2007 Guide Book

Pittsburgh Brain Activity Interpretation Competition:
Interpreting subject-driven actions and sensory experience
in a rigorously characterized virtual world

The Experience Based Cognition Project
University of Pittsburgh

Version 5 – Updated: April 27, 2007
Send comments to: ebc@pitt.edu
Details at http://www.braincompetition.org

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1. Summary

The 2007 Pittsburgh Brain Activity Interpretation Competition is an open competition that will involve fMRI data analysis of subject-driven behavior in a virtual world. Behaviors include navigating, collecting objects, responding to cell phone calls, taking pictures and avoiding a threatening dog. Conceptually, the challenge is to interpret brain activity sufficiently to be able to predict what an observer is experiencing by looking at fMRI data of their brain. A collection of story board images as well as a video of a short sample run can be viewed at http://www.ebc.pitt.edu/2007/materials.html).

Subjects executed tasks during three runs, each approximately 20-minutes in length. For all three runs, tasks were performed in the same virtual world with similar events. Each Competing Group (CG) will be provided with high quality 3T EPI fMRI data and features describing the subjects' experiences for 2 runs to develop and calibrate their brain activity analysis methods and fMRI data only for a third run which will be used for the competition. Subjects experiences are quantified in 14 required features. There are also be 11 extra credit features and other available features that will not be quantitatively scored in competition (see Appendix C for further details) but which may be used in entries for the "Reviewer's Choice" award (See section 12a. Scoring Summary). Some "objective" features were computed from the state of the VR world, the subject's behaviors and eye-tracking acquired during the runs (e.g., whether the subject is moving, picking up objects, etc.,). Other "subjective" features were rated dynamically by subjects after the run (e.g., degree of arousal). In addition CGs will also be able to download videos of subject game play for the first two runs. The CG's task will be to predict the dynamic time-course of the feature data for the third run exclusively from the fMRI data, e.g., predict when the subjects were moving, picking up objects, or feeling aroused.

CG's can download a program that quantifies the extent to which their predictions for feature data reflect subjects' actual feature data for runs 1 and 2. Accuracy of predictions will be determined by correlating predicted features with the empirical feature data for each volume acquisition of the fMRI data, acquired at 1.75s intervals (see section 12a, Scoring Summary). Once CGs have developed and tested their methods on the fMRI and feature data from runs 1 and 2, they will then try to predict the feature data for each subject from only the fMRI data collected in the third run.

Entrants from all nationalities and academic disciplines are encouraged. CGs must disclose their methods in sufficient detail to enable others to replicate their methods. These data will be reported at the Organization of Human Brain Mapping Conference in Chicago, Illinois which will occur on June 10 - 14, 2007 (see http://www.humanbrainmapping.org for more information). Awards will be announced at the meeting on June 14, 2007.

Notice: This document represents the rules for the competition. The Scientific Board reserves the prerogative to make changes depending on the nature of the submissions. Changes to the rules will be posted on the web site www.braincompetition.org. All decisions of the Board are final.

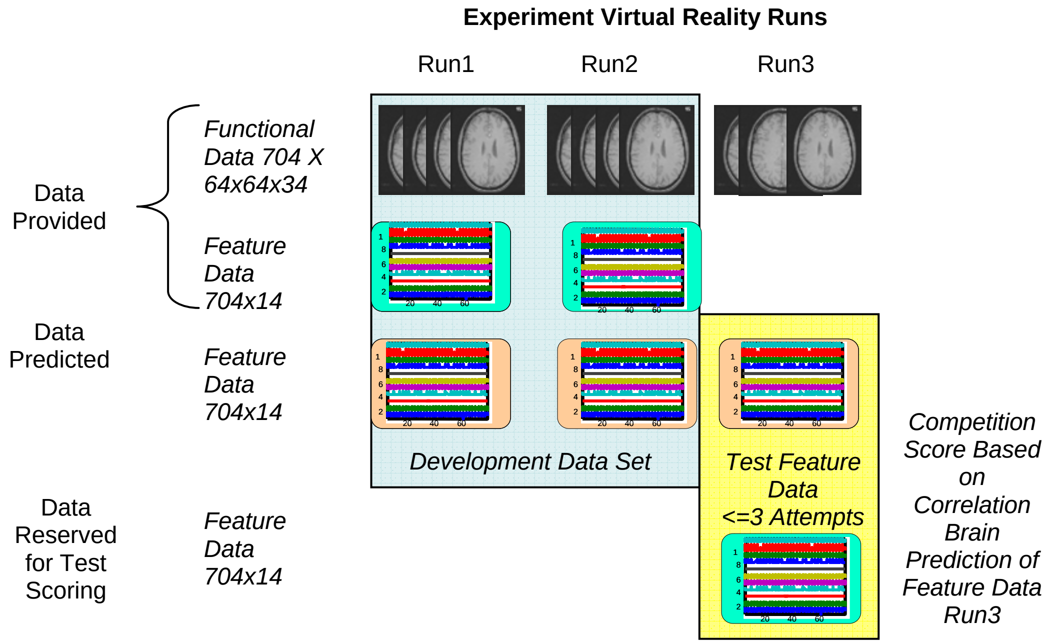
2. Steps Required to Participate in the Competition

1. Read details at http://www.braincompetition.org/
   There you will find the following information:
   - □ Contact information
   - □ Latest news and updates
   - □ Overview of the competition and results from the 2006 competition
   - □ Registration
   - □ Competition materials
   - □ Message board
   - □ Data for download
   - □ Data submission
2. Sign up for the competition at http://www.ebc.pitt.edu/2007/registration.html (Sign up period closed May 1, 2007).
3. Download the functional and feature data (instructions sent after you sign up and after the release date – expected March 19, 2007).
4. Familiarize yourself with the range of formats and tools available to examine the data. Of particular note, we will provide Matlab matrices of the data and a basic framework for

using them (see Appendix G). In addition, the Princeton group has provided their tools, developed to process and analyze the data from the 2006 competition for use this year (see Appendix G).

5. Utilize subject data from runs 1 and 2 to develop your techniques to predict the feature data in run 3.
6. Test your technique by writing a prediction file and using the downloadable scoring program on the data for run 1 or 2.
7. Generate prediction files for run 3 using the fMRI data from run 3 to predict the feature data. You are allowed only 3 submissions of run 3 data, which must be completed by May 21, 2007.

