Computing the Veracity of Information through Crowds: A Method for Reducing the Spread of False Messages on Social Media

Huaye Li
Howe School of Technology Management
Stevens Institute of Technology
hli21@stevens.edu

Yasuaki Sakamoto
Howe School of Technology Management
Stevens Institute of Technology
ysakamoto@stevens.edu

Abstract
Twitter and other social media allow people to post their experiences and opinions online. This information can be useful for making informed decisions. However, people can unintentionally spread false information. The work reported here focused on examining how to reduce the spread of inaccurate information on social media. In particular, we examined the effect of collective opinion on information forwarding in social media environments through an experiment with crowds. In Twitter, an indicator of collective opinion is the number of people who have retweeted a message. The results showed that displaying both retweet counts and collective truthfulness ratings could reduce the spread of inaccurate health-related messages. This finding suggests that collecting and displaying the truthfulness ratings of crowds in addition to their forwarding decisions can reduce the spread of false information on social media.

1. Introduction

Twitter and other social media became the mainstream of many people’s lives. Using these technologies, people share their opinions and experiences with others. Such information on social media can leverage people’s ability to make informed decisions. For example, about two-thirds of the movies rented on Netflix were ones that consumers would never have considered if previous users did not recommend [12].

However, social media can also facilitate the spread of unverified information [13]. For example, the spread of unverified information that turned out to be false could be far reaching during and after a disaster [16, 18, 31]. The spread of unverified information is problematic because it confuses people [30], interferes with the discovery of useful information [18], and, if it turns out to be false, it can result in misbeliefs that are difficult to change [e.g., 10, 20, 31].

To build and sustain healthy social media environments, it is essential to better understand when people spread information on social media [15]. The work presented here contributes to such understanding by examining when people are more or less likely to forward messages with varying truthfulness. In the work reported here, a message is true when it is supported by majority beliefs [7] rather than by reliable sources [23].

The main purpose of the current paper was to systematically study how to reduce the spread of false information on social media and thereby improve the quality of information on social media. In particular, we tested the effectiveness of a method, which exposed people to collective truthfulness ratings by others, in reducing the forwarding of false social media information. By doing so, we endeavored to answer the following question: What is the extent to which exposing people to collective truthfulness judgment influences their truthfulness evaluation of and forwarding of social media information?

The collective truthfulness method was applied to a social media environment similar to Twitter, using health-related statements that varied on veracity. We used health-related statements because accurate health-related information is crucial to the wellbeing of people [16]. The results suggested when the method could be useful in reducing the spread of false information on social media.

1.1. Motivation and Background

A useful function of social media is to collect and display collective opinion [28]. In Twitter, an indicator of collective opinion is the number of people who have forwarded a short text message called tweet. Forwarding of tweets is called retweeting. Twitter displays the total number of retweeting associated with each tweet that has been retweeted. This retweet count signifies the popularity of the associated tweet. Likewise, Facebook shows the total number of ‘likes’ to indicate the collective liking of articles, photos, communities, and the like. In Amazon, eBay, Netflix, and other similar websites, user ratings are aggregated as collective preferences.
Collective opinion is useful because it allows individuals to learn about the majority’s opinion and consider options that they would not have considered otherwise [2]. In this way, collective opinion can increase people’s knowledge and help them make informed decisions.

Although collective opinion is ubiquitous in social media environments, collective truthfulness judgment is rare. A study on crisis response showed that aggregate crowd behavior could help detect false information on Twitter and suggested a possibility of building a verification tool [7, 23]. However, the effectiveness of such a tool in reducing the spread of false information has not been tested, which the work reported in the current paper examined.

Moreover, the effect of collective opinion on people’s forwarding behavior in social media environments is still unclear. Nevertheless, classic studies on conformity in face-to-face environments and more recent studies in social media environments suggest that people use collective opinion when making their decisions in various situations.

1.2. Past Research

Work in social psychology has proposed that people have a strong motivation to compare their opinions with others [11]. People follow collective opinion due to their desire to make correct responses under uncertainty [29] or due to their desire to be liked by others [1]. These studies have shown that conformity takes place in face-to-face environments.

