# Brain Imaging and Analysis Center
# Scientific Research Proposal

| | | | |
|---|---|---|---|
| Title | Brain Activation Evoked by Masked Words and Masked Nonwords | | |
| Investigator (PI) | Michele Diaz | Email | diaz@biac.duke.edu |
| Department | BIAC | Institution | Duke University |
| Faculty Sponsor | Gregory McCarthy | Email | gregory.mccarthy@duke.edu |
| Responsible Investigator (1) | Gregory McCarthy | Email | gregory.mccarthy@duke.edu |
| Other Investigator (1) | | | |
| Experimenter(s) | M.Diaz, J. Morris, G. McCarthy, S. Green, C. Petty | | |
| Scheduler(s) | M.Diaz, J. Morris, G. McCarthy, S. Green, C. Petty, BIAC Subject coordinators | | |
| People with Data Access | M.Diaz, J. Morris, G. McCarthy, S. Green, C. Petty | | |
| Funding source | R01- PI Gregory McCarthy | | |
| IRB or IACUC Registry # | 275-06-1R8 | | |
| IRB or IACUC Expiration Date | 27 January 2007 | | |
| # of Hours requested | 3.0T 45 | 4.0T 0 | Mock 45 |
| MR Technologist needed? | Yes | BIAC disk needed? | Yes |

Other special requirements (e.g. scheduling, special equipment, etc.):

Suggested ID (optional) Mask.04; Mask.54

*(This section will be completed by BIAC.)*

| | | | |
|---|---|---|---|
| Date Reviewed | | Date Approved | |
| Hours allocated | | Expiration Date | |
| Experiment ID | | BIAC Disk Allocated | |

Explanation of Terms:

- Responsible Investigator – person who holds the funding for the research.
- Other Investigator – individual involved in the oversight of scanner usage and/or billing. This individual will also receive a copy of the scanner invoice.
- Experimenter – primary person(s) present during scanning; may be running the experiment or just accompanying the subject. This can be *none* if no one besides the MR tech will be there.
- Scheduler – person(s) with the ability to schedule scanner time; schedulers do not have data access.
- Data Access – person(s) with the level of access can access the data, but are unable to schedule scanner time.

Please attach a short description of your proposed study (3 pages maximum). Be sure to address the following:

- Rationale and Scientific Significance
- Experimental Design
- Imaging Protocol
- Data Analysis

You may also supply optional appendix material if you wish (e.g., preliminary data, relevant publications, etc.).

Please e-mail your proposal to: research@biac.duke.edu; After you have submitted your proposal via email, please fax your IRB "Notification of Approval" to 919-681-7033. Requests for pilot time should be directed via email to Gregory McCarthy, gregory.mccarthy@duke.edu and cc research@biac.duke.edu.

