

How Opinions are Received by Online Communities: A Case Study on Amazon.com Helpfulness Votes

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ABSTRACT

There are many on-line settings in which users publicly express opinions. A number of these offer mechanisms for other users to *evaluate* these opinions; a canonical example is Amazon.com, where reviews come with annotations like “26 of 32 people found the following review helpful.” Opinion evaluation appears in many off-line settings as well, including market research and political campaigns. Reasoning about the evaluation of an opinion is fundamentally different from reasoning about the opinion itself: rather than asking, “What did Y think of X?”, we are asking, “What did Z think of Y’s opinion of X?” Here we develop a framework for analyzing and modeling opinion evaluation, using a large-scale collection of Amazon book reviews as a dataset. We find that the perceived helpfulness of a review depends not just on its content but also but also in subtle ways on how the expressed evaluation relates to other evaluations of the same product. As part of our approach, we develop novel methods that take advantage of the phenomenon of review “plagiarism” to control for the effects of text in opinion evaluation, and we provide a simple and natural mathematical model consistent with our findings. Our analysis also allows us to distinguish among the predictions of competing theories from sociology and social psychology, and to discover unexpected differences in the collective opinion-evaluation behavior of user populations from different countries.

Categories and Subject Descriptors: H.2.8 [Database Management]: Database Applications – Data Mining

General Terms: Measurement, Theory

Keywords: Review helpfulness, review utility, social influence, online communities, sentiment analysis, opinion mining, plagiarism.

1. INTRODUCTION

Understanding how people’s opinions are received and evaluated is a fundamental problem that arises in many domains, such as in marketing studies of the impact of reviews on product sales, or in political science models of how support for a candidate depends on the views he or she expresses on different topics. This issue

is also increasingly important in the user interaction dynamics of large participatory Web sites.

Here we develop a framework for understanding and modeling how opinions are evaluated within on-line communities. The problem is related to the lines of computer-science research on opinion, sentiment, and subjective content [18], but with a crucial twist in its formulation that makes it fundamentally distinct from that body of work. Rather than asking questions of the form “What did Y think of X?”, we are asking, “What did Z think of Y’s opinion of X?” Crucially, there are now three entities in the process rather than two. Such three-level concerns are widespread in everyday life, and integral to any study of opinion dynamics in a community. For example, political polls will more typically ask, “How do you feel about Barack Obama’s position on taxes?” than “How do you feel about taxes?” or “What is Barack Obama’s position on taxes?” (though all of these are useful questions in different contexts). Also, Heider’s theory of *structural balance* in social psychology seeks to understand subjective relationships by considering sets of three entities at a time as the basic unit of analysis. But there has been relatively little investigation of how these three-way effects shape the dynamics of on-line interaction, and this is the topic we consider here.

The Helpfulness of Reviews. The evaluation of opinions takes place at very large scales every day at a number of widely-used Web sites. Perhaps most prominently it is exemplified by one of the largest online e-commerce providers, Amazon.com, whose website includes not just product reviews contributed by users, but also evaluations of the helpfulness of these reviews. (These consist of annotations that say things like, “26 of 32 people found the following review helpful”, with the corresponding data-gathering question, “Was this review helpful to you?”) Note that each review on Amazon thus comes with both a *star rating* — the number of number of stars it assigns to the product — and a *helpfulness vote* — the information that *a* out of *b* people found the review itself helpful. (See Figure 4 for two examples.) This distinction reflects precisely the kind of opinion evaluation we are considering: in addition to the question “what do you think of book X?”, users are also being asked “what do you think of user Y’s review of book X?” A large-scale snapshot of Amazon reviews and helpfulness votes will form the central dataset in our study, as detailed below.

The factors affecting human helpfulness evaluations are not well understood. There has been a small amount of work on automatic

determination of helpfulness, treating it as a classification or regression problem with Amazon helpfulness votes providing labeled data [10, 15, 17]. Some of this research has indicated that the helpfulness votes of reviews are not necessarily strongly correlated with certain measures of review quality; for example, Liu et al. found that when they provided independent human annotators with Amazon review text and a precise specification of helpfulness in terms of the thoroughness of the review, the annotators' evaluations differed significantly from the helpfulness votes observed on Amazon.

All of this suggests that there is in fact a subtle relationship between two different meanings of "helpfulness": helpfulness in the narrow sense — does this review help you in making a purchase decision? — and helpfulness "in the wild," as defined by the way in which Amazon users evaluate each others' reviews in practice. It is a kind of dichotomy familiar from the design of participatory Web sites, in which a presumed design goal — that of highlighting reviews that are helpful in the purchase process — becomes intertwined with complex social feedback mechanisms. If we want to understand how these definitions interact with each other, so as to assist users in interpreting helpfulness evaluations, we need to elucidate what these feedback mechanisms are and how they affect the observed outcomes.

The present work: Social mechanisms underlying helpfulness evaluation. In this paper, we formulate and assess a set of theories that govern the evaluation of opinions, and apply these to a dataset consisting of over four million reviews of roughly 675,000 books on Amazon's U.S. site, as well as smaller but comparably-sized corpora from Amazon's U.K., Germany, and Japan sites. The resulting analysis provides a way to distinguish among competing hypotheses for the social feedback mechanisms at work in the evaluation of Amazon reviews: we offer evidence against certain of these mechanisms, and show how a simple model can directly account for a relatively complex dependence of helpfulness on review and group characteristics. We also use a novel experimental methodology that takes advantage of the phenomenon of review "plagiarism" to control for the text content of the reviews, enabling us to focus exclusively on factors outside the text that affect helpfulness evaluation.

In our initial exploration of non-textual factors that are correlated with helpfulness evaluation on Amazon, we found a broad collection of effects at varying levels of strength.¹ A significant and particularly wide-ranging set of effects is based on the relationship of a review's star rating to the star ratings of other reviews for the same product. We view these as fundamentally *social* effects, given that they are based on the relationship of one user's opinion to the opinions expressed by others in the same setting.²

Research in the social sciences provides a range of well-studied

hypotheses for how social effects influence a group's reaction to an opinion, and these provide a valuable starting point for our analysis of the Amazon data. In particular, we consider the following three broad classes of theories, as well as a fourth straw-man hypothesis that must be taken into account.