Conformity takes place in social media environments, too. For example, in an online experiment, subjects liked the same news stories more when the invented number of supporters was large than when this number was small [25]. Another online experiment showed that the number of times a piece of music was downloaded in the past could predict its future popularity when the number of downloads was available to the users [27]. These results suggest that people have a strong tendency to adopt collective opinion on social media.

The work described thus far also indicates that people attend to collective opinion. If people attend to collective truthfulness judgments, they may refrain from forwarding false information. This is because work in social psychology has shown that refutation could reduce the believability in rumor and impede its transmission [4, 5, 9, 19, 31]. Then, social media technologies, which collect truthfulness ratings from crowds and display the aggregates of these ratings as collective truthfulness judgments, may be able to reduce the spread of false information.

Although many studies have found support for conformity, there is counter evidence in consumer research that people who seek uniqueness may differentiate themselves from others [3, 32]. Based on this account, crowds may differentiate themselves from others and choose to forward information that others have not forwarded. For example, in deciding the likelihood of forwarding a statement on social media, people will go against the collective forwarding decision of others. This account will not apply to perceived truthfulness. It is strange for people to seek uniqueness for truthfulness evaluation and to go against the collective truthfulness judgment.

In sum, the research presented here extends the past work on conformity and rumor transmission to perceived truthfulness and collective sharing decision on social media. Its main focus was on analyzing and understanding how false information propagates on social media and investigating the potential of exposing people to collective truthfulness ratings to help identify false information on social media.

1.3. Hypotheses

There are two main interests. The first interest is the effect of collective truthfulness judgment on people’s perception of the truthfulness of health-related statements. The second interest is how collective truthfulness judgment influences people’s forwarding of health-related messages on social media.

Given that the studies from social psychology reviewed previously tend to find conformity, the following is our first hypothesis, **H1:** In rating the truthfulness of a message on social media, people will adopt the collective truthfulness rating associated with the message. Such behavior will lead to group polarization.

Based on the findings from social psychology that other people’s denial can reduce the spread of false information, we propose our second hypothesis, **H2:** The presence of collective truthfulness ratings reduces the spread of false statements on social media. Such behavior will reduce the quantity of false information on social media.

2. Experiment

The purpose of the experiment was to examine how collective opinion might affect people’s truthfulness rating of a health related statement and their decision to share the statement.

2.1. Method

**Participants.** In return for a nominal fee, 350 workers of Amazon’s Mechanical Turk
(https://www.mturk.com) who had completed more than 1000 tasks with over 95% acceptance rates completed the experiment. There were 220 males and 130 females.

Several groups have shown that researchers can replicate classic psychological phenomena and collect high-quality data through Mechanical Turk [6, 8, 21, 22, 24]. The design and procedure in the current experiment followed their recommendations.

**Materials.** From Discovery, Food Networks, and National Institute of Health, 120 health-related statements were selected with two constrains: first, each statement was identified by health professionals as true, debatable, or false; second, the information carried by each statement was familiar to people. Of 120 statements, 40 were true, 40 were debatable, and 40 were false according to health professionals.

**Design and Procedure.** Experiments were completed online using Mechanical Turk’s interface. Figure 1 shows an example screen shown to subjects. Subjects were instructed to imagine reading a health-related statement on social media, and to rate the extent to which the statement was true using a 7-point scale, where 1 was definitely false and 7 was definitely true. A response around the middle of the scale indicated debatable. Subjects were also asked if they would share the statement on social media, as shown in Figure 1. Sharing is defined as forwarding in the current paper. The 120 statements were presented sequentially in a random order. Each subject was randomly assigned to one of only four conditions.

**Non-exposure condition:** Statements were presented with no information about collective opinion.

**Condition 1 (with collective truthfulness only):** Each statement was presented with perceived truthfulness information, which was the mode of the 20 ratings from the control group. The use of mode preserved extreme ratings. With mean and median, the ratings tended to go toward the middle of the scale.

**Condition 2 (with collective sharing only):** Different from condition 1, each statement was presented with collective sharing decision only, which was the mode of the 20 ratings from the control group. The use of mode preserved extreme ratings. With mean and median, the ratings tended to go toward the middle of the scale.

**Condition 3 (with collective truthfulness & Collective Sharing Decision)**

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**Non-exposure Condition**

**Introduction:** People are bombarded with more information than they can process in social media such as Twitter. Although people can find a lot of useful information on Twitter, they also encounter a significant amount of unverified information. Please help us improve social media environments. Your responses are valuable!

