Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is "None", please specify "None" as your response. "Not applicable" is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Carnegie Mellon University

2. **Reporting Period (start and end date of grant award period):** 1/1/10 – 12/31/13

3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Jim Osborn

4. **Grant Contact Person's Telephone Number:** 412 268-6553

5. **Grant SAP Number:** 410005089

6. **Project Number and Title of Research Project:**

   Project 1: Mid-Level Feature Representation in Human Visual Cortex

7. **Start and End Date of Research Project:** 1/1/10 – 12/31/13

8. **Name of Principal Investigator for the Research Project:** Michael J. Tarr, PhD

9. **Research Project Expenses**.

   9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

   $ 295,283

   9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project	Cost
Tarr, Michael	Professor	5%	$41,482
Clark, Rebecca	Business Administrator	12.5%	$35,690
Stupka, Melissa	Program Coordinator	12.5%	$24,022
Hegedus, Anna	Computer Technician	35.4%	$62,404

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project
Pyles, John	Postdoctoral Fellow	5%
Leeds, Daniel	Graduate Assistant	5%
Xu, Yang	Graduate Assistant	5%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
NONE		

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes **X**_____ No_____

If yes, please indicate the source and amount of other funds:

NIH R01 EUREKA Award $800,000 over 4 year period

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes_____ **No___X_____**

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert "not funded" in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes__X_____ No_____

If yes, please describe your plans:

NIH R01 submission planned for fall of 2014
NSF CRCNS planned for fall of 2014

12. Future of Research Project. What are the future plans for this research project?

This project seeded two new research methodologies, both of which will be developed, under new proposals, into full-fledged research streams. First, our real-time fMRI methods will be used to systematically explore the fine-grained neural coding of object and scene features within the human ventral visual pathway. Second, our MEG decoding methods along with our spatial localization improvements will be used to examine the fine-grained time course of visual object processing across the human ventral visual pathway. Together these two research programs should help further illuminate our understanding of how our brains take 2D visual images and transform them into the perception of objects and scenes.

13. New Investigator Training and Development. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes X_____ No_____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male	1	0	2	1
Female	1	0	0	0
Unknown				
Total	**2**	**0**	**2**	**1**

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic	1			
Non-Hispanic	1	0	2	1
Unknown				
Total	**2**	**0**	**2**	**1**

	Undergraduate	Masters	Pre-doc	Post-doc
White	2	0	2	1
Black				
Asian				
Other				
Unknown				
Total	**2**	**0**	**2**	**1**

14. Recruitment of Out-of–State Researchers. Did you bring researchers into Pennsylvania to carry out this research project?

Yes_X_____ No_____

If yes, please list the name and degree of each researcher and his/her previous affiliation:

Pyles, J.	PhD	U of California, Irvine
Seibert, D.	BS	University of Houston
Toneva, M.	BS	Yale University

15. Impact on Research Capacity and Quality. Did the health research project enhance the quality and/or capacity of research at your institution?

Yes__X_____ No_____

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

We were able to take many more risks in how we designed and implemented our studies using real-time fMRI and MEG. Without this funding, we would have had to run much more conservative studies, thereby reducing the likelihood of a meaningful breakthrough. High-risk research is typically both more time consuming and more expensive, but has a potentially much higher payoff. In the case of this project, we were able to run additional subjects and try additional experimental paradigms in order to optimize our methods.

16. Collaboration, business and community involvement.

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes_____ **No__X_____**

If yes, please describe the collaborations:

16(B) Did the research project result in commercial development of any research products?

Yes_____ **No__X_____**

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes_____ **No__X_____**

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims for the period that the project was funded (i.e., from project start date through end date). Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (ß) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

Specific Aim 1: Develop neuroimaging paradigms using fMRI and MEG that explore the nature of mid-level visual features in human ventral cortex.

This aim was achieved by developing techniques for directly comparing computational models of object representation to patterns of neural activity elicited by the same visual inputs. This project is based on the assumption that feedforward visual object perception recruits a cortical network that is assumed to be hierarchical, progressing from basic visual features to complete object representations. However, it is widely acknowledged that the nature of the intermediate features related to this transformation remains poorly understood. In this project we explored how well different computer vision recognition models accounted for neural object encoding across the human cortical visual pathway as measured using fMRI.