The diagram below shows the basic data involved. The top 2 rows reflect the downloadable fMRI and feature data. The bottom row reflects the predictions created by CGs.



3. Support

a. There will be two web casts:

http://mediasite.cidde.pitt.edu/mediasite/Viewer/?peid=8272a3d7-8c1c-4b0f-ac70-256542c31680

The first provides a competition overview, discusses the data and possible approaches, data formats, competition scoring, and an example regression. The slides from the presentations will be available at *www.braincompetition.org*.

The second web cast will respond to questions and provide an update on the progress of the competition. Its date has not yet been determined.

b. We will be operating an electronic message board for discussion and answering questions. See *www.braincompetition.org*

4. Mission Challenge

If we understand how the brain represents information, and fMRI recordings provide sufficient spatial and temporal information, in principle we should be able to tell what the person is experiencing by looking at patterns of brain activity.

5. Time Table

- **March 14, 2007 -** Announcement of competition via emails and postings
- **March 19, 2007 -** Data available for two runs of one subject with at least 5 required features
- **March 28, 2007 –** Full data for all 3 subjects as well as all features
- **April 16, 2007 –** Submission/scoring of run 3 data open. Only 3 submissions are allowed at a rate of once per day. Most groups do most of the submissions in the last two weeks.
- **May 1, 2007 –** Registration closed. Groups must register to compete and agree to terms of the competition and confidentially constraints of access to the data
- **May 21, 2007 -** Final submissions of project BY 12:00PM EDT
- **May 23, 2007 -** Board teleconference to make judgments
- **May 25, 2007 -** Notify top 25 of their being top contenders
- **June 14, 2007 -** OHBM awards in Chicago, Illinois USA

6. Differences from 2006 to 2007 Competition

The 2006 Pittsburgh Brain Activity Interpretation Competition was a very successful competition involving prediction of movie viewing from fMRI data for prize money. The competition generated widespread interest as evidenced by 25,000 website hits and 273 groups in 31 countries downloading fMRI data sets along with a positive review in **Nature Neuroscience** (2006, Vol. 8, p. 981). Details for the 2006 competition can be found at http://www.ebc.pitt.edu/2006/competition.html. The 2006 website also contains abstracts of the winning entries and their scores. This year we have endeavored to improve on the scientific interest, ease, and likely importance of the competition in a number of ways:

Last Year	This year
Subjects were passive viewers of videos	Subjects are actively engaging in tasks within a virtual world
All of the features were subjective, based on post-hoc ratings made by subjects	Most feature vectors are based on computed metrics of the subject activity in the virtual world based on the world state, subjects' behaviors, or their eye-tracking data. Subjective ratings are used only for truly

	subjective features (e.g., emotionality)
No code to help with the analyses leading to a long start-up period for some groups.	We are providing Matlab data and routines (see Appendix G) to speed up the time it takes groups to get familiar with the data sets and generation of data entries
Scores on all extra credit features were averaged, making it very hard for groups to increase their score by adding specific features they wished to choose	All extra credit features have the same weight. Only the top 6 extra credit features will be used in scoring, so that groups are free to pick whatever extra credit features they would like to submit.
Difficult to determine the robustness of entries	Winning groups will be asked to provide sensitivity analyses of their technique and upload their predictions of specific features. This is to facilitate meta-analysis across all groups.
Exclusively objective scoring based on correlations of feature vectors with ratings	Objective scoring for top 3 prizes. Added an additional "cognitive neuroscience" prize for the group that makes the biggest subjective contribution to contribution to cognitive neuroscience (See section 12h, Cognitive Neuroscience Prize)

7. Scientific Advisory Board

This competition is run under the advice of a scientific advisory board made up of members from the scientific community with extensive knowledge of brain imaging, statistics, and data mining. All decisions are made by the advisory board and no government officials are involved in the competition judging process. The members of the advisory board volunteer their time on setting up and judging the competition. Walter Schneider and Greg Siegle of the University of Pittsburgh chair the competition. See Appendix H for a complete list of the Scientific Advisory Board.

8. Experiment

Subjects performed search tasks in a virtual world. The data were coded by subjective and objective ratings. See Appendix C for features and Appendix B for task description.

9. Feature Data

The rating data includes objective and subjective ratings of features.

9a. Objective features

The objective features were extracted using three methods: VR World recorded features, scene-based features from eye movements, and soundtrack-based features. The table below provides a description of each method with the required objective features collected:

Method	Description	Required Object Feature(s)
VR World recorded	The VR world software logs events (at millisecond timing) as a subject performs actions in the virtual world. The search feature vectors (what tasks are current) and hits feature vector (when the subject picked up fruits or weapons or took a snapshot) were derived from the timestamped events in the VR world logfile. Events such as fruit pickups that were timestamped as occuring at a single millisecond were coded as duration one second.	Hits SearchPeople SearchWeapons SearchFruit Instructions Interior Velocity
Scene-based	The VR word software records the scene (visual display of the world) that was generated and presented to the subject in response to his or her movements through the virtual world. These scene changes are recorded as a movie at 60 frames/second. The eye movements of the subject were recorded as they watched the VR world scene being displayed to them during each run. Because eye fixations occur at a rate of about 3 per second, this type of data provides a high temporal resolution recording of what a subject was looking at. See Appendix K for a description of the eye movement data collection and processing. In post-processing steps the subject eye movements were calibrated to the movie frames the subject had been watching, and the movie frame images were then processed to compute which objects in the scene were in the subject's visual field of view. The faces, fruit&vegetables, and weapons&tools feature vectors represent the degree to which these objects were visible to the subject at each frame. See the Guide book Appendix K for a more detailed description of the scene processing algorithm.	Faces Fruit&Vegetables Weapons&Tools
Soundtrack-based	The dog feature vector indicates when the dog was audible to the subjects. This vector was derived from an analysis of the VR world soundtracks for each run. Due to a technical problem the "dog visible" periods are not yet able to be extracted from the scene data. If this problem is resolved the Dog vector will be updated to reflect dog visible and dog audible periods.	Dog

9b. Subjective features

Subjective features were derived by having each subject rate these features while watching a playback of their actions in the virtual world. Rating data was collected at a rate of 60 frames per second and values were rescaled from 0 to 1. Subjects rated each run by moving a slider along a line of continuous values from 0 to 4 and were instructed as to what feature was to be rated and what each value indicated (see Appendix B for more details on rating instructions given to subjects). Two of the required features were derived in this way; valence (how positive or negative the subject was feeling) and arousal (how calm the subject was feeling)

9c. Feature Categories

The provided features are divided into three categories: Required, Extra Credit, and Other (see Appendix C). Note there may be additions to the list of extra credit features as the data is released. As you develop your methods it is best to allow for changes in the extra-credit feature sets.