**Instructions:** Imagine that you are reading the below statement in the box on Twitter and answer the below questions.

**Question A:** Does the statement below contain the word fiber? ☑ Yes ☐ No

**Oatmeal contains soluble fiber, which reduces your low-density lipoprotein (LDL), the ‘bad’ cholesterol.**

**Question B:** To what extent do you think this statement is true or false?

1 2 3 4 5 6 7 definitely false
definitely true

**Question C:** Would you share this statement? ☑ Share ☐ Not Share

***If you want to know more about the above statement, please email us (intuitive.analyst@gmail.com)***

If this is your first HIT from this batch, please complete the following:

I am a ___ years old _ gender, born in the city of ___.

How often do you use Twitter? ☑ Never ☑ Sometimes ☑ Always

Thank you for your participation!

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**Figure 1. Experimental design**

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Condition 3 (with collective truthfulness and collective sharing decision): Condition 3 was a combination of Conditions 1 and 2. Each statement was presented with both collective truthfulness and collective sharing decision.

A subject could participate in only one condition. A subject could rate the same statement only once. Question A in Figure 1 ensured that the subjects paid attention to the task. Data collection ended when each statement had 20 ratings. Subjects received one cent for each statement they rated, earning one cent to 120 cents.

3. Results and Discussion

All subjects were included in the analyses. Of 40 statements identified by health professionals as true, subjects rated 25 as true, 12 as debatable, and 3 as false. Of 40 statements identified by health professionals as debatable, subjects rated 12 as true, 19 as debatable, and 9 as false. Of 40 statements identified by health professionals as false, subjects rated 3 as true, 9 as debatable, and 28 as false.

The 120 statements were grouped into six groups based on subjects’ perceived truthfulness in the non-exposure condition. The 120 statements were first sorted based on the truthfulness ratings in the non-exposure condition (1 was definitely false). Then 20 statements with the lowest ratings were placed into False category, the next 20 statements into False-Weak, the next 20 into Debatable-False, the next 20 into Debatable-True, the next 20 into True-Weak, and finally the 20 statements with the highest ratings into True category. We used six categories to examine finer-grained patterns.

Figure 2 displays the truthfulness ratings, grouped into these six categories. Figure 4 displays the sharing decisions, grouped into these six categories. Error bars indicate 95% confidence intervals.

![Exposure to collective information](image)

**Figure 2. The effect of exposing people to collective opinion on truthfulness ratings**

<table>
<thead>
<tr>
<th>Exposure &amp; Sharing</th>
<th>False (Tukey)</th>
<th>False-Weak (Games-Howell)</th>
<th>Debatable-False (Games-Howell)</th>
<th>Debatable-True (Games-Howell)</th>
<th>True-Weak (Games-Howell)</th>
<th>True (Tukey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truthfulness</td>
<td>(t = 3.396)</td>
<td>(t = 3.913)</td>
<td>(t = 0.137)</td>
<td>(t = 0.293)</td>
<td>(t = 1.942)</td>
<td>(t = 1.841)</td>
</tr>
<tr>
<td>(p &lt; .005)</td>
<td>(p &lt; .003)</td>
<td>(p = .999)</td>
<td>(p = .991)</td>
<td>(p &lt; .001)</td>
<td>(p &lt; .001)</td>
<td></td>
</tr>
<tr>
<td>Truthfulness</td>
<td>(t = 1.747)</td>
<td>(t = 0.366)</td>
<td>(t = 2.634)</td>
<td>(t = 1.819)</td>
<td>(t = 3.631)</td>
<td>(t = 8.195)</td>
</tr>
<tr>
<td>(p = .307)</td>
<td>(p = .983)</td>
<td>(p = 0.060)</td>
<td>(p = .286)</td>
<td>(p &lt; .001)</td>
<td>(p &lt; .001)</td>
<td></td>
</tr>
<tr>
<td>Sharing</td>
<td>(t = 1.003)</td>
<td>(t = 1.015)</td>
<td>(t = 0.810)</td>
<td>(t = 3.188)</td>
<td>(t = 7.944)</td>
<td>(t = 2.652)</td>
</tr>
<tr>
<td>(p = .749)</td>
<td>(p = .742)</td>
<td>(p = .849)</td>
<td>(p = 0.019)</td>
<td>(p &lt; .001)</td>
<td>(p &lt; .001)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Post-hoc results for truthfulness ratings against the non-exposure condition
3.1 Truthfulness