These neural data, collected during the viewing of 60 images of real-world objects, were analyzed with a searchlight procedure as in Kriegeskorte, Goebel, and Bandettini (2006): Within each searchlight sphere, the obtained patterns of neural activity for all 60 objects were compared to model responses for each computer recognition algorithm using representational dissimilarity analysis (Kriegeskorte et al., 2008). Although each of the computer vision methods significantly accounted for some of the neural data, among the different models, the scale invariant feature transform (SIFT – Lowe, 2004), encoding local visual properties gathered from ‘‘interest points,’’ was best able to accurately and consistently account for stimulus representations within the human ventral visual pathway (Figure 1). More generally, when we did find that a given model was able to explain a significant amount of the neural response in a given brain region, this significance was typically observed in a brain region within the ventral-temporal cortex that was associated with intermediate-level object perception. Finally, we suggest that differences in effectiveness across the models and the neural locations of significant matches for each model may be attributable to the fact that each model implements a different featural basis for representing objects (e.g., more holistic or more parts-based). Overall, this project provides a stepping stone to more complex analyses of neural activity as measured by fMRI in which computer vision recognition systems may serve as proxies for theories of intermediate visual object representation. Future work will build on this result, exploring whether a given computer vision model can be adaptively refined so as to increasingly better account for neural data.