- (i) *The conformity hypothesis.* One hypothesis, with roots in the social psychology of conformity [4], holds that a review is evaluated as more helpful when its star rating is closer to the consensus star rating for the product — for example, when the number of stars it assigns is close to the average number of stars over all reviews.
- (ii) *The individual-bias hypothesis.* Alternately, one could hypothesize that when a user considers a review, he or she will rate it more highly if it expresses an opinion that he or she agrees with.³ Note the contrasts and similarities with the previous hypothesis: rather than evaluating whether a review is close to the mean opinion, a user evaluates whether it is close to their own opinion. At the same time, one might expect that if a diverse range of individuals apply this rule, then the overall helpfulness evaluation could be hard to distinguish from one based on conformity; this issue turns out to be crucial, and we explore it further below.
- (iii) *The brilliant-but-cruel hypothesis.* The name of this hypothesis comes from studies performed by Amabile [3] that support the argument that "negative reviewers [are] perceived as more intelligent, competent, and expert than positive reviewers." One can recognize everyday analogues of this phenomenon; for example, in a research seminar, a dynamic may arise in which the nastiest question is consistently viewed as the most insightful.
- (iv) *The quality-only straw-man hypothesis.* Finally, there is a challenging methodological complication in all these styles of analysis: without specific evidence, one cannot dismiss out of hand the possibility that helpfulness is being evaluated purely based on the textual content of the reviews, and that these non-textual factors are simply correlates of textual quality. In other words, it could be that people who write long reviews, people who assign particular star ratings in particular situations, and people from Massachusetts all simply write reviews that are textually more helpful — and that users performing helpfulness evaluations are simply reacting to the text in ways that are indirectly reflected in these other features. Ruling out this hypothesis requires some means of controlling for the text of reviews while allowing other features to vary, a problem that we also address below.

We now consider how data on star ratings and helpfulness votes can support or contradict these hypotheses, and what it says about possible underlying social mechanisms.

Deviation from the mean. A natural first measure to investigate is the relationship of a review's star rating to the mean star rating of all reviews for the product; this, for example, is the underpinning of the conformity hypothesis. With this in mind, let us define the *helpfulness ratio* of a review to be the fraction of evaluators who found it to be helpful (in other words, it is the fraction a/b when a out of b people found the review helpful), and let us define the *product average* for a review of a given product to be the average star

¹For example, on the U.S. Amazon site, we find that reviews from authors with addresses in U.S. territories outside the 50 states get consistently lower helpfulness votes. This is a persistent effect whose possible bases lie outside the scope of the present paper, but it illustrates the ways in which non-textual factors can be correlated with helpfulness evaluations. Previous work has also noted that *longer* reviews tend to be viewed as more helpful; ultimately it is a definitional question whether review length is a textual or non-textual feature of the review.

²A contrarian might put forth the following non-socially-based alternative hypothesis: the people evaluating review helpfulness are considering actual product quality rather than other reviews, but aggregate opinion happens to coincide with objective product quality. This hypothesis is not consistent with our experimental results. However, in future work it might be interesting to directly control for product quality.

³Such a principle is also supported by structural balance considerations from social psychology; due to the space limitations, we omit a discussion of this here.

rating given by *all* reviews of that product. We find (Figure 1) that the median helpfulness ratio of reviews decreases monotonically as a function the absolute difference between their star rating and the product average. (The same trend holds for other quantiles.) In fact the dependence is surprisingly smooth, with even seemingly subtle changes in the differences from the average having noticeable effects.

This finding on its own is consistent with the conformity hypothesis: reviews in aggregate are deemed more helpful when they are close to the product average. However, a closer look at the data raises complications, as we now see. First, to assess the brilliant-but-cruel hypothesis, it is natural to look not at the absolute difference between a review's star rating and its product average, but at the *signed difference*, which is positive or negative depending on whether the star rating is above or below the average. Here we find something a bit surprising (Figure 2). Not only does the median helpfulness as a function of signed difference fall away on both sides of 0; it does so *asymmetrically*: slightly negative reviews are punished more strongly, with respect to helpfulness evaluation, than slightly positive reviews. In addition to being at odds with the brilliant-but-cruel hypothesis for Amazon reviews, this observation poses problems for the conformity hypothesis in its pure form. It is not simply that closeness to the average is rewarded; among reviews that are slightly away from the mean, there is a bias toward overly positive ones.

Variance and individual bias. One could, of course, amend the conformity hypothesis so that it becomes a “conformity with a tendency toward positivity” hypothesis. But this would beg the question; it wouldn't suggest any underlying mechanism for where the favorable evaluation of positive reviews is coming from. Instead, to look for such a mechanism, we consider versions of the individual-bias hypothesis. Now, recall that it can be difficult to distinguish conformity effects from individual-bias effects in a domain such as ours: if people's opinions (i.e., star ratings) for a product come from a single-peaked distribution with a maximum near the average, then the composite of their individual biases can produce overall helpfulness votes that look very much like the results of conformity. We therefore seek out subsets of the products on which the two effects might be distinguishable, and the argument above suggests starting with products that exhibit high levels of individual variation in star ratings.

In particular, we associate with each product the *variance* of the star ratings assigned to it by all its reviews. We then group products by variance, and perform the signed-difference analysis above on sets of products having fixed levels of variance. We find (Figure 3) that the effect of signed difference to the average changes smoothly but in a complex fashion as the variance increases. The role of variance can be summarized as follows.

- When the variance is very low, the reviews with the highest helpfulness ratios are those with the average star rating.
- With moderate values of the variance, the reviews evaluated as most helpful are those that are slightly above the average star rating.
- As the variance becomes large, reviews with star ratings both above *and* below the average are evaluated as more helpful than those that have the average star rating (with the positive reviews still deemed somewhat more helpful).

These principles suggest some qualitative “rules” for how — all other things being equal — one can seek good helpfulness evaluations in our setting: With low variance go with the average; with

moderate variance be slightly above average; and with high variance avoid the average.

This qualitative enumeration of principles initially seems to be fairly elaborate; but as we show in Section 5, all these principles are consistent with a simple model of individual bias in the presence of controversy. Specifically, suppose that opinions are drawn from a mixture of two single-peaked distributions — one with larger mixing weight whose mean is above the overall mean of the mixture, and one with smaller mixing weight whose mean is below it. Now suppose that each user has an opinion from this mixture, corresponding to their own personal score for the product, and they evaluate reviews as helpful if the review's star rating is within some fixed tolerance of their own. We can show that in this model, as variance increases from 0, the reviews evaluated as most helpful are initially slightly above the overall mean, and eventually a “dip” in helpfulness appears around the mean.

Thus, a simple model can in principle account for the fairly complex series of effects illustrated in Figure 3, and provide a hypothesis for an underlying mechanism. Moreover, the effects we see are surprisingly robust as we look at different national Amazon sites for the U.K., Germany, and Japan. Each of these communities has evolved independently, but each exhibits the same set of patterns. The one non-trivial and systematic deviation from the pattern among these four countries is in the analogue of Figure 3 for Japan: as with the other countries, a “dip” appears at the average in the high-variance case, but in Japan the portion of the curve *below* the average is higher. This would be consistent with a version of our two-distribution individual-bias model in which the distribution below the average has higher mixing weight — representing an aspect of the brilliant-but-cruel hypothesis in this individual-bias framework, and only for this one national version of the site.

