Behavioral Analysis (Part 1)

Spatial Heterogeneity in the Perception of Face and Form Attributes

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Specific cognitive tasks are assessed to measure cognitive ability as well as brain activity in various cognitive states. These tasks often involve memory, language, social attributes, decision-making, perception, and sensorimotor skills. In this project, we intend to investigate spatial heterogeneity in face perception. The identity of an object is a fixed property, independent of where it appears, and an effective visual system should capture this invariancy. We want to know whether the perceived gender of a face is biased toward male or female at different locations in the visual field

Keywords: cognitive task, spatial homogeneity, behavioral analysis, cognitive science, neuroscience

1. Problem Description

To associate gender discriminability with stimuli position, Afraz et.al [1] designed a task in which a range of stimulus signal values (e.g. various morphing levels for faces) are displayed at different locations in the visual field in a fraction of a second, and participants are asked to indicate the gender of presented face. In this assignment, we are to gather insight over behavioral task design while replicating a part of their work. [1]

1: The face stimuli were made with Singular Inversion's FaceGen which produces facial prototypes based on 3D scans of numerous faces (based on methods developed by [2]).

2. Methods

Development of a psycho-physics task requires hardwares (and often softwares) that present stimulus at specific times and capture behavioral data on a precise and real-time basis. While there might be some dedicated hardwares for specific tasks, most of the modern tasks are relying on the computation power of computers. The attraction of using computer displays for visual psychophysics is that they allow software specification of the stimulus. Programs to run experiments are often written in a low-level language (e.g., C

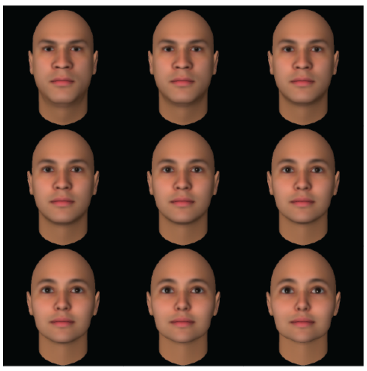

Figure 1: Stimuli set that is going to be used during this assignment

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or Pascal) to achieve full control of the hardware for precise stimulus display. Although these low-level languages provide power and flexibility, they are not conducive to rapid program development. Interpreted languages (e.g., BASIC, LISP, Mathematica, and Matlab) abstract hardware details and provide friendlier development environments, but don't provide the hardware control needed for precise stimulus display. The Psychophysics Toolbox is a software package that adds this capability to the Matlab and Octave application on Macintosh, Linux and Windows computers. Some of PTB's functionalities are available as part of Python toolkits like PsychoPy. To enhance the speed of development for non-programmer community, PSychopy has distributed a task builder, in which the overall flow of task is described using graphical tools, and the corresponding python scripts are generated automatically. Having the convenience of these toolboxes, we chose them as our development platform. You might choose any of the aforementioned methods, although it's highly recommended to write your task from scratch in either python an MATLAB without using the builder, as it gives you more power to write more complex tasks and have more control on your task details. [1]

1: Derived roughly from the Psychtoolbox's official website.

Exposing a subject to multiple repetitions of a condition won't reproduce the exact data, as subject's response is prone to systematic noise. To reduce the effect of this noise, each condition is presented multiple times, so that the "real" response can be averaged, vanishing the systematic noise. So the overall procedure of a psychophysics task is a repetitive procedure. Each chunk of this procedure is called a trial. During each of these trials, some stimuli is presented that might evoking some behavioral or neural response. In more complex task, these responses might form the next steps of the trial.

The task we need in this assignment is an example of Two alternative forced choice (2AFC) task, which is a method for measuring the sensitivity of a person, child, infant or animal to some particular sensory input. 2AFC was developed by Gustav Theodor Fechner. [2]

2: (1801 – 1887) was a German experimental psychologist, philosopher, and physicist (Figure 2). An early pioneer in experimental psychology and founder of psychophysics, he inspired many 20th-century scientists and philosophers. He is also credited with demonstrating the non-linear relationship between psychological sensation and the physical intensity of a stimulus via the formula: $S = K \ln I$, which became known as the Weber–Fechner law. (Wikipedia)