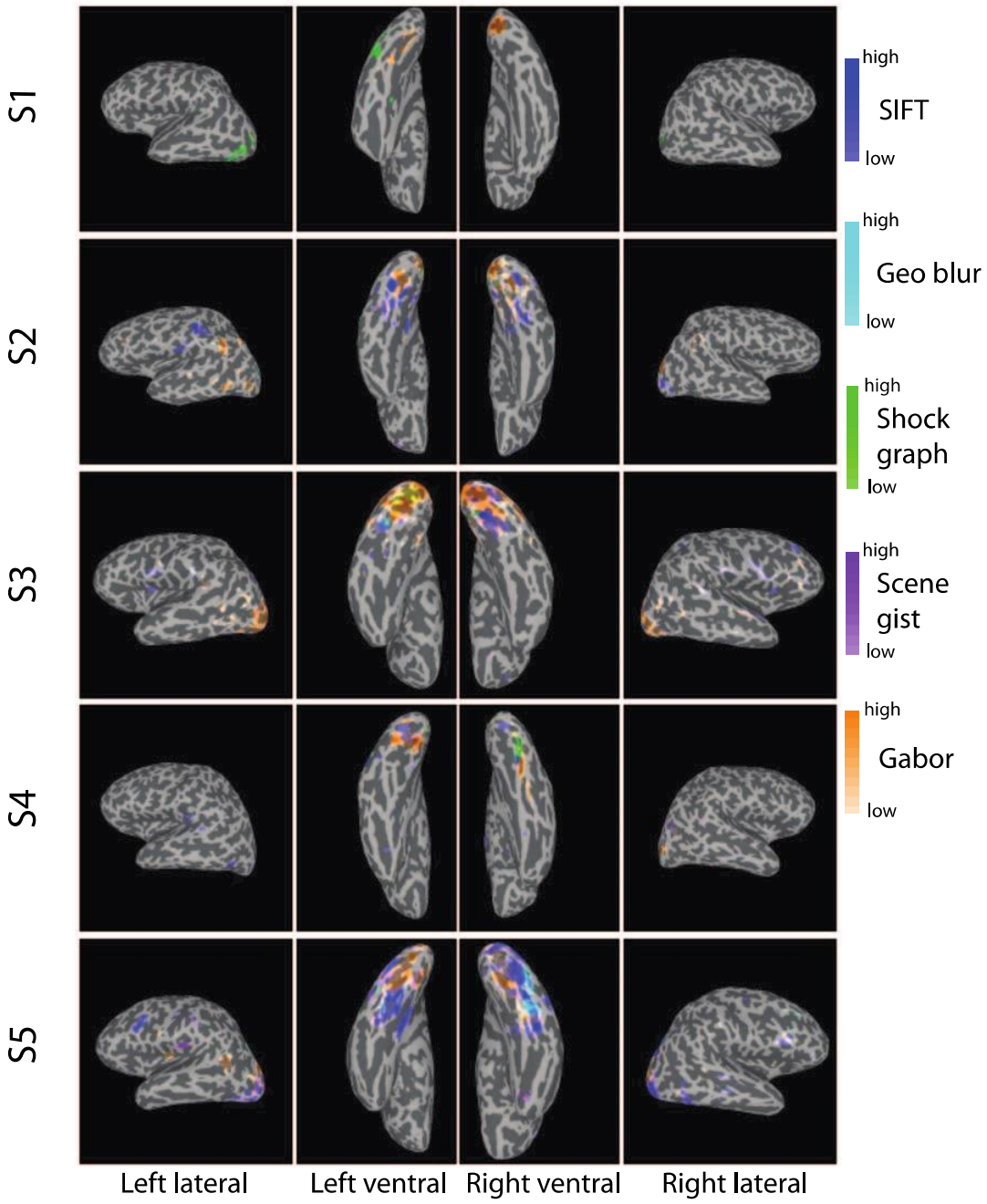

Figure 1. Cortical regions with a dissimilarity structure significantly correlated, $q < .001$, with the dissimilarity structures of the five different models of visual feature coding. Colors are associated as follows: blue for SIFT, cyan for geometric blur, green for shock graph, purple for scene gist, and orange for Gabor filter bank. Color intensity proportional to correlation. Regions matching multiple models show the corresponding colors overlaid. Note first that although we illustrate these results on surface maps, the actual searchlights were run on brain volumes and, second, that color overlap sometimes forms misleading shades, for example, purple as the combination of blue and orange.

Specific Aim 2: Improve the temporal resolution of fMRI via "real-time," adaptive imaging methods and the spatial resolution of MEG via improved signal processing methods.

This aim was achieved in that benchmarks applied to our results indicate a 2X improvement in spatial resolution for localizing sources in MEG as compared to standard methods. To address humans remarkable proficiency at categorizing visually-similar objects, we used magnetoencephalography (MEG) to record neural activity while human observers learned – with feedback – to discriminate two highly-similar, novel visual categories. We hypothesized that although prefrontal regions would mediate early category learning, this role would diminish with increasing category familiarity and that regions within the ventral visual pathway would come to play a more prominent role in encoding category-relevant information as learning progressed.

Early in learning we observed some degree of categorical discriminability and predictability in both prefrontal cortex and the ventral visual pathway. However, consistent with our hypothesis, predictability improved significantly above chance in the ventral visual pathway over the course of learning with the left inferior temporal and fusiform gyri showing the greatest improvement in predictability between 150 and 250ms (*M*200) during category learning (Figure 2). In contrast, there was no comparable increase in discriminability in prefrontal cortex with the only significant post-learning effect being a decrease in predictability in the inferior frontal gyrus between 250 and 350ms (*M*300). Thus, the ventral visual pathway appears to encode learned visual categories over the long term. At the same time these results add to our understanding of the cortical origins of previously reported signature temporal components associated with perceptual learning.