Controlling for text: Taking advantage of “plagiarism”. Finally, we return to one further issue discussed earlier: how can we offer evidence that these non-textual features aren't simply serving as correlates of review-quality features that are intrinsic to the text itself? In other words, are there experiments that can address the quality-only straw man hypothesis above?

To deal with this, we make use of rampant “plagiarism” and duplication of reviews on Amazon.com (the causes and implications of this phenomenon are beyond the scope of this paper). This is a fact that has been noted and studied by earlier researchers [7], and for most applications it is viewed as a pathology to be remedied. But for our purposes, it makes possible a remarkably effective way to control for the effect of review text. Specifically, we define a “*plagiarized*” pair of reviews to be two reviews of different products with near-complete textual overlap, and we enumerate the several thousand instances of plagiarized pairs on Amazon. (We distinguish these from reviews that have been cross-posted by Amazon itself to different versions of the same product.)

Not only are the two members of a “plagiarized” pair associated with different products; very often they also have significantly different star ratings and are being used on products with different averages and variances. (For example, one copy of the review may be used to praise a book about the dangers of global warming while the other copy is used to criticize a book that is favorable toward the oil industry). We find significant differences in the helpfulness ratios within plagiarized pairs, and these differences confirm many of the effects we observe on the full dataset. Specifically, within a “plagiarized” pair, the copy of the review that is closer to the average gets the higher helpfulness ratio in aggregate.

Thus the widespread copying of reviews provides us with a way to see that a number of social feedback effects — based on the

score of a review and its relation to other scores — lead to different outcomes even for reviews that are textually close to identical.

Further related work. We also mention some relevant prior literature that has not already been discussed above. The role of social and cognitive factors in purchasing decision-making has been extensively studied in psychology and marketing [6, 8, 9, 21], recently making use of brain imaging methodology [16]. Characteristics of the distribution of review star ratings (which differ from helpfulness votes) on Amazon and related sites have been studied previously [5, 13, 23]. Categorizing text by quality has been proposed for a number of applications [1, 12, 14, 19]. Additionally, our notion of variance is potentially related to the idea that people play different roles in on-line discussion [22].

2. DATA

Our experiments employed a dataset of over 4 million Amazon.com book reviews (corresponding to roughly 675,000 books), of which more than 1 million received at least 10 helpfulness votes each. We made extensive use of the Amazon Associates Webservice (AWS) API to collect this data.⁴ We describe the process in this section, with particular attention to measures we took to avoid sample bias.

We would ideally have liked to work with *all* book reviews posted to Amazon. However, one can only access reviews via queries specifying particular books by their Amazon product ID, or ASIN (which is the same as ISBN for most books), and we are not aware of any publicly available list of all Amazon book ASINs. However, the API allows one to query for books in a specific category (called a *browse-node* in AWS parlance and corresponding to a section on the Amazon.com website), and the best-selling titles up to a limit of 4000 in each browse-node can be obtained in this way.

To create our initial list of books, therefore, we performed queries for all 3855 categories three levels deep in the Amazon browse-node hierarchy (actually a directed acyclic graph) rooted at “Books→Subjects”. An example category is *Children’s Books→Animals→Lions, Tigers & Leopards*. These queries resulted in the initial set of 3,301,940 books, where we count books listed in multiple categories only once.

We then performed a book-filtering step to deal with “cross-posting” of reviews across versions. When Amazon carries different versions of the same item — for example, different editions of the same book, including hardcover and softcover editions and audio-books — the reviews written for all versions are merged and displayed together on each version’s product page and likewise returned by the API upon queries for any individual version.⁵ This means that multiple copies of the same review exist for “mechanical”, as opposed to user-driven, reasons.⁶ To avoid including mechanically-duplicated reviews, we retained only one of the set of alternate versions for each book (the one with the most complete metadata).

The above process gave us a list of 674,018 books for which we retrieved reviews by querying AWS. Although AWS restricts the number of reviews returned for any given product query to a max-

⁴We used the AWS API version 2008-04-07. Documentation is available at <http://docs.amazonwebservices.com/AWSECommerceService/2008-04-07/DG/>.

⁵At the time of data collection, the API did not provide an option to trace a review to a particular edition for which it was originally posted, despite the fact that the Web store front-end has included such links for quite some time.

⁶We make use of human-instigated review copying later in this study.

imum of 100, it turned out that 99.3% of our books had 100 or fewer reviews. In the case of the remaining 4664 books, we chose to retrieve the 100 *earliest* reviews for each product to be able to reconstruct the information available to the authors and readers of those reviews to the extent possible. (Using the earliest reviews ensures the reproducibility of our results, since the 100 earliest reviews comprise a static set, unlike the 100 most helpful or recent reviews.) As a result, we ended up with 4,043,103 reviews; although some reviews were not retrieved due to the 100-reviews-per-book API cap, the number of missing reviews averages out to roughly just one per ASIN queried. Finally, we focused on the 1,008,466 reviews that had at least 10 helpfulness votes each.

The size of our dataset compares favorably to that of collections used in other studies looking at helpfulness votes: Liu et al. [17] used about 23,000 digital camera reviews (of which a subset of around 4900 were subsequently given new helpfulness votes and studied more carefully); Zhang and Varadarajan [24] used about 2500 reviews of electronics, engineering books, and PG-13 movies after filtering out duplicate reviews and reviews with no more than 10 helpfulness votes; Kim et al. [15] used about 26,000 MP3 and digital-camera reviews after filtering of duplicate versions and duplicate reviews and reviews with fewer than 5 helpfulness votes; and Ghose and Ipeirotis [11] considered “all reviews since the product was released into the market” (no specific number is given) for about 400 popular audio and video players, digital cameras, and DVDs.

3. EFFECTS OF DEVIATION FROM AVERAGE AND VARIANCE

Several of the hypotheses that we have described concern the relative position of an opinion about an entity vis-à-vis the average opinion about that entity. We now turn, therefore, to the question of how the helpfulness ratio of a review depends on its star rating’s deviation from the average star rating for all reviews of the same book. According to the conformity hypothesis, the helpfulness ratio should be *lower* for reviews with star ratings *either above or below* the product average, whereas the brilliant-but-cruel hypothesis translates to the “asymmetric” prediction that the helpfulness ratio should be *higher* for reviews with star ratings *below* the product average than for overly positive reviews. (No specific predictions for helpfulness ratio vis-à-vis product average is made by either the individual-bias or quality-only hypothesis without further assumptions about the distribution of individual opinions or text quality.)