Required features. These are the required features that will be scored by every entry. The current set include: Arousal, Valence, Music, Hits, SearchPeople, SearchWeapons, SearchFruit, Instructions, Dog, Faces, FruitsVegetables, WeaponsTools, InteriorExterior, Velocity

Extra Credit features. These are extra credit features that you can pick and choose from. If you predict these features they can advance your score. The planned set include: Fearful, Picture, FruitGrab, WeaponGrab, Dog, Body, Gender, SeeFruit, ReadSign, Approach

Other Features. The planned set include: VR-Fixation, EyeGood, EyeX, EyeY, Fixation. Other coded features may be added (e.g., opening doors) but will not be part of the competition.

10. Brain Activation Data

The data were collected in Pittsburgh on the Siemens Allegra 3T scanner. Thirty-four axial 3.5mm thick slices wer acquired parallel to the AC-PC line using a reverse EPI sequence (TR = 1.75s, TE = 25ms, FOV = 210mm, flip angle = 76degrees). Structural data were acquired with 1mm spatial resolution. We are providing data from three subjects. The data sets will be made available in DICOM, ANALYZE, and Matlab data formats to make it easier for groups to utilize the data (see Appendix D). We provide data with a variety of preprocessing stages performed (e.g., movement correction, detrending, spatial normalization), so that groups without specific brain analysis experience might quickly gain the benefits of those techniques. We also provide data in Matlab matrices to make it easier to input and work with the data.

11. Submission Process

There are two phases to the submission process. Submission of the predictions and submission of the description of the approach.

11a. Submission of Quantitative Predictions

To submit an entry, groups must first be registered. Groups must have registered prior to May 2007. CGs are assigned a login and password to submit entries. A submission involves predicted feature vectors for all 3 subjects (3 files, one subject per file). CGs can submit data for run 1 and run 2 to test the processing path and data formats an unlimited number of times. **There is a limit of only three scored submissions of run 3.** This process will not be enabled until April 16, 2007.

Groups will get reports on the first two scored submissions of run 3 within 1 business day. The report of submission 3 will be scored but the CGs will receive only a report of whether the final score was better or worse than the previous submissions. After the awards are announced on June 14, 2007 the third and final submission score will be provided to the competitors. Note that after the competition ends groups can continue to submit data for testing purposes only.

11b. Submission of description of the entry

With each entry we require submission of a description of the methods used to make predictions. Templates for the title page and methods description are downloadable at http://www.ebc.pitt.edu/2007/download.html. You can look at examples entries from last year http://www.ebc.pitt.edu/2006/2006results.html. The submission by Alexis Battle of Stanford was a good model: http://www.ebc.pitt.edu/2006/Methods06/2.pdf.

The description is more than a formality as they will be used to determine the Special Cognitive Neuroscience Prize (see section 12h) and possibly the Special Honorary Mentions (see section 12i). In addition, these descriptions will be made available to the public so that knowledge and technologies derived in association with the contest may be shared.

12. Scoring

12a. Summary

Participants will be able to download a scoring program to test run 1 and run 2 data from http://www.ebc.pitt.edu/2007/download.html. The actual competition scoring will be done in Pittsburgh on the run 3 data. For testing purposes, participants can run the scoring program on raw feature vectors or on a version that has been convolved with a canonical hemodynamic response. **The actual competition scoring will be done only on the hemodynamically convolved feature data.**

The scoring program calculates the competition score by correlating the CG's predicted features with the actual "reference" feature time series data. Details of how the competition score is calculated are covered in Appendix E. The scoring algorithm is applied to the required features and extra credit features, if present. Other features are not included in score calculation. You can submit Matlab matrices or tab delimited files (examples provided). If you submit tab delimited files you must match the file formats of the data. Features for which an estimated rating vector has not been calculated should be deleted.

12b. Scoring of Required and Extra Credit Features

Rationale for required and extra credit features

The competition is scored in a manner somewhat analogous to scoring in Olympic competitions such as ice skating. We want to be able to compare all entries based on a set of required features. A good coding of experience requires these features be included (such as basic jumps in ice skating). However, we want groups to choose special stretch features that they feel they might excel at. These are the extra credit features. For example one group might focus on identifying the gender of the faces and another on whether they can tell if a subject is reading signs. A top entry is likely to do very well on the required features and excel at some of the extra credit features. The features are listed in Appendix C.

12c. Weighting of extra credit features

The total score for a subject will be based on the correlation of the required features and up to 6 extra credit features. Extra credit features will only be included if they exceed the average of the required features and hence will only improve a group's score. To illustrate, assume the average correlation for the required features was 0.5 and for the top six extra credit features the ratings were 0.3, 0.4, 0.6, 0.7, 0.8, 0.9. Then only the top 4 scores would be added to the set of required features to calculate the total entry score. Note the addition will be done after transforming the scores with the Fisher transformation method (see Appendix E).

The features are broken down into three categories: required, extra credit and other. Only the required and extra credit features will be used to calculate a participant's score. The "other" features may be used for research purposes.

All required features should be calculated by participants. If a vector is entered without significant variation, a correlation cannot be predicted and it will be set to zero. If a feature is not included its correlation will be assumed to be zero. A zero predicted vector will decrease the final score because the score calculated from the required features is an average of the correlations of all base features. **A required feature score will always be calculated based on the average correlation of the base features (Base score).**

See Appendix E for a detailed description of the scoring algorithm.

12d. Evaluation metric

We seek to have an objective measurement of success. The score will be based on the average of the correlations of features across all 3 subjects. The correlations exclude the Fixation periods during a run. The final score will be calculated in three steps. The scoring program will provide correlations of each step and final competition scores.