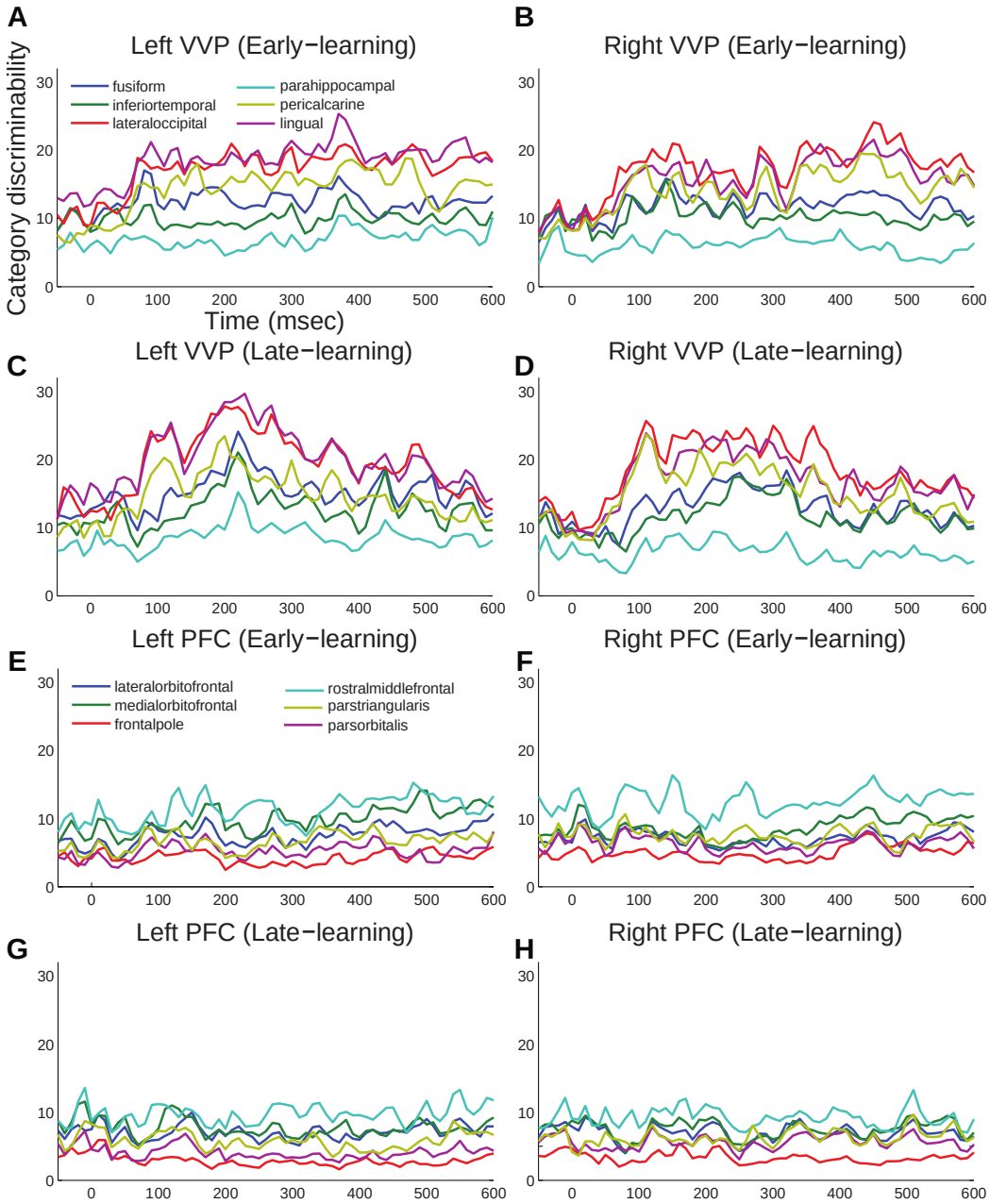

Figure 2. *Category-discriminative time courses in ventral visual and prefrontal cortices.* **A** Group-level discriminative time courses in right-hemispheric VVP contrasting dipole responses in trials containing *A* and *B* blob categories during early learning. **B** Discriminative time courses in left-hemispheric VVP regions during early learning. **C,D** *P*-value time courses in VVP regions from left and right hemispheres during late learning. **E,F,G,H** Discriminative time courses in PFC regions under similar conditions.

Critically, the project outlined above – informative in and of itself – also served as a precursor for a second MEG project on visual category learning using synthetic faces. This latter project was specifically designed to both address theoretical questions as to how human observers categorize visually-similar objects and to do so using improved source spatial

localization methods for MEG data. This latter data is still in the process of being written up for publication, but our basic result has been that we were able to reduce sensor error prediction by as much as 50%.

Our second aim within this component of the project was also achieved in that to improve fMRI, we have developed "real-time", adaptive imaging methods (Figure 3), as to be presented at COSYNE 2014 in a presentation entitled *Evidence towards surround suppression in perception of complex visual properties* by Leeds, D. D., Pyles, J. A., & Tarr, M. J. In particular, this project leveraged what we learned in Specific Aim 1 about the neural coding for objects as explained by the SIFT model.