Defining the average. For a given review, let the *computed product-average star rating* (abbreviation: *computed star average*) be the average star rating as computed over all reviews of that product in our dataset.

This differs in principle from the *Amazon-displayed product-average star rating* (abbreviation: *displayed star average*), the “Average Customer Review” score that Amazon itself displayed for the book at the time we downloaded the data. One reason for the difference is that Amazon rounds the displayed star average to the nearest half-star (e.g., 3.5 or 4.0) — but for our experiments it is preferable to have a greater degree of resolution. Another possible source of difference is the very small (0.7%) fraction of books, mentioned in Section 2, for which the entire set of reviews could not be obtained via AWS: the displayed star average would be partially based on reviews that came later than the first 100 and which would thus not be in our dataset. However, the mean absolute difference between the computed star average when rounded to the nearest half-star (0.5 increment) and the displayed star average is only 0.02.

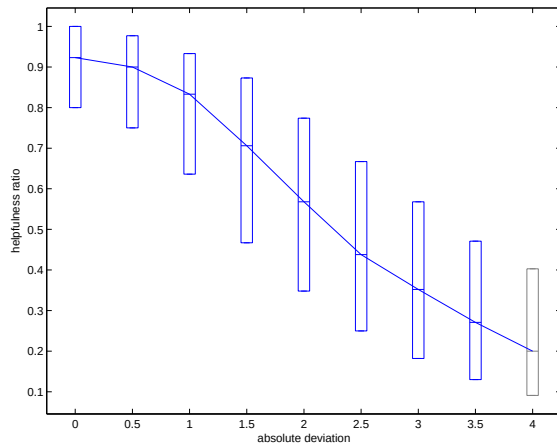


Figure 1: Helpfulness ratio declines with the absolute value of a review’s deviation from the computed star average; this behavior is predicted by the conformity hypothesis but not ruled out by the other hypotheses.

The line segments within the bars (connected by the descending line) indicate the median helpfulness ratio; the bars depict the helpfulness ratio’s second and third quantiles.

Throughout, grey bars indicate that the amount of data at that x value represents .1% or less of the data depicted in the plot.

Note that both scores can differ from the “Average Customer Review” score that Amazon displayed *at the time a helpfulness evaluator provided their helpfulness vote*, since this time might pre-date some of the reviews for the book that are in our dataset (and hence that Amazon based its displayed star average on). In the absence of timestamps on helpfulness votes, this is not a factor that can be controlled for.

Deviation experiments. We first check the prediction of the conformity hypothesis that the helpfulness ratio of a review will vary inversely with the absolute value of the difference between the review’s star rating and the computed product-average star rating—we call this difference the review’s *deviation*.

Figure 1 indeed shows a very strong inverse correlation between the median helpfulness ratio and the absolute deviation, as predicted by the conformity hypothesis. However, this data does not completely disprove the brilliant-but-cruel hypothesis, since for a given absolute deviation $|x| > 0$, it could conceivably happen that reviews with positive deviations $|x|$ (i.e. more favorable than average) could have much worse helpfulness ratios than reviews with negative deviation $-|x|$, thus dragging down the median helpfulness ratio. Rather, to directly assess the brilliant-but-cruel hypothesis, we must consider *signed deviation*, not just absolute deviation.

Surprisingly, the effect of signed deviation on median helpfulness ratio, depicted in the “Christmas-tree” plot of Figure 2, turns out to be different from what *either* hypothesis would predict.

The brilliant-but-cruel hypothesis clearly does not hold for our data: among reviews with the same absolute deviation $|x| > 0$, the relatively positive ones (signed deviation $|x|$) generally have a higher median helpfulness ratio than the relatively negative ones (signed deviation of $-|x|$), as depicted by the positive slope of the green dotted lines connecting $(-|x|, |x|)$ pairs of datapoints.

But Figure 2 *also* presents counter-evidence for the conformity

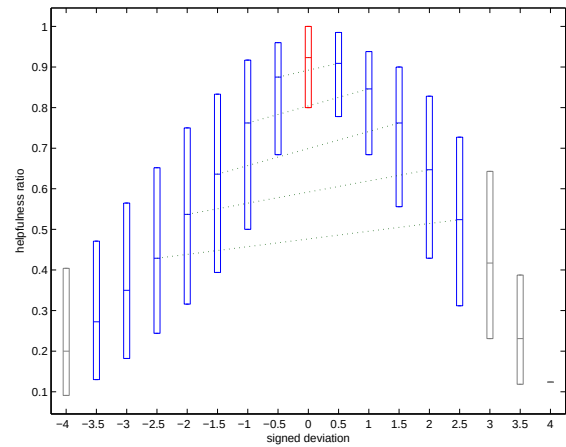


Figure 2: The dependence of helpfulness ratio on a review’s signed deviation from average is inconsistent with both the brilliant-but-cruel and, because of the asymmetry, the conformity hypothesis.

hypothesis, since that hypothesis incorrectly predicts that the connecting lines would be horizontal.

To account for Figure 2, one could simply impose upon the conformity hypothesis an extra “tendency towards positivity” factor, but this would be quite unsatisfactory: it wouldn’t suggest any underlying mechanism for this factor. So, we turn to the individual-bias hypothesis instead.

In order to distinguish between conformity effects and individual-bias effects, we need to examine cases in which individual people’s opinions do *not* come from exactly the same (single-peaked, say) distribution; for otherwise, the composite of their individual biases could produce helpfulness ratios that look very much like the results of conformity. One natural place to begin to seek settings in which individual bias and conformity are distinguishable, in the sense just described, is in cases in which there is at least high *variance* in the star ratings. Accordingly, Figure 3 separates products by the variance of the star ratings in the reviews for that product in our dataset.

One can immediately observe some striking effects of variance. First, we see that as variance increases, the “camel plots” of Figure 3 go from a single hump to two.⁷ We also note that while in the previous figures it was the reviews with a signed deviation of exactly zero that had the highest helpfulness ratios, here we see that once the variance among reviews for a product is 3.0 or greater, the highest helpfulness ratios are clearly achieved for products with signed deviations close to but still noticeably above zero. (The beneficial effects of having a star rating slightly above the mean are already discernible, if small, at variance 1.0 or so.)

Clearly, these results indicate that variance is a key factor that any hypothesis needs to incorporate. In Section 5, we develop a simple individual-bias model that does so; but first, there is one last hypothesis that we need to consider.

⁷This is a reversal of nature, where Bactrian (two-humped) camels are more agreeable than one-humped Dromedaries.

