Editorial Expression of Concern and Correction

PSYCHOLOGICAL AND COGNITIVE SCIENCES

PNAS is publishing an Editorial Expression of Concern regarding the following article: “Experimental evidence of massive-scale emotional contagion through social networks,” by Adam D. I. Kramer, Jamie E. Guillory, and Jeffrey T. Hancock, which appeared in issue 24, June 17, 2014, of Proc Natl Acad Sci USA (111:8788–8790; first published June 2, 2014; 10.1073/pnas.1320040111). This paper represents an important and emerging area of social science research that needs to be approached with sensitivity and with vigilance regarding personal privacy issues.

Questions have been raised about the principles of informed consent and opportunity to opt out in connection with the research in this paper. The authors noted in their paper, “[The work] was consistent with Facebook’s Data Use Policy, to which all users agree prior to creating an account on Facebook, constituting informed consent for this research.” When the authors prepared their paper for publication in PNAS, they stated that: “Because this experiment was conducted by Facebook, Inc. for internal purposes, the Cornell University IRB [Institutional Review Board] determined that the project did not fall under Cornell’s Human Research Protection Program.” This statement has since been confirmed by Cornell University.

Obtaining informed consent and allowing participants to opt out are best practices in most instances under the US Department of Health and Human Services Policy for the Protection of Human Research Subjects (the “Common Rule”). Adherence to the Common Rule is PNAS policy, but as a private company Facebook was under no obligation to conform to the provisions of the Common Rule when it collected the data used by the authors, and the Common Rule does not preclude the use of the data. Based on the information provided by the authors, PNAS editors deemed it appropriate to publish the paper. It is nevertheless a matter of concern that the collection of the data by Facebook may have involved practices that were not fully consistent with the principles of obtaining informed consent and allowing participants to opt out.

Inder M. Verma
Editor-in-Chief

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The authors note that, “At the time of the study, the middle author, Jamie E. Guillory, was a graduate student at Cornell University under the tutelage of senior author Jeffrey T. Hancock, also of Cornell University (Guillory is now a postdoctoral fellow at Center for Tobacco Control Research and Education, University of California, San Francisco, CA 94143).” The author and affiliation lines have been updated to reflect the above changes and a present address footnote has been added. The online version has been corrected.

The corrected author and affiliation lines appear below.

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Experimental evidence of massive-scale emotional contagion through social networks

Adam D. I. Kramer\textsuperscript{a,1}, Jamie E. Guillory\textsuperscript{b,2}, and Jeffrey T. Hancock\textsuperscript{b,c}

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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) \textit{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.

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.


The authors declare no conflict of interest.

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90% chance (based on their User ID) of being omitted from their News Feed for that specific viewing. It is important to note that this content was always available by viewing a friend’s content directly by going to that friend’s “wall” or “timeline,” rather than via the News Feed. Further, the omitted content may have appeared on prior or subsequent views of the News Feed. Finally, the experiment did not affect any direct messages sent from one user to another.

Posts were determined to be positive or negative if they contained at least one positive or negative word, as defined by Linguistic Inquiry and Word Count software (LIWC2007) (9) word counting system, which correlates with self-reported and physiological measures of well-being, and has been used in prior research on emotional expression (7, 8, 10). LIWC was adapted to run on the Hadoop Map/Reduce system (11) and in the News Feed filtering system, such that no text was seen by the researchers. As such, it was consistent with Facebook’s Data Use Policy, to which all users agree prior to creating an account on Facebook, constituting informed consent for this research. Both experiments had a control condition, in which a similar proportion of posts in their News Feed were omitted entirely at random (i.e., without respect to emotional content). Separate control conditions were necessary as 22.4% of posts contained negative words, whereas 46.8% of posts contained positive words. So for a person for whom 10% of posts containing positive content were omitted, an appropriate control would withhold 10% of 46.8% (i.e., 4.68%) of posts at random, compared with omitting only 2.24% of the News Feed in the negativity-reduced control.

The experiments took place for 1 wk (January 11–18, 2012). Participants were randomly selected based on their User ID, resulting in a total of ~155,000 participants per condition who posted at least one status update during the experimental period.

For each experiment, two dependent variables were examined pertaining to emotionality expressed in people’s own status updates: the percentage of all words produced by a given person that was either positive or negative during the experimental period (as in ref. 7). In total, over 3 million posts were analyzed, containing over 122 million words, 4 million of which were positive (3.6%) and 1.8 million negative (1.6%).