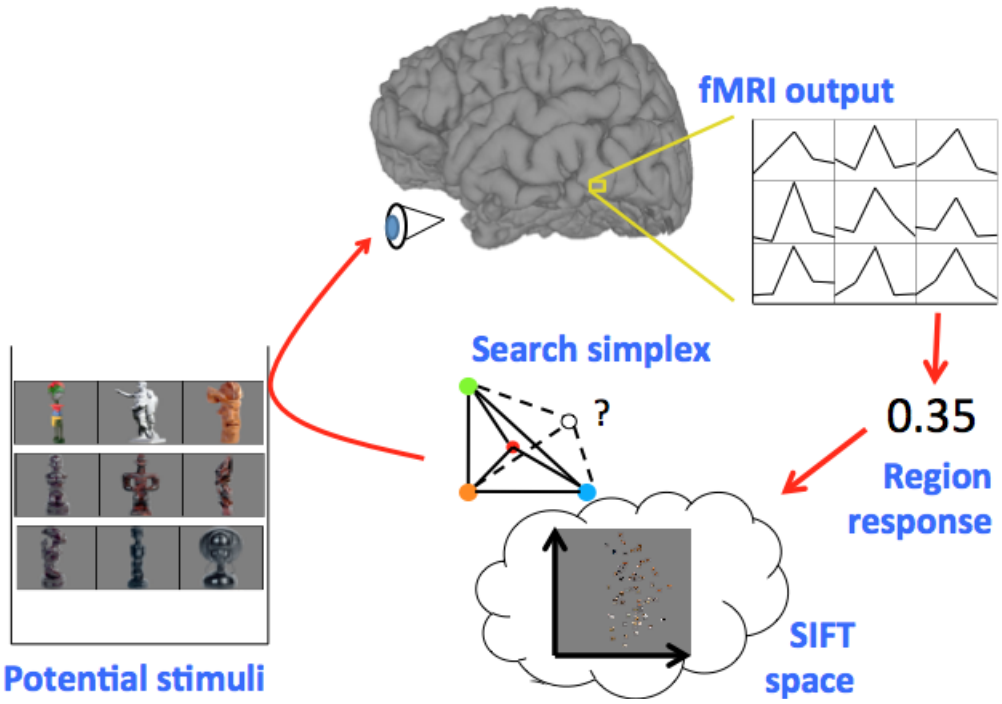

Figure 3. Stimuli selected based on BOLD response to past stimuli shown with simplex simulated annealing (Cardoso 1996).

Perhaps the most important finding to come out of this work to date is evidence for object-level "surround suppression" in which selectivity for a given real-world object exemplar appears to suppress the responses to other object exemplars (Figure 4).

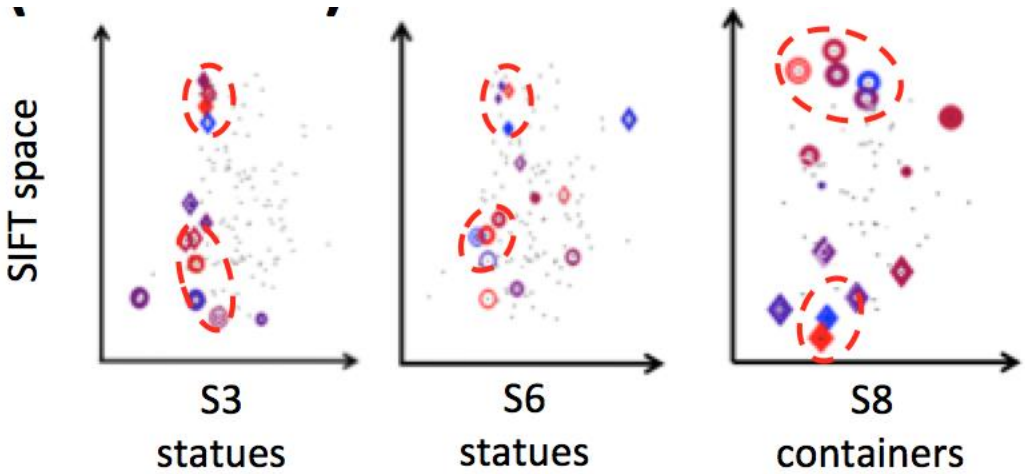

Figure 4. Evidence for surround suppression in the visual feature space defined by the SIFT model (three different subjects for the object categories of statues and containers).