## Rationale and Scientific Significance

Previous research has indicated that stimuli, even when masked to the point at which identification is not possible, provide facilitation in processing subsequent stimuli [3,5]. Traditionally, this has been shown behaviorally using a priming paradigm with prime-target pairs either identical to one another (i.e. repetition priming) or related in meaning (i.e. semantic priming). Both types of prime target pairs have been shown to yield facilitation. Recently, Dehaene and colleagues have demonstrated the efficacy of using masking with functional imaging through a series of experiments using word and numerical stimuli in a masked priming paradigm [1,2]. An addition appeal of using masked words as stimuli is that activation associated with the word represents processing of the word, without contribution from overt strategic or conscious processes. However, it is well established that masked stimuli typically generate smaller amounts of facilitation compared to fully visible stimuli. In traditional behavioral paradigms the magnitude of facilitation is typically between 10 – 20 ms [3,5]; Mask.03-32]. Although Dehaene and colleagues have successfully conducted several studies using masking in conjunction with functional imaging, to date no other research groups have conducted similar experiments [1,2]. Given the typically small effect size and the limited implementation of the masking technique in conjunction with imaging, it is warranted to establish the feasibility of functional imaging in detecting effects of this magnitude. Therefore, the proposed study is designed to test the feasibility of using masking with functional imaging. The purpose of the study is twofold: first we will establish whether the processing of masked words can be differentiated from the processing of masked nonwords through patterns and/or levels of activation obtained via functional imaging. Second, the experiment will allow us to generate estimates of noise, which can be used to calculate power estimations and the required number of trials for future masking experiments. It is important to note, that from this manipulation we will only be able to infer that differences are not due to orthographic or perceptual processing as words and nonwords share these commonalities. Beyond this, we will not be able to precisely infer what level of processing is responsible for differential patterns of activation as words and nonwords differ on many properties (e.g. lexical, phonological, semantic aspects). However, this is an anticipated and understood limitation and it is not the purpose of this study to determine from what differential activations arise, only that differences can arise. Pending the success of implementing masking with functional imaging, it is our intent to conduct subsequent studies utilizing masking that will investigate these levels of processing issues (e.g. masked priming, masking categories of words). The proposed study is a continuation of previous experiments broadly concerned with investigating the neural substrates of semantic and lexical processing of words, without the influence of task-related, strategic activation (Mask.01 & Mask.02, see figure 1).

## Experimental Design

The proposed manipulation will establish the feasibility of using masking and functional imaging. In Mask.04, a baseline of nonwords, preceded and followed by a perceptual mask, will be presented at a rate of 2 per sec with no interval between trials.

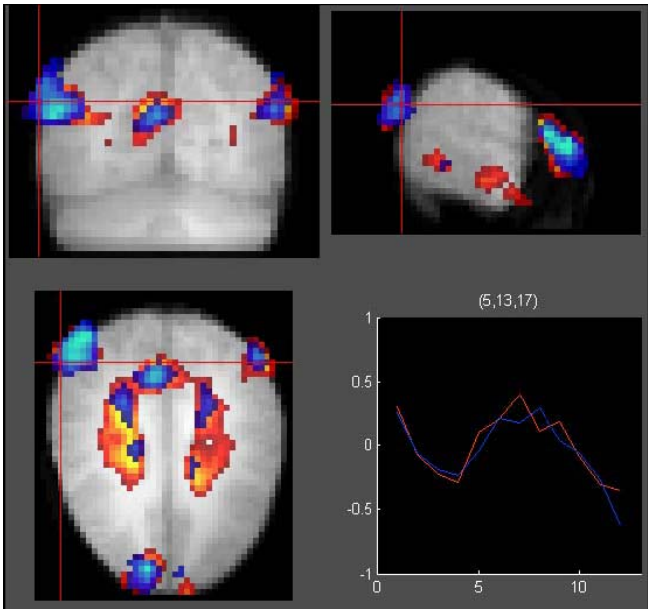


**Figure 1 Mask.02 Activations to content (red) and function (blue) words. Parietal activations are sensitive to lexical aspects, temporal activations are selective to semantic aspects. All activations are t > 3.6.**

The purpose of the continual presentation of masked nonwords is to maximally activate areas that respond only to orthographic or perceptual qualities of the stimuli, further ensuring that any activation above and beyond the baseline is not due to preliminary perceptual analysis [4]. Between the masked nonword trials, masked word trials (concrete nouns) will be interspersed every 12 – 15 seconds. This timing interval will avoid overlap in hemodynamic responses to masked word trials. Concurrent with and orthogonal to the presentation of masked words and nonwords, participants will be asked to perform a button press task on certain trials. During this task participants will be shown colored punctuation marking (e.g. %%%%%%, &&&&&) and asked to respond with a button press (e.g press the left button for blue, right for red). In order to ensure that task related activations are not directly contributing to critical trial activations, participants will not have to perform the task on any masked trial, and the interval for the overt task will be such that it will not occur in close temporal proximity to the masked word trials. The purpose of the overt task is to engage participants and ensure that they are attending to the stimuli. Previous research has indicated that thresholds of perception can vary across individuals. Therefore displaying a masked stimulus for one duration may be long enough for some participants to see the masked stimuli and too brief for others, such that presentation does not result in any meaningful processing. Prior to the anatomical or functional imaging runs, participants will be asked to perform a titration task so that the appropriate duration for

