AMS5 - Final
Thursday 11th June, 2015

READ THE INSTRUCTIONS CAREFULLY

1. Write your answers in a Blue Book. Write, *in ink*, your name, your student ID number, your section day/time and your TA's name on the front of your blue book.
2. This exam consists of three (3) regular questions, and two (2) bonus questions.
3. You should answer all the regular questions. Questions are not necessarily worth equal numbers of marks.
4. You are advised to read the questions carefully, and answer the question asked.
5. Begin your answer to each question on a new page.
6. You must show working or give explanations for all questions to get full marks.
7. A normal table and a χ^2-table can be found at the end of this exam.
8. Hand in this question paper with your answers.
9. One of the questions has a bonus part, and there are two bonus questions. You can get full marks without answering the bonus questions. Correct answers to the bonus questions will earn you additional marks, but you cannot score more than 100%.

1. *(16 marks)* **Jelly Splash (Revisited)**
On the midterm we examined what happened when a player had two moves left at the end of a particular level of Jelly Splash, and found that with probability 4/39 the player scores 9250 bonus points, with probability 7/39 the player scores 8500 bonus points, and with probability 28/39 the player scores 10,000 bonus points. These outcomes were for when the two "splashes" fell in the same row, in the same column, or in distinct rows and columns, respectively.

   (a) On the last 4 occasions when I had two moves left I scored 8500 three times. What is the probabilty of this happening? What assumptions did you make?

   (b) The three occasions before that resulted in a total bonus of 27,750. What is the probability of this happening?

   (c) When playing, I get the feeling that I'm scoring fewer bonus points than I should. I recorded the bonus points scored on 39 occasions with the following results:

bonus points	frequency
9250	8
8500	10
10000	21

   Does it appear that the two positions are indeed chosen at random?

   (d) On a different occasion I recorded the average score over 39 plays when I had two moves left at the end of the level. The average was 9461.5. On this occasion did it appear that the two positions were chosen at random?

2. *(7 marks)* **Cell Phone Use and GPA**
Read the abstract of the article *"The relationship between cell phone use, academic performance, anxiety, and Satisfaction with Life in college students"* printed at the back of this exam.

   (a) Does this describe a controlled experiment or an observational study? Explain briefly.

   (b) What were the hypotheses being studied?

   (c) What did the investigators find?

The table below (extracted from Table 1 in the paper) gives the descriptive statistics for Cell Phone Use (CPUse, in minutes per day). There were 496 people in the Cell Phone data set.

	mean	SD	min	max
CPUse	278.67	218.00	0.00	915.00
GPA	3.06	0.59	1.46	4.00

   (d) Does the distribution of CPUse appear to approximately follow the normal curve? Explain your answer.

The correlation coefficient between CPUse and GPA was -0.20.

   (e) Student B spends an hour per day more time using their cell phone than Student A. By how much would you predict that student A's GPA is higher than Student B's GPA?

   (f) Comment on the validity of your answer to e) based on your answer to d).

   (g) Does increased CPUse reduce GPA?

   (h) [**BONUS**] *(3 marks)* What is the probability that Student A's GPA is *below* that of Student B?
   (Hint: the standard deviation of a difference follows an analogous formula to the standard error of a difference.)

3. *(8 marks)* **Facebook**

Read the abstract (the first paragraph, in bold) of the paper *"Experimental evidence of massive-scale emotional contagion through social networks"* printed at the end of this exam.

This article describes an experiment whereby for some Facebook users the number of posts with positive expressions was reduced, and for others the number of posts with negative expressions was reduced. Control groups did not have their feeds altered.

(a) Express the investigators' hypothesis in terms of a null hypothesis and an alternative hypothesis.

Out of the three million posts analysed as part of the experiment, 22.4% contained negative words, and 46.8% contained positive words.

(b) Give a range of plausible values for the percentage of all Facebook posts that contain words with positive sentiment.

(c) This experiment was conduced in January 2012. Did the percentage of all posts containing positive words lie in the range you computed in b) in that time period?

(d) Do you expect that the percentage of all posts with positive words in June 2015 will lie in the range you computed in part b). Explain your answer.