Specific Aim 3: Deploy machine learning tools (e.g., SVMs, linear pattern classifiers) to both effectively identify the selectively of localized neural substrates and to gain a clearer picture of the distributed representation of objects. First, to search high-dimensional image space in an efficient manner with the objective of identifying the optimal image features that drive a local neural subunit (typically a voxel or local collection of voxels as measured by fMRI). Second, to decode and understand the distributed neural code(s) used in the human brain to represent visual objects over large numbers of (potentially) non-contiguous voxels.

This aim was achieved in that we incorporated these questions in the projects completed in Specific Aims 1 and 2. In particular, in Specific Aim 1, model comparisons to neural data were based on a "multivariate pattern analysis" (MVPA) in which the complex pattern of BOLD responses within a given brain region were considered at the voxel level. Similarly, in our MEG work, we applied, perhaps for the first time, the metric of how information for a given condition contrast evolved over the time course of visual object processing (as measured by MEG). That is, we applied a linear pattern classifier to ask, when, in time, did sufficient information accrue to be able to discriminate one category from another. To our knowledge this is first time such machine learning methods have been applied to MEG data.

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be "No."

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes

___**X**___**No**

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes

___X___No

If "Yes" to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both "No.")

18(C) How many hospital and health care professionals were involved in the research project?

_____Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

_____Number of subjects originally targeted to be included in the study

_____Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:

_____Males

_____Females

_____Unknown

Ethnicity:

_____Latinos or Hispanics

_____Not Latinos or Hispanics

_____Unknown

Race:

_____American Indian or Alaska Native

_____Asian

_____Blacks or African American

_____Native Hawaiian or Other Pacific Islander

_____White

_____Other, specify:_____

_____Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?
_____Yes
___X___No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?
_____Yes
___X___No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, and an abbreviated title of the publication. For example, if you submit two publications for Smith (PI for Project 01), one publication for Zhang (PI for Project 03), and one publication for Bates (PI for Project 04), the filenames would be:

Project 01 – Smith – Three cases of isolated
Project 01 – Smith – Investigation of NEB1 deletions
Project 03 – Zhang – Molecular profiling of aromatase
Project 04 – Bates – Neonatal intensive care

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed

acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1. Comparing visual representations across human fMRI and computational vision	Leeds, D. D., Seibert, D. A., Pyles, J. A., & **Tarr, M. J.**	*J. of Vision*	2013	☐Submitted ☐Accepted ☒Published
2. Fine-grained temporal coding of visually-similar categories in the ventral visual pathway and prefrontal cortex	Xu, Y., D'Lauro, C., Pyles, J. A., Kass, R. E., **Tarr, M. J.**	*Front. Psychol.*	2013	☐Submitted ☐Accepted ☒Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes_X_____ No_____

If yes, please describe your plans:

We have two papers in progress. The first presents our real-time methods identifying local shape selectivity using fMRI. The second using MEG to examine both the neural localization and the time course of visual category learning across novel faces. Both should be submitted within the next 6 months.

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project. Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment. Describe major discoveries, new drugs, and new approaches for prevention,

diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes_____ **No** X__

If "Yes" to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is "No.")

a. Title of Invention:

b. Name of Inventor(s):

c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):

d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____

If yes, indicate date patent was filed:

e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____
If yes, indicate number of patent, title and date issued:
Patent number:
Title of patent:
Date issued:

f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No____

If yes, how many licenses were granted?_____

g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes___ No____

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ **No_X_____**

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Tarr, Michael Jay	Co-Director, The Center for the Neural Basis of Cognition, Carnegie Mellon Univ. Professor of Psychology, Carnegie Mellon Univ.
eRA COMMONS USER NAME (credential, e.g., agency login) MICHAEL_TARR	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
Cornell University, Ithaca, NY	B.A.	06/84	Psychology
M.I.T., Cambridge, MA	Ph.D.	09/89	Brain and Cognitive Sciences