- **A.** The average correlation of the required 14 features across subjects. The three search features R5-R7 correlations are averaged to provide a single feature for search {i.e., the correlations of (R5+R6+R7)/3} This provides 12 required feature scores.
- **B.** The extra credit features will be calculated and compared to the average of the required features.
- ***C.*** The final score will be based on the required features score and up to 6 extra credit features. To illustrate, if the average correlation of the required features was 0.5 and there were 4 extra credit features with an average of 0.75 the score would be weighted 12 *0.5 + 4*0.75 or 0.5625. The actual score is based on Fisher transformation before the averaging (see Appendix E). *There are still ongoing Advisory Board discussions on the final weighting and there may be changes in the relative weight of the extra credit scores.*

12e. Judging of the entries

The judging will be the prerogative of the scientific advisory committee (see Appendix H). All decisions made by the board are final. Members are expected to vote on issues of concern. All top contenders must present a detailed scientific account of how they derived the predictions and provide presentation materials to be presented at the OHBM workshop. The advisory board members will review those materials and only consider entries where the scientific description of the methods is sufficient to allow understanding of the methods employed (see section 11b for a description of relevant materials).

12f. Resolution of ties

If the top three entries are quantitatively significantly different from each other (i.e., if the differences between scores is greater than the within entry standard deviation across subjects) prizes will be awarded by the quantitative ratings alone of the accepted entries. In the case that multiple scores are statistically indistinguishable, the advisory board will discuss the entries and may judge other factors (e.g., uniqueness of the approach, ability to predict some features extremely well). Judges will rank-order the top contenders. Should there be a clear consensus of the judges as to the best submissions within the range of statistical reliability, the board may modify the rankings. In the 2006 competition the board went with the straight quantitative rankings and is likely to do so this year.

12g. Limitation of only one cash prize to entries from a single institution

The advisory committee has decided that it would be inappropriate to award any one institution multiple prizes. In the case that multiple entries from a single institution place in the top positions, only the highest ranked of the entries will receive a cash prize and the prize money for the lower groups will be made available to other entries. In the case there are multiple high placing awards from one organization, they may be offered to combine as a single rank. This can happen if a group placed 2nd and 4th due to submitting 2 different approaches. Only if the submitting captains wish to be reported as 1 group and agree how to share a single prize within the combined group will the ranks be combined. We do encourage groups to work together and share methods; for example, several computer science students submitted as part of a course in 2006.

12h. Cognitive Neuroscience Prize

This award is new this year and will be of an amount of $5,000. It will be given for the best cognitive neuroscience result independent of the quantitative score. This will be a subjectively scaled award based on judgments of the advisory board of merit other than the quantitative score. To be eligible for this award, the CG must describe in the write up something new about the brain activity they found in this data set in their description of their methods and results (see section 11b).

Preference, for this award, will be given to groups that make substantial contributions to understanding brain function associated with subjective experience, which may go well beyond simple predictions of feature vectors. For example a group could decide to take on a scientific problem such as understanding the extent to which functional connectivity between two regions was associated with a specific feature or whether the dog being on screen interfered with prefrontal function needed for search behaviors. Relevant work done in this regard can reflect 1, 2, or all 3 runs. That is, it does not need to pertain to the "hidden" features for Run 3.

As for all other aspects of the competition, it is acceptable for CG's to co-opt their entries for use as conference submissions or manuscripts.

12i. Special Honorary Mentions

The advisory board will award honorary mentions to entries with particular strengths in some features or particularly noteworthy approaches that may not have placed in the top quantitative scores. These are not cash prizes but honors for advancements that the advisory board feels should be noted by the scientific community.

13. Access to the underlying video

We will provide CGs with the videos for run 1 and run 2. However these materials include copyrighted material owned by the University of Pittsburgh and Psychology Software Tools Inc. A CG must get written permission to distribute or post the videos of the runs. We anticipate that these will be granted for research/non-commercial purposes but will require written permission. Contact ebc@pitt.edu for details.

14. Publication of reports on the analysis

Groups will be allowed to publish their work separately describing the techniques and including the data made available in the competition. They will be required to credit the EBC project for the data collection but do not need to include EBC project members as co-authors. There will be no restriction as to nationality of entrants or type of publication. We request that groups which publish based on the EBC data let us know so that we can link from the EBC website to relevant publications.

In addition, we are seeking space in a neuroimaging publication for a Special Section on interpreting brain activation which will report the results from the 2006 and 2007 competitions. Winners from the 2006 and 2007 competitions would be asked to contribute to this section.

15. Contact Information

Information regarding the board discussions is available at http://braincompetition.org/. All documents relating to the competition are available for public review on the competition website. Questions regarding the competition should be sent to ebc@pitt.edu.

16. Grant Support

This project was supported in part by a grant to the University of Pittsburgh with Walter Schneider as Principal Investigator and Greg Siegle as Co-Principal Investigator. Data collection is part of grant number N00014-05-1-0881 to the University of Pittsburgh. The funds for the awards are provided by internal University of Pittsburgh funds.

Appendix A: Subject Training Methods

Fifteen subjects participated in this study. One subject was excluded because of excessive motion, five subjects were excluded because of nausea related to the virtual world task, one subject was excluded because of eyetracking difficulties; and one subject was excluded due to an incomplete data set. All subjects were right-handed, had normal/corrected-to-normal vision (not colorblind) and normal hearing, were not claustrophobic or uncomfortable in confined spaces, did not have any metal in or on the body that could not be removed, were not on any psychotropic medication and did not have a known history of mental illness. The three subjects whose data has been made available for the competition ranged in age from (20 – 26).

The study was completed over a four day period. Subjects earned $7/hr for behavioral participation time outside the scanner, $15/hr for sessions that involved additional physiological measurements and $25/hr for time spent in the scanner. Upon completion of all 4 parts of this study, subjects received a $3 bonus for each behavioral hour in the study.

Day 1

For the first day, subjects completed a battery of questionnaires, implicit association tests on ingroup/outgroup and canines well as engaging in extensive training within the video game. Questionnaires given to subjects included the following:

1. Motion History Questionnaire
2. Sense of Direction
3. Computer Familiarity Scale
4. Penn State Worry Questionnaire
5. BIS-BAS
6. State-Trait Anxiety Inventory
7. Immersion Questionnaire
8. Simulator Sickness Questionnaire

Training involved a verbal description of the world and its contents by the experimenter with the aid of color maps and images. After subjects indicated how they were feeling using the scale:

0 = no symptoms

1 = some symptoms but no nausea

2 = mild nausea

3 = moderate nausea

4 = severe nausea

Subjects watched a 13-minute video of someone walking through the world as she explained what to expect, where things were, what to do, and how to do it. Subjects were again asked to rate their level of sickness. Subjects were then allowed to explore the world for as long as they needed to get familiar with the controls, which usually lasted 3 to 15 minutes. Subjects were asked to rate their sickness level and then had to perform a series of timed tests involving navigation between 3 outdoor points, navigation in 4 indoor locations, and picking up 10 objects in under a minute. At the end subjects were asked to rate their level of sickness and filled out the Simulator Sickness Questionnaire and Level of Comfort with Control Manipulation Questionnaire. The duration of the session was 2 hours.