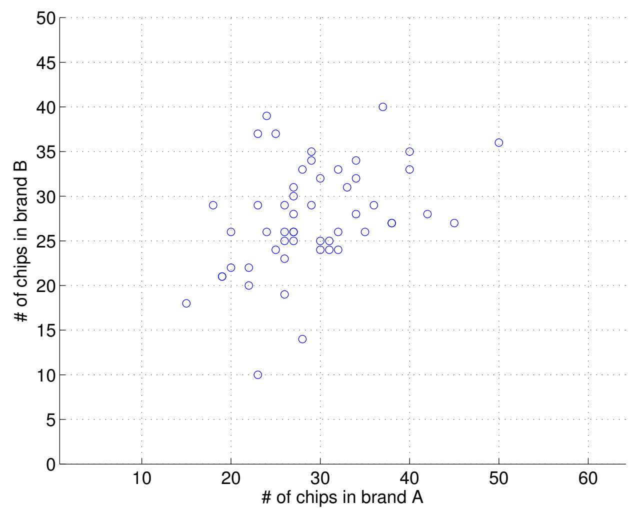
The investigators found that

> "When positive posts were reduced in the News Feed, the percentage of positive words in people's status updates decresed by B=-0.1% compared with control"

(e) Does manipulating the News Feed cause social contagion?

(f) Is the observed difference important?

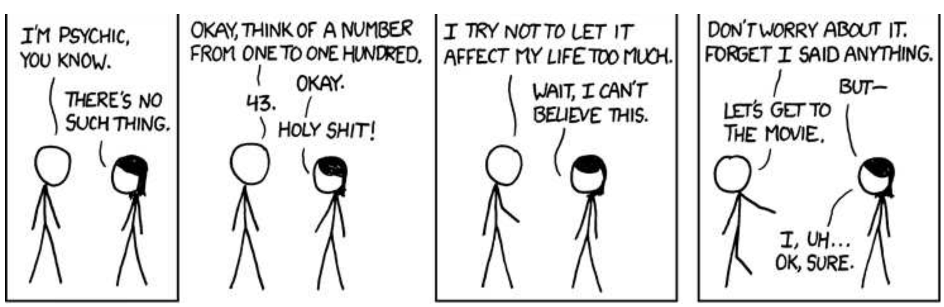
4. [**BONUS**] *(1 mark)* **Chocolate Chip Cookies**
We ate chocolate chip cookies in class. The figure below shows a scatter diagram of the # of chips in brand B vs. the # of chips in brand A for the data collected in a previous quarter. The correlation coefficient, r, is 0.40.



The cookies were handed out randomly – I had no way of arranging how many chips were in the cookies eaten by a given individual.

How do you explain the positive correlation between the number of chips reported for the two brands?

5. [**BONUS**] *(1 mark)* Why is the following cartoon[1] funny?



[1] xkcd.org

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The relationship between cell phone use, academic performance, anxiety, and Satisfaction with Life in college students

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ABSTRACT

While functional differences between today's cell phones and traditional computers are becoming less clear, one difference remains plain – cell phones are almost always on-hand and allow users to connect with an array of services and networks at almost any time and any place. The Pew Center's Internet and American Life Project suggests that college students are the most rapid adopters of cell phone technology and research is emerging which suggests high frequency cell phone use may be influencing their health and behavior. Thus, we investigated the relationships between total cell phone use ($N = 496$) and texting ($N = 490$) on Satisfaction with Life (SWL) in a large sample of college students. It was hypothesized that the relationship would be mediated by Academic Performance (GPA) and anxiety. Two separate path models indicated that the cell phone use and texting models had good overall fit. Cell phone use/texting was negatively related to GPA and positively related to anxiety; in turn, GPA was positively related to SWL while anxiety was negatively related to SWL. These findings add to the debate about student cell phone use, and how increased use may negatively impact academic performance, mental health, and subjective well-being or happiness.