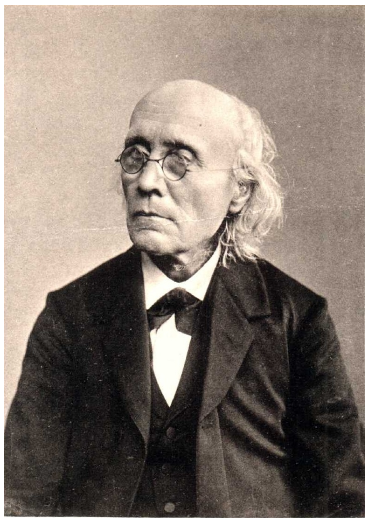


Figure 2: Gustav Theodor Fechner

Each trial starts with appearance of a small red fixation point in the middle of the screen. After 500ms the test stimulus is displayed for 50 ms (see Figure 3). The stimuli are placed in the center of monitor, or are spread on two circles around the fixation point with either 4°, 7° radius. The foveal stimulus (diplayed over fixation point) is 2.5° in diameter, while the peripheral stimuli are 4° and 6° in diameter, respectively (Area of stimulus increases as it gets further from fixation point). The change in stimulus diameter is required in order to associate the changes in receptive field size of striate cortex. The Figure 5 contains the spread of stimulus locations. Subjects responded by pressing one of the two keys on the computer keyboard.

A block, which consists of 468 trials, is a combination of locations (13), stimulus type (9), repetitions (2) and the hand in use (2). So in each block, each of participants respond to $13 \times 9 \times 3$ trials with each of their hands. The participants are required to report the identity of the gender in 4 blocks. The arrangement of hand responses within the block, position of stimuli in visual fields and the displayed face should all be random.

Reaction times are captured by means of subtracting the time of keypress on the keyboard (Q:female and W:male in blocks that use the left-hand and O:female and P:male in blocks that use the right-hand, refer to Figure 4) from time of stimulus onset. **Before each section, participants are told to answer as quickly and accurately as possible by pressing the appropriate key.**

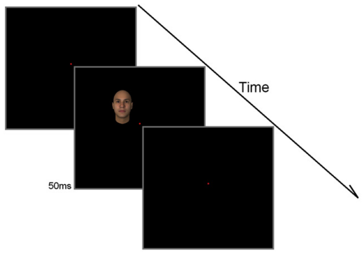


Figure 3: Task timing and paradigm

Figure 4: Subjects selecting their response with their left (top panel) and right (bottom panel) hand. The key buttons corresponding to fingers with mahogany nail polish represent female response, while the pale pink color indicate male option.

3. Data Format

The results of task should be saved in a `.csv` file with 11 columns. Each row of the output data would represent a single trial performed by the subject and each column corresponds to an attribute of that trial. These attributes are listed in Table 1. Column names are case sensitive. Value entries for each of variables are as follows:

1. **sbj**: a unique label for the participant that performed this trial. e.g. 8123456781
2. **stm**: name of presented stimuli. e.g. “10.bmp”
3. **rt**: is a float number, reaction time in seconds. e.g. 0.53.
4. **key**: the pressed key, either ‘q’, ‘w’, ‘o’, ‘p’
5. **pos**: position of stimulus, an integer described in Figure 5
6. **uhnd**: the hand that was used in the block containing this trial. Either ‘l’ (left) or ‘r’ (right).
7. **hndns**: the subjects hand dominancy. Either ‘l’ (left) or ‘r’ (right).
8. **eye**: the subjects occular dominancy. Either ‘l’ (left) or ‘r’ (right).
9. **sex**: subject’s gender
10. **age**: subject’s age. An integer number, e.g. 27.
11. **edu**: subject’s highest academic graduation level. 1 for high school diploma, 2 for bachelor’s degree, 3 for master’s degree and 4 for p.h.d or higher.

All alphabetic characters and strings should be in lower case and all numbers should be English.

Table 1: Output data columns

Attribute	Column Name
Subject ID	sbj
Stimulus Index	stm
Condition Index	ind
Reaction Time	rt
key Response	key
Stimulus Position	pos
Used Hand	uhnd
Sbj. Handedness	hndns
Sbj. Eyeness	eye
Sbj. Gender	sex
Sbj. Age	age
Sbj. Education	edu

4. Important Notes

1. Participants should sit symmetrically in front of the monitor screen while performing the task, otherwise the visual field would vary subject by subject and contaminates the data set.
2. In addition to the visual field, the arrangement of each block must be random to prevent the effect of the exercise.
3. Between 4 blocks, it is preferable to rest for a few minutes to reduce the effect of fatigue.