A. Personal Statement

The goal of my research is to uncover the neural and behavioral bases of visual cognition, in particular, focusing on human object, face, and scene representation and recognition in human visual cortex. To this end, for the past decade I have been using a variety of neuroimaging methods, including fMRI, DSI, MEG, and EEG, to explore the organization of ventral-temporal cortex with reference to three core problems in visual processing. First, I have been interested in how object invariance is achieved over changes in pose, lighting, position, configuration, and within-category identity. Second, I have been interested in long-term neural and behavioral plasticity across the acquisition of visual and semantic category knowledge. Third, I have been interested in characterizing intermediate feature/part representations in human ventral-temporal cortex. Building on this research program, my lab is presently developing a variety of new neuroimaging methods and analysis tools designed to decode object representation in the human ventral-temporal cortex at a much more fine-grained level.

B. Positions and Honors

Positions and Employment

1989-1991 *Assistant Professor* of Psychology, Yale University
1991-1995 *Assistant Professor* of Psychology and Computer Science, Yale University
1991 *Visiting Scientist*, University of Pennsylvania GRASP Laboratory (Jun-Aug)
1993-1996 *Visiting Scientist*, Max-Planck Institut für biologische Kybernetik, Tübingen, Germany
1995-1997 *Assistant Professor* of Cognitive and Linguistic Sciences, Brown University
1997-2000 *Associate Professor* of Cognitive and Linguistic Sciences, Brown University
2001, 2004 *Associate Chair* of the Department of Cognitive and Linguistic Sciences, Brown University
2002-2003 *Interim Executive Director*, Brain Science Program, Brown University

2000-2009 *Professor* of Cognitive and Linguistic Sciences, Brown University
2001-2009 *Fox Professor of Ophthalmology and Visual Sciences*, Brown University
2007-2009 *Co-Director, Center for Vision Research*, Brown University
2009-2013 *Co-Director, The Center for the Neural Basis of Cognition,* Carnegie Mellon University
2009- *Professor* of Psychology, Carnegie Mellon University
2010-2013 *Cowan Professor of Cognitive Neuroscience*, Carnegie Mellon University
2012-pres. *Founder/Advisor*, Neon Labs, Inc., San Francisco, CA
2014-pres. *Head*, Department of Psychology, Carnegie Mellon University

Other Experience and Professional Memberships

1992 Founder, *Annual Meeting on Object Perception and Memory* (OPAM)
1996 Ad Hoc Member, Perception and Cognition Panel, NIMH
1997-2000 Member, Human Cognition and Perception Panel, NSF
2001- Founding Member, Vision Sciences Society
2001- Member, Vision Sciences Society Abstract Review Committee
2005- Member, American Psychological Society
2009-2015 Member, Scientific Advisory Board, Max-Planck Institut für biologische Kybernetik, Tübingen, Germany
2010- Member, Society for Neuroscience
2010- Member, American Association for the Advancement of Science
2010- Associate Editor, *Frontiers in Psychology: Perception Science*
2012- Advisor, Fellowship Competition, Guggenheim Foundation

Honors

1984-87 National Science Foundation Graduate Fellowship
1987-89 James R. Killian Fellowship, MIT (competitive fellowship)
1987 Goodwin Medal Graduate Teaching Award Nominee, MIT
1988-89 Whitaker College Fellow, MIT (competitive fellowship)
1993-94 Junior Faculty Fellowship, Yale University
1997 American Psychological Association (APA) Distinguished Scientific Award for Early Career Contribution to Psychology in the area of cognition/human learning
1998 Finalist for the James S. McDonnell Centennial Fellowship
2003 Troland Research Award from the National Academy of Sciences
2005 Fellow of the American Psychological Society
2007-2007 James McKeen Cattell Fund Fellowship (declined)
2007-2008 Guggenheim Fellowship
2008 NIH EUREKA Award
2011 Fellow of The Society of Experimental Psychologists

C. Selected Peer-reviewed Publications (Selected from 80+ peer-reviewed publications)

Most relevant to the current application

1. Rossion, B., Kung, C. C., & Tarr, M. J. (2004). Visual expertise with nonface objects leads to competition with the early perceptual processing of faces in the human

occipitotemporal cortex. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(40), 14521-6.