1. Introduction

Distinctions between today's cellular phones (henceforth cell phones) and traditional notions of the computer are becoming less and less clear. For example, in 2011, the 8th US Circuit Court of Appeals ruled that smart phones as well as ordinary cell phones (those used only to make calls and send text messages) are, from a legal standpoint, computers (United States v. Kramer, 2011). In terms of functionality, cell phones complete many of the same tasks as an Internet connected computer. As such, today's cell phones allow users to call, text, e-mail, video conference, micro-blog, interact on social-networks, surf the Internet, watch and share videos and pictures, play video games, and utilize a tremendous array of software driven applications. In contrast to traditional notions of the computer, the mobile nature of the cell phone allows these services to be accessed almost anywhere and at almost any time. Considering that cell phones and their growing suite of applications are typically within arm's reach of nearly everyone, it is worth considering what influence they may have on users' beliefs, attitudes, behaviors and behavioral outcomes. It may be that cell phone use (CPUse) has implications for human behavior which extend beyond the realm of communication.

For example, a recent study by our group (Lepp, Barkley, Sanders, Rebold, & Gates, 2013) found that CPUse was negatively related to an objective measure of physical fitness (VO2peak) among a sample of typical college students. In other words, high cell phone users were less physically fit than low cell phone users. Interview data collected as part of the study explained the negative relationship by suggesting that CPUse disrupts physical activity behavior, causing high frequency users to be less physically active and more sedentary in comparison to low frequency users. Unpublished interview data collected during the same study also suggested that CPUse may disrupt college students' academic achievement and contribute to anxiety. Specifically, when participants were asked to provide details about their CPUse, several indicated that it occurred during class time or while studying. For example, one participant stated "I usually go on my phone if I am bored sitting there in class. Or during homework I will take little Twitter breaks." Likewise, when asked to explain their experience of CPUse, some indicated that CPUse is associated with feelings of anxiety. For example, another participant stated:

> The social network sometimes just makes me feel a little bit tied to my phone. It makes me feel like I have another obligation in my life that I have to stick to. Sometimes the cell phone just makes me feel like it is a whole new world of obligations that I have because anybody can get a hold of me at any time by just thinking about me. You know, if my mom wanted to give me a call right now, and just talk for a second, she could. And if I did

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Experimental evidence of massive-scale emotional contagion through social networks

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Emotional states can be transferred to others via emotional contagion, leading people to experience the same emotions without their awareness. Emotional contagion is well established in laboratory experiments, with people transferring positive and negative emotions to others. Data from a large real-world social network, collected over a 20-y period suggests that longer-lasting moods (e.g., depression, happiness) can be transferred through networks [Fowler JH, Christakis NA (2008) *BMJ* 337:a2338], although the results are controversial. In an experiment with people who use Facebook, we test whether emotional contagion occurs outside of in-person interaction between individuals by reducing the amount of emotional content in the News Feed. When positive expressions were reduced, people produced fewer positive posts and more negative posts; when negative expressions were reduced, the opposite pattern occurred. These results indicate that emotions expressed by others on Facebook influence our own emotions, constituting experimental evidence for massive-scale contagion via social networks. This work also suggests that, in contrast to prevailing assumptions, in-person interaction and nonverbal cues are not strictly necessary for emotional contagion, and that the observation of others' positive experiences constitutes a positive experience for people.

computer-mediated communication | social media | big data

Emotional states can be transferred to others via emotional contagion, leading them to experience the same emotions as those around them. Emotional contagion is well established in laboratory experiments (1), in which people transfer positive and negative moods and emotions to others. Similarly, data from a large, real-world social network collected over a 20-y period suggests that longer-lasting moods (e.g., depression, happiness) can be transferred through networks as well (2, 3).

The interpretation of this network effect as contagion of mood has come under scrutiny due to the study's correlational nature, including concerns over misspecification of contextual variables or failure to account for shared experiences (4, 5), raising important questions regarding contagion processes in networks. An experimental approach can address this scrutiny directly; however, methods used in controlled experiments have been criticized for examining emotions after social interactions. Interacting with a happy person is pleasant (and an unhappy person, unpleasant). As such, contagion may result from experiencing an interaction rather than exposure to a partner's emotion. Prior studies have also failed to address whether nonverbal cues are necessary for contagion to occur, or if verbal cues alone suffice. Evidence that positive and negative moods are correlated in networks (2, 3) suggests that this is possible, but the causal question of whether contagion processes occur for emotions in massive social networks remains elusive in the absence of experimental evidence. Further, others have suggested that in online social networks, exposure to the happiness of others may actually be depressing to us, producing an "alone together" social comparison effect (6).