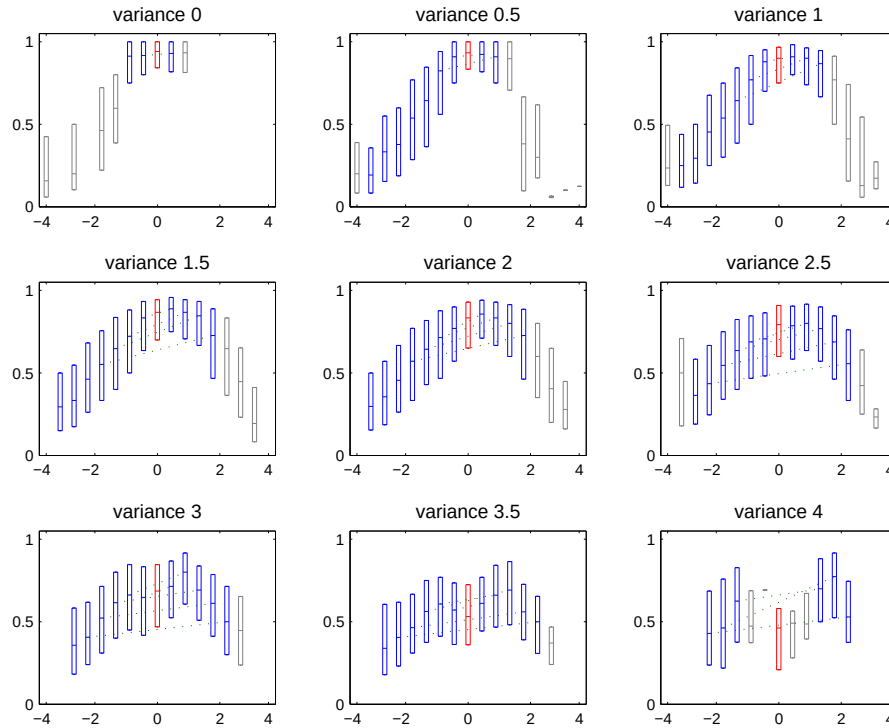


Figure 3: As the variance of the star ratings of reviews for a particular product increases, the median helpfulness ratio curve becomes two-humped and the helpfulness ratio at signed deviation 0 (indicated in red) no longer represents the unique global maximum. There are non-zero signed deviations in the plot for variance 0 because we rounded variance values to the nearest .5 increment.

4. CONTROLLING FOR TEXT QUALITY: EXPERIMENTS WITH “PLAGIARISM”

As we have noted, our analyses do not explicitly take into account the actual text of reviews. It is not impossible, therefore, that review text quality may be a confounding factor and that our straw-man quality-only hypothesis might hold. Specifically, we have shown that helpfulness ratios appear to be dependent on two key non-textual aspects of reviews, namely, on deviation from the computed star average and on star rating variance within reviews for a given product; but we have not shown that our results are not simply explained by review quality.

Initially, it might seem that the only way to control for text quality is to read a sample of reviews and determine whether the Amazon helpfulness ratios assigned to these reviews are accurate. Unfortunately, it would require a great deal of time and human effort to gather a sufficiently large set of re-evaluated reviews, and human re-evaluations can be subjective; so it would be preferable to find a more efficient and objective procedure.⁸

⁸Liu et al. [17] did perform a manual re-evaluation of 4909 digital-camera reviews, finding that the original helpfulness ratios did not seem well-correlated with the stand-alone comprehensiveness of the reviews. But note that this could just mean that at least some of the original helpfulness evaluators were using a different standard of text quality (Amazon does not specify any particular standard or definition of helpfulness). Indeed, the exemplary “fair” review quoted by Liu et al. begins, “There is nothing wrong with the [product] except for the very noticeable delay between pics. [Description of the delay.] Otherwise, [other aspects] are fine for anything from Internet apps to ... print enlarging. It is competent, not specu-

A different potential approach would be to use machine learning to train an algorithm to automatically determine the degree of helpfulness of each review. Such an approach would indeed involve less human effort, and could thus be applied to larger numbers of reviews. However, we could not draw the conclusions we would want to: any mismatch between the predictions of a trained classifier and the helpfulness ratios observed in held-out reviews could be attributable to errors by the algorithm, rather than to the actions of the Amazon helpfulness evaluators.⁹

lar, but it gets the job done at an agreeable price point.” Liu et al. give this a rating of “fair” because it only comments on some of the product’s aspects, but the Amazon helpfulness evaluators gave it a helpfulness ratio of 5/6, which seems reasonable. Also, reviews might also be evaluated vis-à-vis the totality of all reviews, i.e., a review might be rated helpful if it provides complementary information or “adds value”. For instance, a one-line review that points out a serious flaw in another review could well be considered “helpful”, but would not rate highly under Liu et al.’s scheme.

It is also worth pointing out subjectiveness can remain an issue even with respect to a given text-only evaluation scheme. The two human re-evaluators who used Liu et al.’s [2007] standard assigned different helpfulness categories (in a four-category framework) to 619=12.5% of the reviews considered, indicating that there can be substantial subjectiveness involved in determining review quality even when a single standard is initially agreed upon.

⁹Ghose and Ipeirotis [11] observe that their trained classifier often performed poorly for reviews of products with “widely fluctuating” star ratings, and explain this with an assertion that the Amazon helpfulness evaluators are not judging text quality in such situations. But there is no evidence provided to dismiss the alternative hypothesis that the helpfulness evaluators are correct and that,

We thus find ourselves in something of a quandary: we seem to lack any way to derive a sufficiently large set of objective and accurate re-evaluations of helpfulness. Fortunately, we can bring to bear on this problem two key insights:

1. Rather than try to re-evaluate all reviews for their helpfulness, we can focus on reviews that are *guaranteed* to have very similar levels of textual quality.
2. Amazon data contains many instances of nearly-identical reviews [7] — and identical reviews must *necessarily* exhibit the same level of text quality.

Thus, in the remainder of this section, we consider whether the effects we have analyzed above hold on pairs of “*plagiarized*” reviews.

Identifying “plagiarism” (as distinct from “justifiable copying”). Our choice of the term “plagiarism” is meant to be somewhat evocative, because we disregard several types of arguably justifiable copying or duplication in which there is no overt attempt to make the copied review seem to be a genuinely new piece of text; the reason is because this kind of copying does not suit our purposes. However, ill intent cannot and should not be ascribed to the authors of the remaining reviews; we have attempted to indicate this by the inclusion of scare quotes around the term.