2. Nestor, A., Vettel, J. M., & Tarr, M. J. (2008). Task-Specific codes for face recognition: How they shape the neural representation of features for detection and individuation. *PLoS ONE*, *3*(12).
3. Pyles, J. A., Verstynen, T. D., Schneider, W., & Tarr, M. J. (2013). Explicating the face perception network with white-matter connectivity. *PLoS ONE*, *8*(4): e61611. doi:10.1371/journal.pone.0061611
4. Xu, Y., D'Lauro, C., Pyles, J. A., Kass, R. E., Tarr, M. J. (In Press). Fine-grained temporal coding of visually-similar categories in the ventral visual pathway and prefrontal cortex. *Front. Psychol.*
5. Leeds, D. D., Seibert, D. A., Pyles, J. A., & Tarr, M. J. (In Press). Comparing visual representations across human fMRI and computational vision. *Journal of Vision*.

Additional recent publications of importance to the field (in chronological order)

1. Tarr, M. J. & Pinker, S. (1989). Mental rotation and orientation-dependence in shape recognition. *Cognitive Psychology*, *21*(2), 233-282.
2. Gauthier, I. & Tarr, M. J. (1997). Becoming a "Greeble" expert: Exploring mechanisms for face recognition. *Vision Research*, *37*(12), 1673-82.
3. Gauthier, I., Anderson, A. W., Tarr, M. J., Skudlarski, P., & Gore, J. C. (1997). Levels of categorization in visual recognition studied using functional magnetic resonance imaging. *Current Biology*, *7*(9), 645-51.
4. Tarr, M. J., Williams, P., Hayward, W. G., & Gauthier, I. (1998). Three-Dimensional object recognition is viewpoint dependent. *Nat. Neuroscience*, *1*(4), 275-7.
5. Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform 'face area' increases with expertise in recognizing novel objects. *Nat. Neuroscience*, *2*(6), 568-73.
6. Gauthier, I., Tarr, M. J., Moylan, J., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). The fusiform "face area" is part of a network that processes faces at the individual level. *J. of Cognitive Neuroscience*, *12*(3), 495-504.
7. Gauthier, I. & Tarr, M. J. (2002). Unraveling mechanisms for expert object recognition: Bridging brain activity and behavior. *JEP: HPP*, *28*(2), 431-46.
8. Behrmann, M., Marotta, J., Gauthier, I., Tarr, M. J., & McKeeff, T. J. (2005). Behavioral change and its neural correlates in visual agnosia after expertise training. *J. of Cognitive Neuroscience*, *17*(4), 554-68.
9. Kung, C., Peissig, J. J., & Tarr, M. J. (2007). Is region-of-interest overlap comparison a reliable measure of category specificity?. *Journal of Cognitive Neuroscience*, *19*(12), 2019-2034.
10. Nestor, A. & Tarr, M. J. (2008). Gender recognition of human faces using color. *Psych Sci*, *19*(12), 1242-1246.

D. Research Support

Ongoing Research Support

UCSD	Cottrell (PI)	09/01/2009-08/31/2016

Temporal Dynamics of Learning Center (TDLC)
NSF $35,000 Annual Direct
Role: Co-PI Effort: 1/2 Calendar Month

MURI - BAA-10-002 Hebert (PI) 09/01/2010-08/31/2015
Rich Representations with Exposed Semantics for Deep Visual Reasoning
ONR $100,000 Annual Direct
Role: Co-PI Effort: 1 Academic, 1 Summer Month

Completed Research Support

Awards from NSF, NIH, ONR, NGA, McDonnell Foundation, DAAD

RO1 MH084195 Tarr (PI) 09/01/09-05/31/13
Exceptional, Unconventional Research Enabling Knowledge Acceleration (EUREKA)
NIH $200,000 Annual Direct
Role: PI Effort: 2 Academic, 2 Summer Months