Day 2

The second day involved performing search tasks during 3 20-minute runs of the game outside the scanner. Before the start of the first run subjects filled out the Simulator Sickness Questionnaire. Head motion data was collected during this session. Subjects were awarded a monetary amount for every correct item picked up and could earn up to $50 in this manner. Every 2 minutes in the game subjects were asked to rate their level of sickness. Between every run subjects were asked to describe their experience. At the end of the session subjects filled out the following questionnaires:

1. Simulator Sickness Questionnaire
2. Level of Presence Questionnaire
3. Level of Comfort with Control Manipulation Questionnaire

The duration of this session was 2 hours.

Day 3

The third day involved performing search tasks during 3 20-minute runs of the game inside the scanner. Before the start of the first run subjects filled out the Simulator Sickness Questionnaire. Eye tracking data was collected during the scan. Subjects were awarded a monetary amount for every correct item picked up and could earn up to $50 in this manner. Every 2 minutes in the game subjects were asked to rate their level of sickness. At the end of the session subjects filled out the following questionnaires:

1. Simulator Sickness Questionnaire
2. Level of Presence Questionnaire
3. Level of Comfort with Control Manipulation Questionnaire

The duration of this session was 3 hours.

Day 4

For the last part, participants viewed playbacks of their performances from the scanner sessions and completed 4 ratings for each run. Before and after the session subjects filled out a Simulator Sickness Questionnaire. The duration of this session was 4 hours.

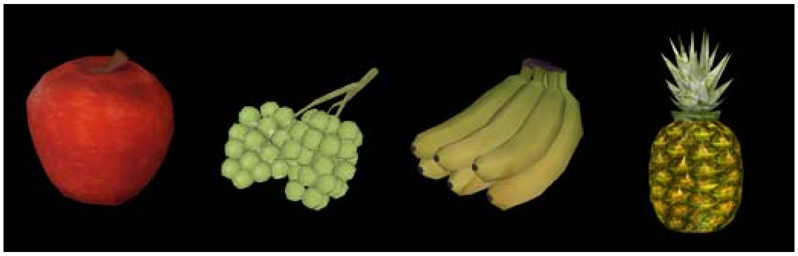
Appendix B: Task Description

Subjects received the following task description during the orientation on the first day of training.

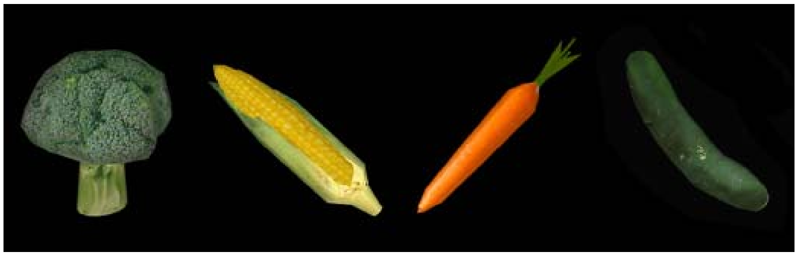
In this study you will be playing a game in a virtual world. In the game you are being paid by an anthropology department grant to gather information on urban culture. You will be visiting a neighborhood several times to get the information you need. You will be collecting samples of toy weapons, fruits, and pictures of the piercings people are currently wearing. The grant is paying you per item so you should try to collect as much as you can. In fact, any money you earn in the game corresponds to real-life earnings so keep that in mind as you play.

Anthropology researchers before you have observed several people living in the neighborhood. It has been documented that the kinds of piercings worn are earrings, nose rings, eyebrow rings, and lip rings. The people you will be encountering are fond of changing the kinds of piercings they are wearing so even if you've seen a person before that didn't have piercings, you may see them again and they will have a piercing. Thus, your strategy is to look for piercings on any person, not a specific person. If you see the same person in two different locations you should take two different pictures. You will earn money for each picture you take of a piercing. Money will be subtracted for each picture you take of someone who isn't wearing one of the four types of piercing.

As mentioned previously you will be collecting fruit. Specifically you will be collecting fruit in the order apples, grapes, bananas, pineapples. The order is important for the thesis of a paper. As with your other tasks, you must pick up only fruit and in the right order to be paid otherwise money will be deducted from your pay.



Make sure not to pick up any of the vegetables in the world which include broccoli, corn, carrots, or cucumbers or you will lose money.



You are collecting four types of toy weapons in the neighborhood. These include plastic models of guns, rocket launchers, grenades, and swords.

There are other tools in the world such as screwdrivers, hammers, tape measures, and pliers. Once again, you will be paid for each toy weapon you remove from the world and you will lose money should you pick up a tool.

Here is the layout of the world. Note that there are several places in which you are able to investigate. Try to visit as many of these places as you can in the time you have. People and objects will be both outside and inside of buildings so look in as many places as possible and you will most likely gather more information and be paid more!

Anywhere outside is fair game, with the exception of the area behind the houses. Do not worry about going in this area as nothing will be there. Do look on the lawns, porches, stairs, streets, sidewalks, parking lots, the playground, etc.

The places where you can go inside include the following:

- Residential street:

- Condemned house
- Cul-du-sac house
- Exterior apartment

- Gas station street:
  - Motel
  - Interior apartment
  - Bar

Only doors that go into these places and doors inside these places open, so don't waste your time trying to open any other doors. All doors that you can open will be marked clearly with a green sign. Also, though there are cabinets and appliances in these locations, you do not need to open any cabinets/appliances as you will find nothing of value.