In brief, we only considered pairs of reviews where the two reviews were posted to different books — this avoids various types of relatively obvious self-copying (e.g., where an author reposts a review under their user ID after initially posting it anonymously), since obvious copies might be evaluated differently.

We next adapted the code of Sorokina et al. [20] to identify those pairs of reviews of different products that have highly similar text. To do so, we needed to decide on a similarity threshold that determines whether or not we deem a review pair to be “plagiarized”. A reasonable option would have been to consider only reviews with identical text, which would ensure that the reviews in the pairs had exactly the same text quality. However, since the reviews in the analyzed pairs are posted for different products, it is normal to expect that some authors modified or added to the text of the original review to make the “plagiarized” copy better fit its new context. For this reason, we employed a threshold of 70% or more nearly-duplicate sentences, where near-duplication was measured via the code of Sorokina et al. [20].¹⁰ This yielded 8,313 “plagiarized” pairs; an example is shown in Figure 4. Manual inspection of a sample revealed that the review pairs captured by our threshold indeed seem to consist of close copies.

Confirmation that text quality is not the (only) explanatory factor. Since for a given pair of “plagiarized” reviews the text quality of the two copies should be essentially the same, a statistically significant difference between the helpfulness ratios of the members of such pairs is a strong indicator of the influence of a non-textual factor on the helpfulness evaluators.

An initial test of the data reveals that the mean difference in helpfulness ratio between “plagiarized” copies is very close to zero. rather, the algorithm makes mistakes because reviews are more complex in such situations and the classifier uses relatively shallow textual features.

¹⁰Kim et al. [15], who also noticed that the phenomenon of review alteration affected their attempts to remove duplicate reviews, used a similar threshold of 80% repeated bigrams.

26 of 30 people found the following review helpful:

★★★★★ **Skull-splitting headache guaranteed!!**, June 16, 2004

By **A Customer**

If you enjoy a thumping, skull splitting migraine headache, then Sing N Learn is for you.

As a longtime language instructor, I agree with the attempt and effort that this series makes, but it is the execution that ultimately weakens Sing N Learn Chinese.

To be sure, there are much, much better ways to learn Chinese. In fact, I would recommend this title only as a last resort and after you've thoroughly exhausted traditional ways to learn Chinese. . . .

7 of 11 people found the following review helpful:

★★★★★ **Migraine Headache at No Extra Charge**, May 28, 2004

By **A Customer**

If you enjoy a thumping, skull splitting migraine headache, then the Sing N Learn series is for you.

As a longtime language instructor, I agree with the effort that this series makes, but it is the execution that ultimately weakens Sing N Learn series. To be sure, there are much, much better ways to learn a foreign language. In fact, I would recommend this title only as a last resort and after you've thoroughly exhausted traditional ways to learn Korean. . . .

Figure 4: The first paragraphs of “plagiarized” reviews posted for the products Sing 'n Learn Chinese and Sing 'n Learn Korean. In the second review, the title is different and the word “chinese” has been replaced by “korean” throughout. Sources: http://www.amazon.com/review/RHE2G1M8V0H9N/ref=cm_cr_rdp_perm and http://www.amazon.com/review/RQYHTSDUNM732/ref=cm_cr_rdp_perm.

However, a confounding factor is that for many of our pairs, the two copies may occur in contexts that are practically indistinguishable. Therefore, we bin the pairs by how different their absolute deviations are, and consider whether helpfulness ratios differ at least for pairs with very different deviations. More formally, for $i, j \in \{0, 0.5, \dots, 3.5\}$ where $i < j$, we write $i \succ j$ (conversely, $i \prec j$) when the helpfulness ratio of reviews with absolute deviation i is significantly larger (conversely, smaller) than that for reviews with absolute deviation j . Here, *significantly larger* or *smaller* means that the Mantel-Haenszel test for whether the helpfulness odds ratio is equal to 1 returns a 95% confidence interval that does not contain 1.¹¹ The Mantel-Haenszel test [2] measures the strength of association between two groups, giving more weight to groups with more data. (Experiments with an alternate empirical sampling test were consistent.) We disallow $j = 4$ since there are only relevant 24 pairs which would have to be distributed among 8 (i, j) bins.

The existence of even a *single* pair (i, j) in which $i \succ j$ or $i \prec j$ would already be inconsistent with the quality-only hypothesis. Table 1 shows that in fact, there is a significant difference in a *large majority* of cases. Moreover, we see no “ $\prec$ ” symbols; this is consistent with Figure 1, which showed that the helpfulness ratio is inversely correlated with absolute deviation prior to controlling for text quality.

We also binned the pairs by *signed* deviation. The results, shown in Table 2, are consistent with Figure 2. First, all but one of the statistically significant results indicate that “plagiarized” reviews with star rating closer to the product average are judged to be more help-

¹¹To avoid drawing conclusions based on possible numerical-precision inaccuracies, we consider any confidence interval that overlaps the interval $[0.995, 1.005]$ to contain 1. This “overlap” policy affects only two bins in Table 1 and two bins in Table 2.

ful. Second, the $(-i, i)$ results are consistent with the asymmetry depicted in Figure 2 (i.e., the “upward slant” of the green lines).

Note that the sparsity of the “plagiarism” data precludes an analogous investigation of variance as a contextual factor.

$i \backslash j$	0.5	1	1.5	2	2.5	3	3.5
0		✓	✓	✓	✓	✓	✓
0.5			✓		✓	✓	✓
1				✓	✓	✓	✓
1.5					✓	✓	✓
2						✓	✓
2.5							✓
3							

Table 1: “Plagiarized” reviews with a lower absolute deviation tend to have larger helpfulness ratios than duplicates with higher absolute deviations. Depicted: whether reviews with deviation i have an helpfulness ratio significantly larger (✓) or significantly smaller (✗, no such cases) than duplicates with absolute deviation j (blank: no significant difference).

5. A MODEL BASED ON INDIVIDUAL BIAS AND MIXTURES OF DISTRIBUTIONS

We now consider how the main findings about helpfulness, variance, and divergence from the mean are consistent with a simple model based on individual bias with a mixture of opinion distributions. In particular, our model exhibits the phenomenon observed in our data that increasing the variance shifts the helpfulness distribution so it is first unimodal and subsequently (with larger variance) develops a local minimum around the mean.

The model assumes that helpfulness evaluators can come from two different distributions: one consisting of evaluators who are positively disposed toward the product, and the other consisting of evaluators who are negatively disposed toward the product. We will refer to these two groups as the *positive* and *negative* evaluators respectively.