If affective states are contagious via verbal expressions on Facebook (our operationalization of emotional contagion), people in the positivity-reduced condition should be less positive compared with their control, and people in the negativity-reduced condition should be less negative. As a secondary measure, we tested for cross-emotional contagion in which the opposite emotion should be inversely affected: People in the positivity-reduced condition should express increased negativity, whereas people in the negativity-reduced condition should express increased positivity. Emotional expression was modeled, on a per-person basis, as the percentage of words produced by that person during the experimental period that were either positive or negative. Positivity and negativity were evaluated separately with respect to their correlation, such that people who had more content omitted were given higher weight in the regression. When positive posts were reduced in the News Feed, the percentage of positive words in people’s status updates decreased by $B = -0.1\%$ compared with control $[(310,044) = -5.63, P < 0.001, \text{Cohen’s } d = 0.02]$, whereas the percentage of words that were negative increased by $B = 0.04\%$ $(t = 2.71, P = 0.007, d = 0.001)$. Conversely, when negative posts were reduced, the percent of words that were negative decreased by $B = -0.07\%$ $[(310,541) = -5.51, P < 0.001, d = 0.02]$ and the percentage of words that were positive, conversely, increased by $B = 0.06\%$ $(t = 2.19, P < 0.005, d = 0.008)$.

The results show emotional contagion. As Fig. 1 illustrates, for people who had positive content reduced in their News Feed, a larger percentage of words in people’s status updates were negative and a smaller percentage were positive. When negativity was reduced, the opposite pattern occurred. These results suggest that the emotions expressed by friends, via online social networks, influence our own moods, constituting, to our knowledge, the first experimental evidence for massive-scale emotional contagion via social networks (3, 7, 8), and providing support for previously contested claims that emotions spread via contagion through a network.

These results highlight several features of emotional contagion. First, because News Feed content is not “directed” toward anyone, contagion could not be just the result of some specific interaction with a happy or sad partner. Although prior research examined whether an emotion can be contracted via a direct interaction (1, 7), we show that simply failing to “overhear” a friend’s emotional expression via Facebook is enough to buffer

![Fig. 1. Mean number of positive (Upper) and negative (Lower) emotion words (percent) generated people, by condition. Bars represent standard errors.](image-url)
one from its effects. Second, although nonverbal behavior is well established as one medium for contagion, these data suggest that contagion does not require nonverbal behavior (7, 8): Textual content alone appears to be a sufficient channel. This is not a simple case of mimicry, either; the cross-emotional encouragement effect (e.g., reducing negative posts led to an increase in positive posts) cannot be explained by mimicry alone, although mimicry may well have been part of the emotion-consistent effect. Further, we note the similarity of effect sizes when positivity and negativity were reduced. This absence of negativity bias suggests that our results cannot be attributed solely to the content of the post: If a person is sharing good news or bad news (thus explaining his/her emotional state), friends’ response to the news (independent of the sharer’s emotional state) should be stronger when bad news is shown rather than good (or as commonly noted, “if it bleeds, it leads;” ref. 12) if the results were being driven by reactions to news. In contrast, a response to a friend’s emotion expression (rather than news) should be proportional to exposure. A post hoc test comparing effect sizes (comparing correlation coefficients using Fisher’s method) showed no difference despite our large sample size ($z = -0.36, P = 0.72$).

We also observed a withdrawal effect: People who were exposed to fewer emotional posts (of either valence) in their News Feed were less expressive overall on the following days, advertising the question about how emotional expression affects social engagement online. This observation, and the fact that people were more emotionally positive in response to positive emotion updates from their friends, stands in contrast to theories that suggest viewing positive posts by friends on Facebook may somehow affect us negatively, for example, via social comparison (6, 13). In fact, this is the result when people are exposed to less positive content, rather than more. This effect also showed no negativity bias in post hoc tests ($z = -0.09, P = 0.93$).

Although these data provide, to our knowledge, some of the first experimental evidence to support the controversial claims that emotions can spread throughout a network, the effect sizes from the manipulations are small (as small as $d = 0.001$). These effects nonetheless matter given that the manipulation of the independent variable (presence of emotion in the News Feed) was minimal whereas the dependent variable (people’s emotional expressions) is difficult to influence given the range of daily experiences that influence mood (10). More importantly, given the massive scale of social networks such as Facebook, even small effects can have large aggregated consequences (14, 15): For example, the well-documented connection between emotions and physical well-being suggests the importance of these findings for public health. Online messages influence our experience of emotions, which may affect a variety of offline behaviors. And after all, an effect size of $d = 0.001$ at Facebook’s scale is not negligible: In early 2013, this would have corresponded to hundreds of thousands of emotion expressions in status updates per day.

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