Three studies have laid the groundwork for testing these processes via Facebook, the largest online social network. This research demonstrated that (*i*) emotional contagion occurs via text-based computer-mediated communication (7); (*ii*) contagion of psychological and physiological qualities has been suggested based on correlational data for social networks generally (7, 8); and (*iii*) people's emotional expressions on Facebook predict friends' emotional expressions, even days later (7) (although some shared experiences may in fact last several days). To date, however, there is no experimental evidence that emotions or moods are contagious in the absence of direct interaction between experiencer and target.

On Facebook, people frequently express emotions, which are later seen by their friends via Facebook's "News Feed" product (8). Because people's friends frequently produce much more content than one person can view, the News Feed filters posts, stories, and activities undertaken by friends. News Feed is the primary manner by which people see content that friends share. Which content is shown or omitted in the News Feed is determined via a ranking algorithm that Facebook continually develops and tests in the interest of showing viewers the content they will find most relevant and engaging. One such test is reported in this study: A test of whether posts with emotional content are more engaging.

The experiment manipulated the extent to which people (N = 689,003) were exposed to emotional expressions in their News Feed. This tested whether exposure to emotions led people to change their own posting behaviors, in particular whether exposure to emotional content led people to post content that was consistent with the exposure—thereby testing whether exposure to verbal affective expressions leads to similar verbal expressions, a form of emotional contagion. People who viewed Facebook in English were qualified for selection into the experiment. Two parallel experiments were conducted for positive and negative emotion: One in which exposure to friends' positive emotional content in their News Feed was reduced, and one in which exposure to negative emotional content in their News Feed was reduced. In these conditions, when a person loaded their News Feed, posts that contained emotional content of the relevant emotional valence, each emotional post had between a 10% and

Significance

We show, via a massive (N = 689,003) experiment on Facebook, that emotional states can be transferred to others via emotional contagion, leading people to experience the same emotions without their awareness. We provide experimental evidence that emotional contagion occurs without direct interaction between people (exposure to a friend expressing an emotion is sufficient), and in the complete absence of nonverbal cues.

Author contributions: A.D.I.K., J.E.G., and J.T.H. designed research; A.D.I.K. performed research; A.D.I.K. analyzed data; and A.D.I.K., J.E.G., and J.T.H. wrote the paper.

The authors declare no conflict of interest.

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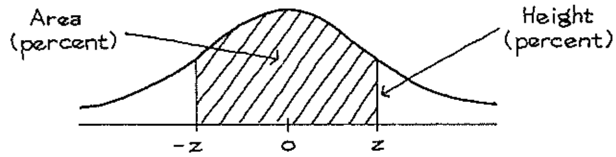
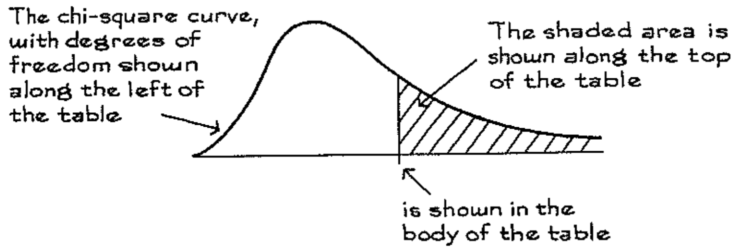
Tables



