PSYC 51.09: Problem Set 3

Introduction

This problem set is intended to solidify the concepts you learned about in this week's lectures and readings. Your responses will be worth 5% of your final grade. You are encouraged to work together with your classmates in small groups, and/or to post and answer questions on the course's Canvas site. ***However, you must clearly indicate who your collaborated with and submit your own (uniquely worded) responses.***

We will go over the answers to this problem set in class on **Thursday, January 25, 2018 at 10:10 am**. You must upload your answers before then in order to receive credit. No late submissions will be accepted.

Readings

1. Read Chapter 3 of *Foundations of Human Memory*. What were your thoughts on the reading? For example, did you learn something interesting? Were you surprised by something? Do you disagree with the author? Did you think some concept was described especially well (or confusingly)? **(Ungraded)**

2. Blei (2012) describes a "topic model," which is a computational algorithm that can mathematically discover and describe "topics" or "categories" by analyzing a large collection of documents. Read the paper (skimming or skipping the equations and the descriptions of "graphical models"). What did you think? **(Ungraded)**

3. Mitchell et al (2008) describes a technique for decoding which word someone is thinking of using their brain activity (recorded using a technique called functional magnetic resonance imaging, or fMRI). This technique allows researchers to obtain a 3D "snapshot" of someone's brain activity about once per second during an experiment. Read the paper (skimming the equations). What did you think? What are the ethical implications of this paper? **(Ungraded)**

Graded questions

Show all work and provide answers rounded to the nearest thousandth (third decimal place).

1. After studying a list of 4 items during a trial of a Sternberg task, a participant's memory matrix M is given by

$$\begin{aligned} M &= \begin{pmatrix} 1 & 3 & 5 & 7 \\ 2 & 4 & 6 & 8 \\ 4 & 3 & 2 & 1 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix} \\ &= \begin{pmatrix} \mathbf{m}_1 & \mathbf{m}_2 & \mathbf{m}_3 & \mathbf{m}_4 \end{pmatrix} \end{aligned}$$

   (a) **(1.5 pt)** Suppose the probe item is the target $\mathbf{m}_3$. Compute the similarities to $\mathbf{m}_1$, $\mathbf{m}_2$, and $\mathbf{m}_4$ using **distance-based similarity** (let $\tau = 0.5$):

$$\text{similarity}(\mathbf{a}, \mathbf{b}) = e^{-\tau \|\mathbf{a}-\mathbf{b}\|} = e^{-\tau \sqrt{\sum_{i=1}^{N} (a(i)-b(i))^2}}.$$

(b) **(1.5 pt)** Compute the same similarity values using **cosine-based similarity**:

$$\cos\theta(\mathbf{a},\mathbf{b}) = \frac{\mathbf{a}\cdot\mathbf{b}}{||\mathbf{a}||\,||\mathbf{b}||}, \text{ where}$$
$$\mathbf{x}\cdot\mathbf{y} = \sum_{i=1}^{N} x(i)y(i), \text{ and}$$
$$||\mathbf{c}|| = \sqrt{\sum_{i=1}^{N} c(i)^2} \tag{1}$$

(c) **(1 pt)** Consider your calculations in (a) and (b). Would choosing one similarity metric (versus the other) have led to any different predictions about similarity or memory judgements? Explain (1-2 paragraphs).

(d) **(1 pt)** Suppose the participant instead receives the probe item $\mathbf{p}_1$:

$$\mathbf{p}_1 = \begin{pmatrix} 5 \\ 7 \\ 1 \\ 0 \\ 0 \end{pmatrix}.$$

If the participant's summed similarity decision threshold is 0.75, do you predict that they'll call the probe item old or new? Use distance-based similarity (with $\tau = 0.5$) to justify your prediction.