

TITLE**:** **Human shape judgments**

PROTOCOL VERSION DATE**:** March 21, 2019

VERSION**:** 1

# **PRINCIPAL INVESTIGATOR (PI)**:

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# KEY PERSONNEL

**Name**: John Rohrlich

**Role in project**: co-investigator

# OBJECTIVES

We have developed a computational model of how people might learn to categorize objects according to their overall shape features. This model uses a biologically-motivated predictive learning mechanism. In these experiments, we want to test the categories developed by this model against those exhibited by human participants. We will present the same visual object stimuli as presented to the model to people, using the mTurk platform, and record their judgments of shape similarity. This will then be compared against the similarities learned by the model.

# BACKGROUND AND SIGNIFICANCE

It is not currently known how pre-verbal infants, or non-verbal non-human primates, learn to categorize objects, without access to explicit category labels. Current computational models of visual object recognition depend on massive datasets of human-labeled images, which are then used to train deep convolutional neural networks to generate these same labels for each such image. We have developed a biologically-based alternative model that uses predictive learning to learn visual object categories without requiring access to any explicit category labels. These models view brief movies of objects moving and rotating through space, and learn by predicting what will be seen in the next frame of these movies based on what has come before. This prediction problem is challenging, and it requires the model to learn about the visual structure of the objects it is seeing, along with their motion trajectories. We found that by replicating the what / where organization of the visual system, these two aspects of the problem could be solved by separable pathways, and that the what pathway learned to categorize objects in a way that goes beyond the surface-level visual similarity present in the raw visual inputs. Furthermore, it appears to us that this organization makes overall sense in terms of the broad shape of the objects. For example, it grouped traffic cones, sailboats, and layer cakes into a “pyramid-shaped” category. Other categories included “tall vertical” and “wide horizontal” along with “round” and “square / boxy”.

If we can confirm that people use these same categories to organize the same visual objects, then that provides some indication that the model is generating sensible abstract shape-based categories that go beyond the raw visual input similarities. This would provide a valuable addition to our paper describing this model, providing empirical validation that it has learned sensible categories.

# PRELIMINARY STUDIES

none

# RESEARCH STUDY DESIGN

In this experiment, participants will be shown a series of displays, composed of two pairs of images, on the Left and Right (see Figure 1). Participants are asked whether the Left, Right, or Neither pair is more similar in terms of overall shape. Based on these judgments, we can compile the overall probabilities of each type of pair being judged as more similar, and compare those similarity levels with those generated by our computational model.



Figure 1-One example trial

# FUNDING

This research will be funded by the Office of Naval Research (ONR), with final funding pending IRB approval. The grant is title, “Bidirectional Vision.”

# ABOUT THE SUBJECTS

We will run 30 participants for each version of the experiment, with multiple versions run as needed pending discovery of any unforeseen limitations or issues in the previous design(s). They will be from Amazon.com’s mechanical turk workforce. These subjects voluntarily enroll in amazon’s program in order to complete research for pay. We will select those participants who qualify as “masters” – i.e., have demonstrated a significant level of reliability over time in performing a wide variety of mTurk tasks.

# VULNERABLE POPULATIONS

none

# RECRUITMENT METHODS

The study description posted on amazon.com’s mechanical turk will be as follows, which serves as the informed consent per typical mTurk protocol (i.e., the decision to proceed with the study represents an acceptance of this consent information).

This research will investigate how people categorize or group together different shapes. The results will be used to test the predictions from computer models based on how learning might work in the brain. It is being conducted by Dr. Randall O’Reilly of the University of Colorado, and has been reviewed and approved by an Institutional Review Board (“IRB”). You may talk to them at (303) 735-3702 or irbadmin@colorado.edu if: Your questions, concerns, or complaints are not being answered by the research team; You cannot reach the research team; You want to talk to someone besides the research team; You have questions about your rights as a research subject; You want to get information or provide input about this research. Any mechanical Turk worker that is over 18 years old is eligible to participate. During this study, you will see and respond to a series of images containing pairs of shapes, and you will judge which pairs of shapes are more similar to each other. You will receive $8.00 for completing this research, which should take 30 minutes to complete. Your data will be recorded without retention of any link to your amazon ID, in a secure and encrypted format. There are no known or suspected risks to participants in this study beyond the risks encountered in daily living. Your decision to proceed with this study represents your understanding and acceptance of the above information.

# COMPENSATION

We will compensate participants at the rate of $.01 per image (HIT in mTurk terminology), and there will be 800 such images presented in the full study. Assuming a rate of approximately one image every 2 seconds, this will take slightly under 30 minutes to complete, and yield a total compensation of $8.00.

# INFORMED CONSENT

The above study description and decision to proceed with the study represents the informed consent process. The study description contains the essential information provided by a typical informed consent form.

# PROCEDURES

The procedures are as described above. Participants will provide informed consent by reading the project description and deciding to proceed (or not). 800 trials of paired shape stimuli will then be presented, and they will judge which pair has the highest similarity. The entire experiment should take approximately 30 minutes.

# SPECIMEN MANAGEMENT

n/a

# DATA MANAGEMENT

Data will be stored electronically on a password-protected computer that will only be accessible by lab members. No identifying information will be stored in the data and furthermore, individuals’ responses will be anonymized using a numerical subject identifier.

Data will be backed up nightly during the course of the study. After the conclusion of the study, the data will be password protected and archived on O’Reilly’s servers. Non-identified data will be retained indefinitely. The justification for indefinitely retaining the data is to allow subsequent reanalysis of existing data, which would minimize unnecessary data collection in the future.

# PROVISIONS TO PROTECT THE PRIVACY INTERESTS OF PARTICIPANTS

Data will be stored without any connection to amazon worker ID, safely stored (see previous section), and thus data will be kept private.

# WITHDRAWAL OF PARTICIPANTS

n/a

# RISKS TO PARTICIPANTS

There are no known or suspected risks to participants in this study beyond the risks encountered in daily living.

# MANAGEMENT OF RISKS

n/a

# POTENTIAL BENEFITS

Although there are no immediate benefits to individual participants beyond reimbursement, their participation will help foster an understanding of the brain mechanisms related to perception and learning.

# PROVISIONS TO MONITOR THE DATA FOR THE SAFETY OF PARTICIPANTS

There are no stigmas or privacy issues associated with participation in this research.

# MEDICAL CARE AND COMPENSATION FOR INJURY

n/a

# COST TO PARTICIPANTS

There are no foreseeable costs to the participants.

# DRUG ADMINISTRATION

n/a

# INVESTIGATIONAL DEVICES

n/a

# COLLABORATIVE STUDIES

**n/a**

# SHARING OF RESULTS WITH PARTICIPANTS

Due to the anonymous nature of the mTurk platform, we do not have any plans to share the data with participants.