Some examples of areas in the world:

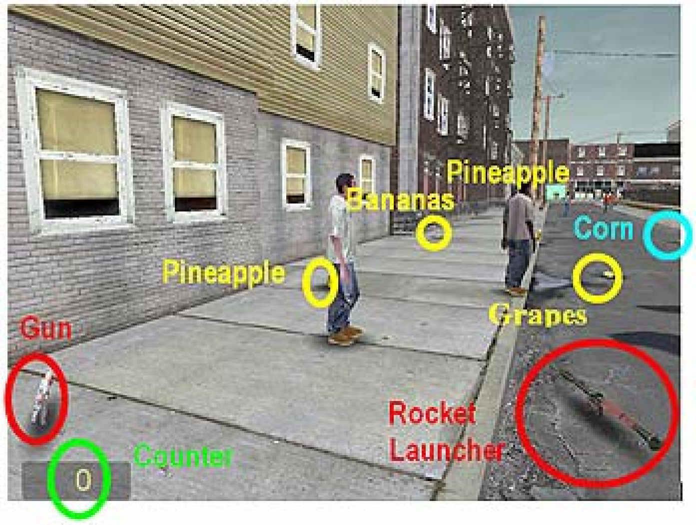
Park **House**

Apartment **Gas Station**

Also, there are signs in the world placed by previous anthropology researcher on where to find things, which look similar to other signs in the world. Pay attention to these signs give as they could save you time in where you look. Other signs weren't placed there the researchers and won't be relevant to your mission so try to read them all

There is one thing you must keep in mind as you go about collecting things. There is a vicious dog that roams the neighborhood. He is a Rottweiler with a deep growl that indicates when he is lurking around. Watch out for him – he can attack at any time and any where. Should you be bitten by him, you will lose all the money that you've earned up to that point. Keep in mind though that if you're constantly hiding from him you will also lose money so go about your job as best as you can; not only that but he will most likely find you, so hiding is really a waste of time. To complete your tasks you will have to continue searching even when the dog is around.

Here is an idea of what the neighborhood would look like if you were walking around in it.



Appendix C: Behavioral Rating Procedure

Subjects rated their arousal and valence levels, whether they felt specific emotions, and the presence of music. Subjects were asked to rate the feature as they thought they experienced the feature on the first presentation of the run in the scanner. The data was then rescaled in the 0-1 range for predictions of the competition.

Rate whether **you** felt positive (pleasant) or negative (unpleasant) as when you first played the video game - pay attention to your own feeling	0 - Exceedingly positive (good, pleasant) (e.g., I felt very happy or amused)		2 - Neutral. Neither positive or negative		4 - Exceedingly negative (bad, unpleasant) (e.g., I felt very unhappy, sad, angry etc)
How much playing the game affected how calm you were (positive or negative)	0 - Exceedingly calm. Low physiological arousal. Not affected by the game.		2 - Level of arousal/calmness on average when you are usually watching a video game or movie		4 - Much less calm than in an average video game or movie-viewing session (e.g., very engaged, heart beating faster, hair on arms standing up, sweating)
Rate when you felt the following specific feelings	0 - Sad	1 - Happy	2 - Neutral	3 - Fearful/Anxious	4 - Angry/Annoyed
Rate when you heard music	0 - No music heard		NA		4 - Music heard

Appendix D: Feature Descriptions

Required Features				
Code	**Feature**	**Description**	**Weight**	**Rating Type**
R1	Arousal	How much does what is going on in the scene affect how calm the subject is (subjective rating)	1	Subjective
R2	Valence	How positive or negative is the environment	1	Subjective
R3	Hits	Times when subject correctly picked up fruit or weapon or took picture of a pierced person	1	Computed
R4	SearchPeople	Times when subject searched for pierced people	0.33	Computed
R5	SearchWeapons	Times when subject searched for weapons	0.33	Computed
R6	SearchFruit	Times when subject searched for fruits	0.33	Computed
R7	Instructions	Times when task instructions were presented	1	Computed
R8	Dog	Times when dog was seen or heard by subject	1	Computed
R9	Faces	Times when subject looked at faces of a pierced or unpierced person	1	Computed
R10	FruitsVegetables	Times when subject looked at fruits or vegetables	1	Computed
R11	WeaponsTools	Times when subject looked at weapons or tools	1	Computed
R12	InteriorExterior	Times when subject was inside a building (1=subject was inside, 0=subject was outdoors)	1	Computed
R13	Velocity	Times when subject was moving but not interacting with an object	1	Computed

Extra Credit Features				
Code	**Feature**	**Description**	**Weight**	**Rating Type**
X1	FearfulAnxious, Happy, AnnoyedAngry	Separate predictions of three subjective emotional states (fearful/anxious, happy, annoyed/angry)	3*0.33	Subjective
X2	HitsFruits, HitsPeople, HitsWeapons	Of the interactions with objects, determine which of three types of interaction occurred (Take Picture, FruitGrab, Weapon Grab)	3*0.33	Computed
X3	DogVisible	Out of the times when the dog is present, when was the subject viewing the dog – eye fixation on the dog (*computed over only times when the dog was visible*)	1	Computed
X4	Body	Body Parts – Degree to which subject viewed on body parts (i.e. not face)	1	Computed
X5	Gender	Of the fixations on faces or body parts, determine the gender of person fixated	1	Computed
X6	ReadSign	Degree to which legible signs are viewed by the subject in the environment	1	Computed

Other Features (for reference but not for competition scoring)				
Code	**Feature**	**Description**	**Weight**	**Rating Type**
S1	VR-Fixation	In VR world versus Fixation	0	Computed
S2	EyeGood	Eye Tracking (OK, not)	0	Computed
S3	EyeX	Eye position X	0	Computed
S4	EyeY	Eye Position Y	0	Computed
S5	Fixation	Times of Fixations	0	Computed

Appendix E: Provided Data Formats

Datasets will be provided in three different formats (DICOM, Analyze and MatLab .mat). All data is little-endian. Details concerning the provided data formats will be released later. The following table contains a general description of files to be released.

FileName	Description
Structurals	Structural MRI MPRAGE data
BrainMask	Mask of cortex and subcortical Brain areas
Raw DICOM Functional	Functional data for runs 1,2, and 3 in DICOM format that has not been preprocessed
Not Preprocessed Functional	FMRI data that has not been preprocessed
Preprocessed Functional	FMRI data after motion correction, slice time correction, and trend removal
FeatureVectorsRaw	Raw feature vectors before hemodynamic delay is applied
FeatureVectorsHR	Feature vectors after hemodynamic delay is applied

Appendix F: Scoring Algorithm

1. **Exclusion of Fixation Periods**
   Correlations are calculated only during periods when the Run was playing ("Run on"). We excluded from the correlations any data when no VR events were being presented ("Run off"). The periods of Run on/off are determined by the Fixation feature vector (S5). If these vector values are greater than zero fixation state is on, if zero the Fixation state is off. Note when the fixation state is on the VR world is off, else it is on.