5. Submission

The overall flow of task's script is up to the students. Only it should display the stimulus to the subjects exactly according to the described paradigm and receive responses in that specified manner. The output data table can be generated directly or be modified later by yourself (adding or removing columns manually). Note that table's columns name should be exactly as are given in Table 1. Deviation from these conditions might create problems in your next assignment preparation, therefore such errors might lead to your submission's annulment. Each of the students should submit their working task scripts and data tables gathered from at least two independent subjects (preferably different from themselves.) Each of your participants should be labeled with a unique number, generate by concatenation of your student ID and the index of that subject.

So a student with sid 812345678, uploads a zip file containing files with names `8123456781.csv`, `8123456782.csv` and so on. Besides that, he/she submits the final version of his/her task scripts in a separate zip file.

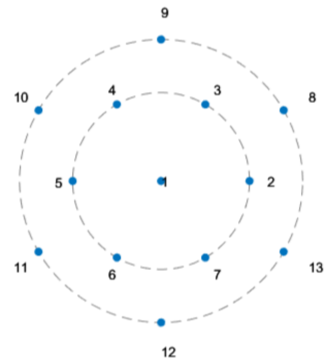


Figure 5: Labels corresponded to each stimulus position

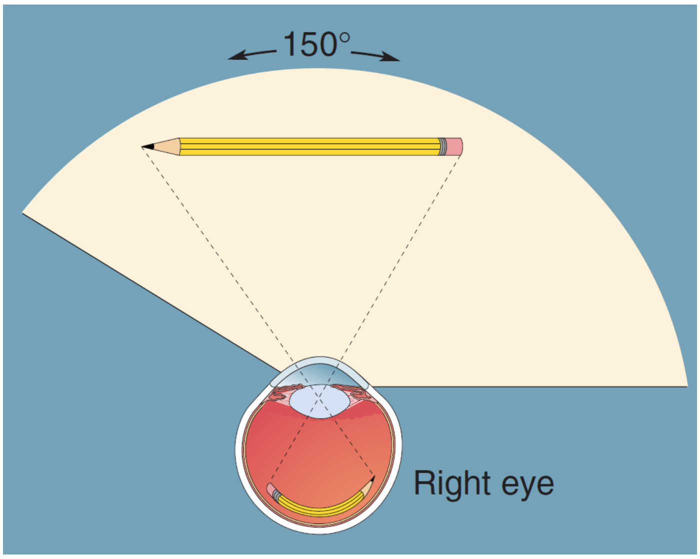
A. Appendix: Visual Angle, Visual Field [3]

Visual Field

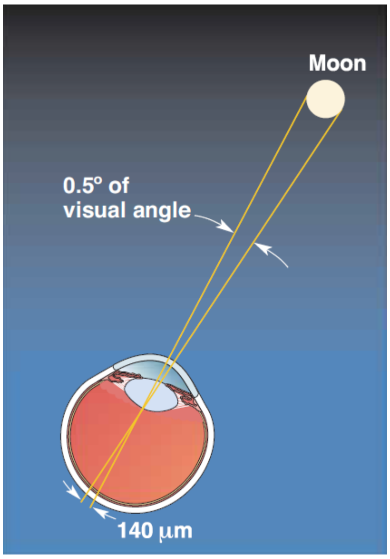
The structure of the eyes, and where they are positioned in the head, limits how much of the world we can see at any one time. Let's investigate the extent of the space seen by one eye. Holding a pencil vertically in your right hand, close your left eye and look at a point straight ahead. Keeping your eye fixated on this point, slowly move the pencil to the right (toward your right ear) across your field of view until the pencil disappears. Repeat this exercise, moving the pencil to the left where it will disappear behind your nose, and then up and down. The points where you can no longer see the pencil mark the limits of the visual field for your right eye. Now look at the middle of the pencil as you hold it horizontally in front of you. Figure 6a shows how the light reflected off this pencil falls on your retina. Notice that the image is inverted; the left visual field is imaged on the right side of the retina, and the right visual field is imaged on the left side of the retina. Similarly, the upper visual field is imaged on the bottom of the retina and the lower visual field is imaged on the upper retina.