the masked stimuli can be determined. Specifically we are interested in determining the longest duration at which participants cannot report what stimulus was presented. In this task, participants will be shown a masked stimulus asked to report what if anything was shown between the masks. This procedure was successfully used in behavioral pilot studies (Mask.03- 32). Because goggle display quality is known to change within and outside the scanner, the titration portion of the experiment will be conducted inside the scanner, prior to anatomical and functional scanning. We anticipate using the CIGAL program [6] to control stimulus presentation. Subjects will be male and female typically developing healthy young adults. We estimate that the titration procedure will require 15 minutes, collection of anatomical data will require 30 minutes and the collection of functional data will require approximately 45 minutes, for a total scanner time of 90 minutes. We anticipate requiring approximately 15 subjects for this study, so we have requested 20 1.5 hour imaging slots in the 4T scanner to account for normal subject dropout rates. Additionally, we have requested 15 hours on the mock scanner (Mask.41), to allow for practice and training sessions for naïve subjects.

## Imaging Protocol

MR scanning will be conducted on the 4T BIAC scanner. Following localizer, anatomical series, and high-order shimming, a series of 34 functional slices (axial) will be acquired using Dr. Song's inverse-spiral pulse sequence. The functional voxel dimensions will be isotropic 3.8 mm3 and the TR will be 1.5 s (TE: 35 ms; 24 cm2 FOV), allowing full-brain coverage. High-resolution spin-echo structural images will be acquired for each slice in axial orientation (2:1 ratio, in-plane resolution of 1.9 mm2).

## Data Analysis

Preprocessing steps will include quality assurance procedures, TR alignment, and motion correction, which will be conducted using SPM (Wellcome Dept. of Cognitive Neurology) and custom written MATLAB scripts. After preprocessing, several analysis techniques will be employed. One analysis will consist of an anatomical region of interest (ROI) approach. Previous experiments conducted here indicated several regions of interest in inferior parietal and anterior inferior temporal gyri. Other research has also indicated fusiform gyrus and inferior frontal regions. The average hemodynamic response (HDR) time-locked to the onset of each stimulus type will be measured for each slice. The distribution of activity in the regions of interest will be evaluated, as will potential hemispheric differences, as a function of stimulus condition. For other analyses, the data will be normalized into stereotaxic space and analysis will involve correlating the hemodynamic responses of each voxel with a standard hemodynamic response. Regions of activation will be identified as a function of stimulus condition, and we will again examine the topographic distribution and intensity of activity as a function of stimulus condition. Regression models will be constructed to identify voxels activated by each stimulus condition.

## References

[1] Dehaene, S., Naccache, L., Cohen, L., Le Bihan, D., Mangin, J., Poline, J. and Riviere, D., Cerebral mechanisms of word masking and unconscious repetition priming, Nature Neuroscience, 4 (2001) 752-758.

[2] Dehaene, S., Naccache, L., LeClec'h, G., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., van de Moortele, P. and Le Bihan, D., Imaging unconscious semantic priming, Nature, 395 (1998) 597-600.

[3] Forster, K.I., The pros and cons of masked priming., Journal of Psycholinguistic Research, 27 (1998) 203-233.

[4] Grill-Spector, K. and Malach, R., fMR-adaptation: a tool for studying the functional properties of human cortical neurons, Acta Psychologica, 107 (2001) 293-321.

[5] Marcel, A.J., Conscious and unconscious perception: experiments on visual masking and word recognition, Cognitive Psychology, 15 (1983) 197-237.

[6] Voyvodic, J.T., Real-time fMRI integrating paradigm control, physiology, behavior and on-line statistical analysis., Neuroimage, 10 (1999) 91-106.