We need not make specific distributional assumptions about the evaluators; rather, we simply assume that their opinions are drawn from *some* underlying distribution with a few basic properties. Specifically, let us say that a function $f: \mathbf{R} \rightarrow \mathbf{R}$ is μ -centered, for some real number μ , if it is *unimodal* at μ , centrally symmetric, and C^2 (i.e. it possesses a continuous second derivative). That is, f has a unique local maximum at μ , f' is non-zero everywhere other than μ , and $f(\mu+x) = f(\mu-x)$ for all x . We will assume that both positive and negative evaluators have one-dimensional opinions drawn from (possibly different) distributions with density functions that are μ -centered for distinct values of μ .

Our model will involve two parameters: the *balance* between positive and negative reviewers p , and a *controversy level* $\alpha > 0$. Concretely, we assume that there is a p fraction of positive evaluators and a $1-p$ fraction of negative evaluators. (For notational simplicity, we sometimes write q for $1-p$.) The controversy level controls the distance between the means of the positive and negative populations: we assume that for some number μ , the density function f for positive evaluators is $(\mu + q\alpha)$ -centered, and the density function g for negative evaluators is $(\mu - p\alpha)$ -centered. Thus, the density function for the full population is $h(x) = pf(x) + qg(x)$, and it has mean $p(\mu + q\alpha) + q(\mu - p\alpha) = \mu$. In this way, our parametrization allows us to keep the mean and balance fixed while observing the effects as we vary the controversy level α .

$i \backslash j$	-0.5	-1	-1.5	-2	-2.5	-3	-3.5
0		✓	✓	✓	✓	✓	✓
-0.5			✓		✓	✓	
-1						✓	
-1.5					✓		
-2							
-2.5						✓	✓
-3							

$i \backslash j$	0.5	1	1.54	2	2.5	3	3.5
0			✓	✓			
0.5		✓	✓				
1			✓	✗			
1.5							
2							
2.5							
3							

$i \backslash j$	-0.5	-1	-1.5	-2	-2.5	-3	-3.5
$-i$		✓	✓				

Table 2: The same type of analysis as Table 2 but with *signed* deviation. The first (resp. second) table is consistent with the lefthand (resp. righthand) side of Figure 2. The third table is consistent with the “upward slant” of the green lines in Figure 2: for the same absolute deviation value, when there is a significant difference in helpfulness odds ratio, the difference is in favor of the positive deviation.

(There are a noticeable number of blank cells, indicating that a statistically significant difference was not observed for the corresponding bins, due to sparse data issues: there are twice as many bins as in the absolute-deviation analysis but the same number of pairs.)

Now, under our individual-bias assumption, we posit that each helpfulness evaluator has an opinion x drawn from h , and each regards a review as helpful if it expresses an opinion that is within a small tolerance of x . For small tolerances, we expect therefore that the helpfulness ratio of reviews giving a score of x , as a function of x , can be approximated by $h(x)$. Hence, we consider the shape of $h(x)$ and ask whether it resembles the behavior of helpfulness ratios observed in the real data.

Since the controversy level α in our model affects the variance in the empirical data (α is the distance between the peaks of the two distributions, and is thus related to the variance, but the balance p is also a factor), we can hope that at as α increases one obtains qualitative properties consistent with the data: first a unimodal distribution with peak between the means of f and g , and then a local minimum near the mean of h . In fact, this is precisely what happens. The main result is the following.

THEOREM 5.1. *For any choice of f , g , and p as defined as above, there exist positive constants $\varepsilon_0 < \varepsilon_1$ such that*

- (i) *When $\alpha < \varepsilon_0$, the combined density $h(x)$ is unimodal, with maximum strictly between the mean of f and the mean of g .*
- (ii) *When $\alpha > \varepsilon_1$, the combined density function $h(x)$ has a local minimum between the means of f and g .*

Proof. We first prove (i). Let us write $\mu_f = \mu + q\alpha$ for the mean of f , and $\mu_g = \mu - p\alpha$ for the mean of g . Since f and g have

unique local maxima at their means, we have $f''(\mu_f) < 0$ and $g''(\mu_g) < 0$. Since these second derivatives are continuous, there exists a constant δ such that $f''(x) < 0$ for all x with $|x - \mu_f| < \delta$, and $g''(x) < 0$ for all x with $|x - \mu_g| < \delta$. Since $\mu_f - \mu_g = \alpha$, if we choose $\alpha < \delta$, then $f''(x)$ and $g''(x)$ are both strictly negative over the entire interval $[\mu_g, \mu_f]$.

Now, $f'(x)$ and $g'(x)$ are both positive for $x < \mu_g$, and they are both negative for $x > \mu_f$. Hence $h(x) = pf(x) + qg(x)$ has the properties that (a) $h'(x) > 0$ for $x < \mu_g$; (b) $h'(x) < 0$ for $x > \mu_f$, and (c) $h''(x) < 0$ for $x \in [\mu_g, \mu_f]$. From (a) and (b) it follows that h must achieve its maximum in the interval $[\mu_g, \mu_f]$, and from (c) it follows that there is a unique local maximum in this interval. Hence setting $\varepsilon_0 = \delta$ proves (i).

For (ii), since f and g must both, as density functions that are both centered around their respective means, go to 0 as x increases or decreases arbitrarily, we can choose a constant c large enough that $f(\mu_f - x) + g(x + \mu_g) < \min(pf(\mu_f), qg(\mu_g))$ for all $x > c$. If we then choose $\alpha > c/\min(p, q)$, we have $\mu_f - \mu > c$ and $\mu - \mu_g > c$, and so $h(\mu) = pf(\mu) + qg(\mu) \leq f(\mu) + g(\mu) < \min(pf(\mu_f), qg(\mu_g)) \leq \min(h(\mu_f), h(\mu_g))$, where the second inequality follows from the definition of c and our choice of α . Hence, h is lower at its mean μ than at either of μ_f or μ_g , and hence it must have a local minimum in the interval $[\mu_g, \mu_f]$. This proves (ii) with $\varepsilon_1 = c/\min(p, q)$. ■

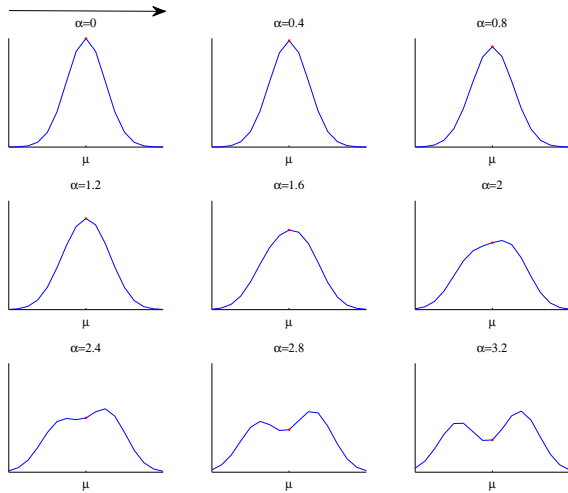


Figure 5: An illustration of Theorem 5.2, using translated Gaussians as an example — the theorem itself does not require any Gaussian assumptions.