   The Fixation vectors were not convolved with the hemodynamic response. Because of the hemodynamic delay in the brain image data, timepoints six volumes (6 volumes * 1.75s/volume = 10.5s) after the end of each Run off period (at the start of each Run segment) were excluded from consideration.

   To summarize, the following timepoints are excluded from score calculation:
   - All timepoints with Fixation vector value greater than zero
   - Timepoints that are within six volumes of the end of each Run off period

2. **Correlation**
   The Pearson product-moment correlation coefficient (r) between the predicted feature and the observed subject rating is calculated for each non-constant feature vector. This provides a measure of the degree to which the observed values agree with the predicted values (0 indicates no agreement; positive correlation indicates that there is a strong linear relationship between the vectors (1 indicates perfect match); negative correlation indicates that the vectors vary together in opposite directions). Negative correlations will decrease a participant's score. If is fine for you method to reverse the sign of the correlation (e.g., in come cases a reduction in brain activity may relate to a feature state, but it is you responsibility to set the sign in predicting the results.

3. **Fisher Transformation**
   The Fisher transformation is a non-linear transformation that makes the scores normally distributed and gives higher value to improvements of higher correlations than lower correlations (Fisher, 1921). The transformation is applied to each correlation calculated in step 2. If calculated vectors are included for all features (not including the Fixation vector), this step results in the calculation of Fisher transformations.
   Equation:

   $z' = \frac{1}{2}\log\left(\frac{1+r}{1-r}\right)$, r = correlation calculated in step 2

4. **Composite Average**
   In the first part of this step, up to three averages are calculated <u>for each subject</u> (resulting in up to 9 values):
   A. The average of the z' values of the 14 Required features calculated in step 3 for each subject. In the case of the search features R5-R7 the average of all three

searches provide a single search scores. The average of the required features is base on the 12 scores. This will produce an average z’ value for the required scores.

B. Extra Credit features The z’ values of the extra credit features will be calculated, rank ordered and compared to the Required average Z’s score.
C. Combined subject score, a combined score average will be calculated using the formula of (12*Required a’ + up to five extra credit scores in part B) / (12+#extra credit scores).
D. The average of the values calculated in part C will be averaged across the three subjects. Special note in averaging across subjects the same extra credit features must be use for all three subjects. The program will calculate the data and automatically select the best extra credit features across subjects.

5. Inverse Fisher Transform of the Average Z’ Scores

The inverse Fisher transformation transforms a z’ value to a correlation coefficient of step 4D.

Equation:

$r = \frac{e^{2z'} - 1}{e^{2z'} + 1}$, z’ = Fisher transformation value calculated in step 4

Appendix G: Example Feature Prediction

Three segment approach for within subject prediction with training on that subject. Our intent was to provide CGs material to develop their methods and a final test set.

a) **Run1.** Primary training run. This included materials to calibrate the pattern analysis technique being used for predictions. Provided data included all the raw and processed data plus all the feature ratings.

b) **Run2.** Secondary training run. Provided data included all the raw and processed data plus all the feature ratings. To avoid overfitting of parameters, you can use the prediction method in Run1 to predict Run2 features.

c) **Run3.** Test run. Only the functional and structural data were provided. The goal was to predict the feature vectors.

We have provided below a description of how an analysis was applied to predicting a single feature of the Instructions (R8) a single subject. This is provided to illustrate the steps a group might go through in the competition and provide examples of the expected effect. This example can be treated as an exercise that one can go through to become familiar with the steps of processing the data. We illustrate these steps using Matlab but any analysis stream is allowed.

1. Read details at http://www.braincompetition.org and sign up for the competition at http://www.ebc.pitt.edu/register.asp
2. Download the functional and behavioral data (instructions sent after you sign up).
3. Familiarize yourself with the range of formats and tools available to examine the data.
   3.1. Determine what format of data you wish to use (in our illustration we will use the Matlab files). Note you can use the tutorial at https://compmem.princeton.edu/mvpa_docs/TutorialEBC to replicate how the second place winners in the 2006 competition processed the data, as an exercises created in Pittsburgh. *(Link to be added).*
   3.2. Examine the feature rating data that needs to be predicted for subject 1.
   3.3. For an example of how to predict feature rating data, please see the section titled "Example of how to use simple regression for computing predictors" of the Brain Image Data README document
4. Test your technique by writing a prediction file and the data for Run1or Run2 for automatic scoring.
5. Refine your prediction method on subject 1, then go on to subjects 2-3 using data sets for Run1 and Run2
6. Generate prediction files for Run3 using the functional data to predict the behavior rating data and submit the data on the web site.
7. For details on how to use the Princeton group's MVPA tool kit for this process follow following steps:
   7.1. Step-up toolbox: Follow instruction at: https://compmem.princeton.edu/mvpa_docs/Setup?highlight=%28CategoryMain%29

7.2. Do same tutorial to familiar with toolbox: https://compmem.princeton.edu/mvpa_docs/TutorialIntro

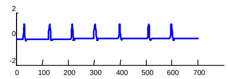
7.3. EBC tutorial: Note have load data for vr runs and follow the step as explained in this page: https://compmem.princeton.edu/mvpa_docs/TutorialEBC

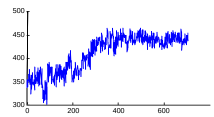
7.4. For optimization you results follow steps in Advanced tutorial.

8. Alternately, for a simplified process see the very basic matlab script on the following page.

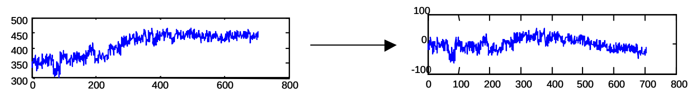
The matlab script below loads data, does a regression to predict one feature vector, and creates a simple plot based on a mask volume

```
% first load the raw data
load sub1_run1_baseregs.mat
load sub1_run1_fmri.mat
load sub1_run1_vr_mask.mat
```

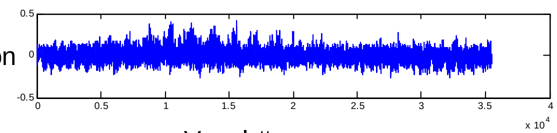




```
% preprocess by detrending the data
for ct=1:size(epi_run1,1)
  epi_run1(ct,:)=detrend(epi_run1(ct,:));
end
```