A NORMAL TABLE

z	*Height*	*Area*	*z*	*Height*	*Area*	*z*	*Height*	*Area*
0.00	39.89	0	1.50	12.95	86.64	3.00	0.443	99.730
0.05	39.84	3.99	1.55	12.00	87.89	3.05	0.381	99.771
0.10	39.69	7.97	1.60	11.09	89.04	3.10	0.327	99.806
0.15	39.45	11.92	1.65	10.23	90.11	3.15	0.279	99.837
0.20	39.10	15.85	1.70	9.40	91.09	3.20	0.238	99.863
0.25	38.67	19.74	1.75	8.63	91.99	3.25	0.203	99.885
0.30	38.14	23.58	1.80	7.90	92.81	3.30	0.172	99.903
0.35	37.52	27.37	1.85	7.21	93.57	3.35	0.146	99.919
0.40	36.83	31.08	1.90	6.56	94.26	3.40	0.123	99.933
0.45	36.05	34.73	1.95	5.96	94.88	3.45	0.104	99.944
0.50	35.21	38.29	2.00	5.40	95.45	3.50	0.087	99.953
0.55	34.29	41.77	2.05	4.88	95.96	3.55	0.073	99.961
0.60	33.32	45.15	2.10	4.40	96.43	3.60	0.061	99.968
0.65	32.30	48.43	2.15	3.96	96.84	3.65	0.051	99.974
0.70	31.23	51.61	2.20	3.55	97.22	3.70	0.042	99.978
0.75	30.11	54.67	2.25	3.17	97.56	3.75	0.035	99.982
0.80	28.97	57.63	2.30	2.83	97.86	3.80	0.029	99.986
0.85	27.80	60.47	2.35	2.52	98.12	3.85	0.024	99.988
0.90	26.61	63.19	2.40	2.24	98.36	3.90	0.020	99.990
0.95	25.41	65.79	2.45	1.98	98.57	3.95	0.016	99.992
1.00	24.20	68.27	2.50	1.75	98.76	4.00	0.013	99.9937
1.05	22.99	70.63	2.55	1.54	98.92	4.05	0.011	99.9949
1.10	21.79	72.87	2.60	1.36	99.07	4.10	0.009	99.9959
1.15	20.59	74.99	2.65	1.19	99.20	4.15	0.007	99.9967
1.20	19.42	76.99	2.70	1.04	99.31	4.20	0.006	99.9973
1.25	18.26	78.87	2.75	0.91	99.40	4.25	0.005	99.9979
1.30	17.14	80.64	2.80	0.79	99.49	4.30	0.004	99.9983
1.35	16.04	82.30	2.85	9.69	99.56	4.35	0.003	99.9986
1.40	14.97	83.85	2.90	0.60	99.63	4.40	0.002	99.9989
1.45	13.94	85.29	2.95	0.51	99.68	4.45	0.002	99.9991

A CHI-SQUARE TABLE



Degrees of freedom	*99%*	*95%*	*90%*	*70%*	*50%*	*30%*	*10%*	*5%*	*1%*
1	0.00016	0.0039	0.016	0.15	0.46	1.07	2.71	3.84	6.64
2	0.020	0.10	0.21	0.71	1.39	2.41	4.60	5.99	9.21
3	0.12	0.35	0.58	1.42	2.37	3.67	6.25	7.82	11.34
4	0.30	0.71	1.06	2.20	3.36	4.88	7.78	9.49	13.28
5	0.55	1.14	1.61	3.00	4.35	6.06	9.24	11.07	15.09
6	0.87	1.64	2.20	3.83	5.35	7.23	10.65	12.59	16.81
7	1.24	2.17	2.83	4.67	6.35	8.38	12.02	14.07	18.48
8	1.65	2.73	3.49	5.53	7.34	9.52	13.36	15.51	20.09
9	2.09	3.33	4.17	6.39	8.34	10.66	14.68	16.92	21.67
10	2.56	3.94	4.86	7.27	9.34	11.78	15.99	18.31	23.21
11	3.05	4.58	5.58	8.15	10.34	12.90	17.28	19.68	24.73
12	3.57	5.23	6.30	9.03	11.34	14.01	18.55	21.03	26.22
13	4.11	5.89	7.04	9.93	12.34	15.12	19.81	22.36	27.69
14	4.66	6.57	7.79	10.82	13.34	16.22	21.06	23.69	29.14
15	5.23	7.26	8.55	11.72	14.34	17.32	22.31	25.00	30.58
16	5.81	7.96	9.31	12.62	15.34	18.42	23.54	26.30	32.00
17	6.41	8.67	10.09	13.53	16.34	19.51	24.77	27.59	33.41
18	7.00	9.39	10.87	14.44	17.34	20.60	25.99	28.87	34.81
19	7.63	10.12	11.65	15.35	18.34	21.69	27.20	30.14	36.19
20	8.26	10.85	12.44	16.27	19.34	22.78	28.41	31.41	37.57

Source: Adapted from p. 112 of Sir R. A. Fisher, *Statistical Methods for Research Workers* (Edinburgh: Oliver & Boyd. 1958).