Visual Acuity

The ability of the eye to distinguish two points near each other is called visual acuity. Acuity depends on several factors but especially on the spacing of photoreceptors in the retina and the precision of the eye's refraction. Distance across the retina can be described in terms of degrees of visual angle. (Figure 6b) A right angle subtends (spans) 90°, and the moon, for example, subtends an angle of about 0.5° (Figure 9.10). At arm's length, your thumb is about 1.5° across and your fi st about 10°. We can speak of the eye's ability to resolve points that are separated by a certain number of degrees of visual angle. The Snellen eye chart, which we have all read at the doctor's office, tests our ability to discriminate letters and numbers at a viewing distance of 20 feet. Your vision is 20/20 when you can recognize a letter that subtends an angle of 0.083° (equivalent to 5 minutes of arc, where 1 minute is 1/60 of a degree).



(a) The visual field for one eye: The visual field is the total amount of space that can be viewed by the retina when the eye is fixated straight ahead. Notice how the image of an object in the visual field (pencil) is left–right reversed on the retina. The visual field extends nearly 100° to the temporal side but only about 60° to the nasal side of the retina, where vision is blocked by the nose.



(b) Visual angle: Distances across the retina can be expressed as degrees of visual angle.

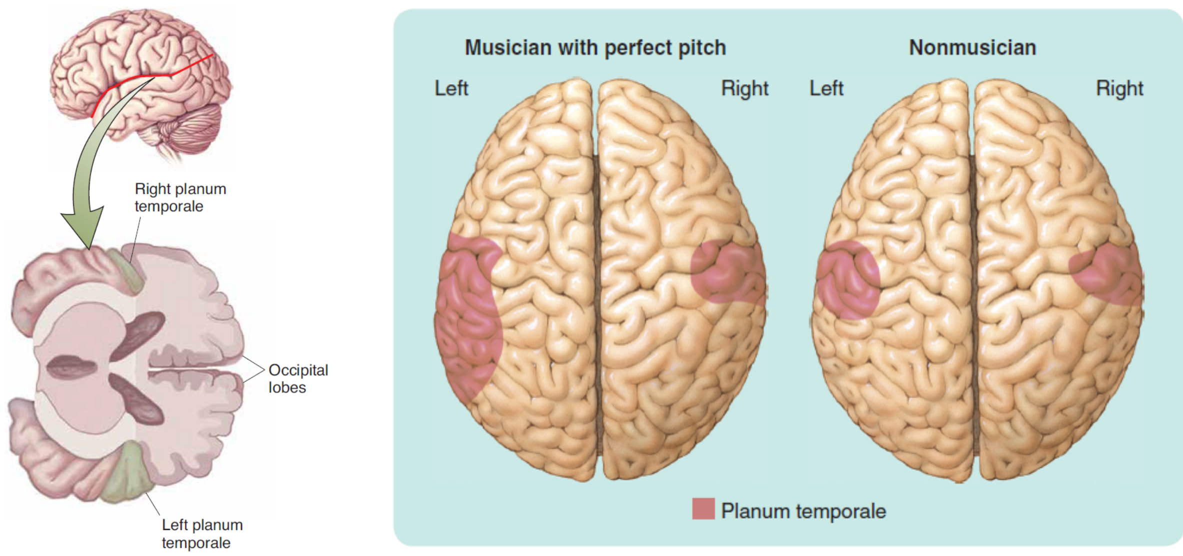
Figure 6: Visual field and visual acuity are related to length of projections on retina.

B. Appendix: Hemisphere Dominancy

Anatomical Asymmetry and Language [4]

In the nineteenth century, there were reports of anatomical differences between the two hemispheres. For example, it was noted that the left Sylvian fi ssure is longer and less steep than the right (Figure 20.15). However, as recently as the 1960s, there was considerable doubt about the existence of signifi cant cortical asymmetries. Because of the strikingly asymmetrical control of speech demonstrated by the Wada procedure, it would be interesting to know if the two cerebral hemispheres are anatomically different. Some of the fi rst good quantitative data demonstrating hemispheric differences came from the work of Geschwind and his colleague Walter Levitsky. Initial observations were made of postmortem brains, but more recently, the results were confirmed with magnetic resonance imaging (MRI).