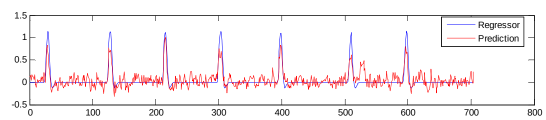


```
% get zero order correlations of each voxel with the reference vector
for ct=1:size(epi_run1,1)
  xy=corrcoef(baseregs_run1(1,:),epi_run1(ct,:));
  corrs(ct)=xy(1,2);
end
```




```
% find the best voxels (i.e., correlations > .25)
[inds]=find(abs(corrs>.25));
voxtouse=epi_run1(inds,:);
```

R^2=.69!!




```
% simultaneously regress all the voxels against
% the feature vector using our provided multiple
% regression code
[Rsq,B,B0,Ypred]=mreg(voxtouse',baseregs_conv_run1');
```

```
% make a brain image by finding which voxels in the
% data set correspond to which voxels in the brain
% and setting their values to the obtained correlations
[goodvox]=find(wholebrain_run1);
predbrain=zeros(size(wholebrain_run1));
for ct=1:length(goodvox)
  predbrain(goodvox(ct))=corrs(ct).*(corrs(ct)>.25);
end
```

```
% plot a few slices
for ct=11:15
  subplot(1,5,ct-11+1);
  pcolor((wholebrain_run1(:,:,ct)'+5.*predbrain(:,:,ct)'));
  shading interp;
  colormap bone;
  view(-180,90); axis off;
end
```

For more advanced processing it may also be useful to consider tools developed for the 2006 competition. The Princeton MVPA toolbox provides functions for processing brain imaging data. You can add your own Matlab functions for processing the data.
It provides:

- A container object which includes necessary data for processing. It contains four basic objects called: Pattern, Regressors, Selector and Mask.
- Different function for preprocessing steps for example z-scoring, detrending etc.
- Different statistical map for example using ANOVA, Cross correlation etc.
- Regression for classification
- Many more ...

See MVPA toolkit at http://www.csbmb.princeton.edu/mvpa/. More details to follow.

Appendix H: Board of Scientists

- University of Pittsburgh: Walter Schneider, Greg Siegle (Chairs)
- Carnegie Mellon University: Tom Mitchell
- ITC-IRST; Italy: Emanuele Olivetti
- Max Planck Institute for Biological Cybernetics: Andreas Bartels
- Maastricht University: Elia Formisano, Rainer Goebel
- Princeton University: Greg Stephens, James Haxby
- New York University & Weizmann Institute: Uri Hasson
- Stanford University: Alexis Battle
- University of Michigan: Tom Nichols

Appendix I: Credits

The competition required a hundreds of hours of careful dedicated work my many professionals. Below is list of the major contributors and their contribution. Special thanks to the staff at the University of Pittsburgh for support covering the awards. Thanks to Psychology Software Tools Inc (www.pstnet.com) for providing the VR world software and many special features to enable the computation coding. We also want to thank the Princeton MVPA group for providing the Matlab software (see http://www.csbmb.princeton.edu/mvpa/)

University of Pittsburgh Staff	
Person	**Project Role**
Kate Fissell	Computational coding of virtual world eye movements, feature coding, fMRI data analysis
Lena Gemmer	Eye movement coding and programming, VR world testing, video rating software
Kevin Jarbo	Subject running, VR world testing and data processing and analysis
Dan Jones	Web support, server support, competition registration
Lori Koerbel	Web and administrative support
Kyung Hwa Lee	Behavioral and fMRI running
Adrienne McGrail	VR world testing
Maureen McHugo	Project technical lead, design, testing, data management
Sudhir Pathak	Matlab analysis routines
David Pfendt	Coding of eye movement virtual object detection programs
Melissa Thomas	Design and testing of VR task, behavioral and fMRI data collection, analysis & documentation
Psychology Software Tools Inc www.pstnet.com Staff	
Person	**Project Role**
Kyle Brauch	Development of most of the models, objects and characters in the virtual world
Tom Yothers	Development of virtual world software VR 2

Appendix J: Background Readings

There is a large amount of literature for fMRI and cognitive neuroscience. We will update this listing on the web site as groups provide recommendations. Last year the Italian group that took first place knew little about brain imaging, but started by looking up the Wikipedia reference on fMRI http://en.wikipedia.org/wiki/FMRI.

For a textbook we recommend Scott A. Huettel, Allen W. Song, Gregory McCarthy, *Functional Magnetic Resonance Imaging*, Sinauer Associates, 2004, ISBN 0-87893-288-7

For an overview paper see Robert L. Savoy, (2007) Functional Magnetic Resonance Imaging (fMRI) Encyclopedia of the Brain

Appendix K: Eye Tracking and the Eye Movement Attention Model

MR Eye Tracker: The system is equipped with a long-range optics video-based eyetracking system (Applied Sciences Laboratories, Bedford, MA, model 504LRO) for obtaining pupillary and eye-tracking measures during scanning. This system calculates eye position and pupil dilation by recording the reflection of an infra-red light off the cornea. The data were sampled at 60 Hz in sync with the scanner pulse onset.

Eyetracking preprocessing: Eyegaze was computed as the pupil position minus the corneal reflection. Blinks were identified in the eyetracking data as encompassing 4 points on either side of regions in which the pupil was not recognized or in which the X or Y indices were outside 3+/- the interquartile range from the 25th or 75th percentiles. Linear interpolation through blinks in the X and Y traces was performed. Eye calibrations were generated by having participants look at a 9-point grid before each run, and non-linearly transforming the resulting fixations to lie upon the fixation points. This transformation was applied to the X and Y data from each run. Fixations were identified as regions at least 0.1 seconds long in which the pupil remained within a small grid and never moved more than a short distance during that time.

The eye movements were coded as a weighted fall off as a function of distance. Details will be updated later and described in the web cast.

Appendix L: Document Revision History

04/27/07 – The Sad feature was removed from the Extra Credit Features list under X1 and the Weight column for the X1 feature was changed to 3*0.33 in Appendix D.

04/26/07 – Music has been removed from the feature list.

04/10/07 – Updated Extra Credit Features in Appendix D

03/22/07 – Appendix K now includes a description of the eye tracker used in the scanner as well as how the eye tracking data was preprocessed

03/21/07 – The step in Appendix G *Example Feature Prediction* (formally step 4) describing how to use 2 matrix files with data from run 1 and run 2 to train/develop techniques to predict the feature rating data has been removed. Extensive notes are provided for this step in the Brain Image Data README document.

A table was added with more details of how the objective feature ratings were obtained.

03/16/07 – Release of Version 1; provisional draft