For density functions at this level of generality, there is not much one can say about the unimodal shape of h in part (i) of Theorem 5.1. However, if f and g are translates of the same function, and their next non-zero derivative at 0 is positive, then one can strengthen part (i) to say that the unique maximum occurs between the means of h and f when $p > \frac{1}{2}$, and between the means of h and g when $p < \frac{1}{2}$. In other words, with this assumption, one recovers the additional qualitative observation that for small separations between the functions, it is best to give scores that are slightly above average. We note that Gaussians are one basic example of a class of density functions satisfying this condition; there are also others. See Figure 5 for an example in which we plot the mixture when f and g are Gaussian translates, with p fixed but changing α and hence changing the variance. (Again, it is not necessary to make

a Gaussian assumption for anything we do here; the example is purely for the sake of concreteness.)

Specifically, our second result is the following. In its statement, we use $f^{(j)}(x)$ to denote the j^{th} derivative of a function f , and recall that we say a function is C^j if it has at least j continuous derivatives.

THEOREM 5.2. *Suppose we have the hypotheses of Theorem 5.1, and additionally there is a function k such that $f(x) = k(x - \mu_f)$ and $g(x) = k(x - \mu_g)$. (Hence k is unimodal with its unique local maximum at $x = 0$.)*

Further, suppose that for some j , the function k is C^{j+1} and we have $k^{(j)}(0) > 0$ and $k^{(i)}(0) = 0$ for $2 < i < j$. Then in addition to the conclusions of Theorem 5.1, we also have

- (i') *There exists a constant ε'_0 such that when $\alpha < \varepsilon'_0$, the combined density $h(x)$ has its unique maximum strictly between the mean of f and the mean of h when $p > \frac{1}{2}$, and strictly between the mean of g and the mean of h when $p < \frac{1}{2}$.*

Proof. We omit the proof, which applies Taylor's theorem to k' , due to space limitations. ■

We are, of course, not claiming that our model is the only one that would be consistent with the data we observed; our point is simply to show that there exists at least one simple model that exhibits the desired behavior.

6. CONSISTENCY AMONG COUNTRIES

In this section we evaluate the robustness of the observed social-effects phenomena by comparing review data from three additional different national Amazon sites: Amazon.co.uk (U.K), Amazon.de (Germany) and Amazon.co.jp (Japan), collected using the same methodology described in Section 2, except that because of the particulars of the AWS API, we were unable to filter out mechanically cross-posted reviews from the Amazon.co.jp data. It is reasonable to assume that these reviews were produced independently by four separate populations of reviewers (there exist customers who post reviews to multiple Amazon sites, but such behavior is unusual).

There are noticeable differences between reviews collected from different regional Amazon sites, in both average helpfulness ratio and review variance (Table 3). The review dynamics in the U.K. and Japan communities appear to be less controversial than in the U.S. and Germany. Furthermore, repeating the analysis from Section 3 for these three new datasets reveals the same qualitative patterns observed in the U.S. data and suggested by the model introduced in Section 5. Curiously enough, for the Japanese data, in contrast to its general reputation of a collectivist culture [4], we observe that the left hump is higher than the right one for reviews with high variance, i.e., reviews with star ratings *below* the mean are more favored by helpfulness evaluators than the respective reviews with positive deviations (Figure 6). In the context of our model, this would correspond to a larger proportion of negative evaluators (balance $p < 0.5$).

7. CONCLUSION

We have seen that helpfulness evaluations on a site like Amazon.com provide a way to assess how opinions are evaluated by members of an on-line community at a very large scale. A review's perceived helpfulness depends not just on its content, but also the relation of its score to other scores. This dependence on the score contrasts with a number of theories from sociology and social psychology, but is consistent with a simple and natural model of individual bias in the presence of a mixture of opinion distributions.

	Total reviews	Avg h.ratio	Avg star rating var.
U.S.	1,008,466	0.72	1.34
U.K.	127,195	0.80	0.95
Germany	184,705	0.74	1.24
Japan	253,971	0.69	0.93

Table 3: Comparison of review data from four regional sites: number of reviews with 10 or more helpfulness votes, average helpfulness ratio, and average variance in star rating.

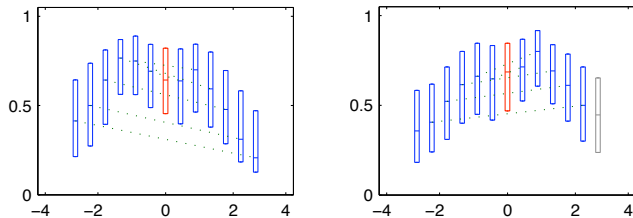


Figure 6: Signed deviations vs. helpfulness ratio for variance = 3, in the Japanese (left) and U.S. (right) data. The curve for Japan has a pronounced lean towards the left.

There are a number of interesting directions for further research. First, the robustness of our results across independent populations suggests that the phenomenon may be relevant to other settings in which the evaluation of expressed opinions is a key social dynamic. Moreover, as we have seen in Section 6, variations in the effect (such as the magnitude of deviations above or below the mean) can be used to form hypotheses about differences in the collective behaviors of the underlying populations. Finally, it would also be very interesting to consider social feedback mechanisms that might be capable of modifying the effects we observe here, and to consider the possible outcomes of such a design problem for systems enabling the expression and dissemination of opinions.

Acknowledgments. We thank Daria Sorokina, Paul Ginsparg, and Simeon Warner for assistance with their code, and Michael Macy, Trevor Pinch, Yongren Shi, Felix Weigel, and the anonymous reviewers for helpful (!) comments. Portions of this work were completed while Gueorgi Kossinets was a postdoctoral researcher in the Department of Sociology at Cornell University. This paper is based upon work supported in part by a University Fellowship from Cornell, DHS grant N0014-07-1-0152, the National Science Foundation grants BCS-0537606, CCF-0325453, CNS-0403340, and CCF-0728779, a John D. and Catherine T. MacArthur Foundation Fellowship, a Google Research Grant, a Yahoo! Research Alliance gift, a Cornell University Provost's Award for Distinguished Scholarship, a Cornell University Institute for the Social Sciences Faculty Fellowship, and an Alfred P. Sloan Research Fellowship. Any opinions, findings, and conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views or official policies, either expressed or implied, of any sponsoring institutions, the U.S. government, or any other entity.

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