falls below 2.5 SDs of the overall mean across conditions will be excluded.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
A sample size of n = 24 will be collected. This number is based on a medium effect size and behavioral data from Brandman & Peelen (2017).

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

As mentioned before, susceptibility to TMS effects vary inter-individually. Therefore, in an exploratory analysis the main analysis will be repeated with the addition of the phosphene threshold as covariate.