The most significant difference seen was in a region called the **planum temporale**, which is a part of Wernicke's area on the superior surface of the temporal lobe (Figure 7a). Based on measurements of 100 brains, Geschwind and Levitsky found that in about 65% of the brains, the left planum temporale was larger than the right, whereas in only about 10%, the right was larger. In some instances, the left area was more than five times larger than the right. Interestingly, the asymmetry in this area is seen even in the human fetus, suggesting that it is not a developmental consequence of the use of the left hemisphere for speech. Indeed, apes also have a larger left planum temporale. This suggests the possibility that speech became dominant in the left hemisphere because of a preexisting size difference. Other studies found that a portion of Broca's area also tends to be larger in the left hemisphere. Are these larger areas in the left hemisphere related to the common dominance of the left hemisphere for speech?



(a) Left planum temporale is bigger **(b)** Assymetry is more intense in musicians. From [5]

Figure 7: Anatomical assymetry of planum temporal.

More recent investigations of gray matter volume have been made using MRI in living subjects, making it possible to test correlations among brain anatomy, asymmetries, and language dominance. One challenge in these studies is fi nding enough people who are right hemisphere dominant for language. Several language areas, including the planum temporale, Broca's area, and the insula, are generally larger in the left hemisphere than the right, and this is true in people with a left or right hemisphere dominant for language. The big question is whether the hemisphere dominant for language can be predicted from the degree to which the structure on the left is larger than on the right. Perhaps some structure on the left side is much bigger in a person with a dominant left hemisphere but only a little bigger or smaller in a person with a dominant right hemisphere.

There have been mixed reports about a correlation between the size of the left and right planum temporale and the hemisphere dominant for language. There have also been reports about a correlation between the language-dominant hemisphere and the relative size of Broca's area on each side of the brain. At present, it appears there may be some correlation between the asymmetric sizes of Broca's area and the planum temporale with the hemisphere dominant for language, but the correlation is not strong enough to allow one to predict the language-dominant hemisphere from anatomical measurements alone. The brain region that presently appears to best predict which hemisphere is dominant for language is the insula , which is the cerebral cortex within the lateral sulcus that is between the temporal and parietal lobes. Even though the insula has been thought to be involved in human language for some time, the relationship between its size and language lateralization is somewhat surprising, as the language functions of the insula have been studied less and are less well understood than other language areas in the brain. Also, the insula appears to be involved in numerous brain functions ranging from taste to emotion. Further research is needed to clarify its role in language and its relationship with hemispheric dominance.

It has probably occurred to you that a functional human asymmetry more obvious than language is handedness. More than 90% of humans are right-handed and usually relatively uncoordinated with their left hand, implying that in some way the left hemisphere is specialized for fine motor control. Is this related to the left hemispheric dominance for language? The answer is not known, but it is interesting that humans are different from nonhuman primates in handedness as well as language. While animals of many species show a consistent preference for using one hand, there are typically equal numbers of left-handers and right-handers.

Occular Domainace [6]

Your dominant eye is the eye that provides a slightly greater degree of input to the visual part of your brain and more accurately relays information about the location of objects. Most of the time, the term "dominant eye" is used when describing the normal visual condition where the two eyes function well as a team and have equal visual acuity. One eye is simply the "leading" or preferred eye.

Though eye dominance and handedness (being right-handed or left-handed) are not directly related, these traits are significantly associated. Population studies show that about 90% of people are right-handed and about 67% are right-eye dominant. Although research has shown that the odds of a person who is right-handed being right-eye dominant are high — approximately 2.5 times greater than the odds of that person being left-eye dominant — it is impossible to predict eye dominance based on handedness alone.

Here's a simple dominant eye test to determine which eye is your preferred eye:

1. Extend your arms out in front of you and create a triangular opening between your thumbs and forefingers by placing your hands together at a 45-degree angle
2. With both eyes open, center this triangular opening on a distant object — such as a wall clock or door knob.
3. Close your left eye.
4. If the object stays centered, your right eye (the one that's open) is your dominant eye. If the object is no longer framed by your hands, your left eye is your dominant eye.

Figure 8: Occular Dominancy Test

References

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