According to H1, in rating the truthfulness of a statement on social media, people will adopt the collective truthfulness judgment. The truthfulness condition and the truthfulness & sharing condition in Figure 2 and Table 1 show that, in these two conditions, the truthfulness ratings tend to become more extreme: that is, statistically more positive for true statements and statistically more negative for false statements. This pattern of results is exactly what one expects. Because collective truthfulness ratings were based on mode, they tended to become more extreme than the average ratings. Thus, the results support H1.

We further analyzed the data. A 6 (statement: the six groups based on people’s perceived truthfulness) by 4 (exposure: non-exposure, truthfulness and sharing, truthfulness, and sharing) analysis of variance (ANOVA), with truthfulness ratings as a dependent measure, revealed that, collapsing across exposure, the truthfulness ratings for False (2.00), False-Weak (3.17), Debatable-False (4.22), Debatable-True (4.74), True-Weak (5.71), and True (5.69) differed statistically, $F(5, 114) = 174.24, p < .001$. This verifies that the statements varied in truthfulness. Collapsing across statement, the truthfulness ratings in the non-exposure (4.31), truthfulness (4.42), sharing (4.07), and truthfulness & sharing conditions (4.21) differed statistically, $F(3, 475) = 26.07, p < .001$, indicating that collective opinion influenced the truthfulness ratings. There was a statement by exposure interaction, $F(3, 342) = 11.24, p < .001$, indicating that the effect of collective opinion differed depending on how truthful the statement was.

![Figure 3. Social influence score for the truthfulness ratings](image-url)
Given the interaction between statement and exposure, we further analyzed the effect of condition within each group using a one-way ANOVA, with exposure as an independent variable and truthfulness ratings as a dependent measure. Within each group, the non-exposure, truthfulness & sharing, truthfulness, and sharing conditions differed statistically in the truthfulness ratings: $F(3, 57) = 15.04, p < .001$ for False; $F(3, 57) = 7.90, p = .029$ for False-Weak; $F(3, 57) = 5.24, p < .001$, for Debatable-False; $F(3, 57) = 12.78, p < .001$ for Debatable-True; $F(3, 57) = 27.01, p < .001$ for True-Weak; and $F(3, 57) = 59.78, p < .001$ for True.

Table 1 shows the results of post hoc tests between the truthfulness ratings in the non-exposure condition and those in each of the other conditions. The cells with grey background indicate that their truthfulness ratings do not differ statistically from those of the non-exposure condition. The post hoc test results explain the statement by exposure interaction.

We conducted another analysis to further examine the effect of collective opinion. For this analysis, we reduced the number of categories from six to three. The new False category had 40 statements, a combination of 20 from False and 20 from False-Weak in the previous analysis. Similarly, the new Debatable category had 40 statements, 20 from the Debatable-False and 20 from Debatable-True. The new True category also had 40 statements, 20 from True-Weak and 20 from True in the previous analysis. Thus there were three categories, True, Debatable, and False, with 40 statements in each category.

We then calculated a social influence score for each statement when it was in the truthfulness & sharing condition, another score when it was in the truthfulness condition, and another score when it was in the sharing condition. For the truthfulness & sharing condition, the social influence score of a statement was defined as subtracting its truthfulness rating in the non-exposure condition from its truthfulness rating in the truthfulness & sharing condition. The same method was used in the other two conditions.

Figure 3 shows the social influence score for each statement grouped into True, Debatable, and False. There are 40 bars in each bar plot of Figure 3. The presence of a bar indicates the presence of social influence, or an effect of collective opinion. When there is no social influence, the social influence score is zero.

According to H1, collective truthfulness judgment influences truthfulness ratings. Figure 3 shows that, in the truthfulness condition and truthfulness & sharing condition, true statements tend to have positive social influence scores and false statements tend to have negative social influence scores. Because collective truthfulness ratings were based on mode, they tended to be more extreme than the average ratings. Thus, adopting collective truthfulness ratings would result in more extreme truthfulness ratings. In other words, conformity would result in more positive social influence scores for true statements and more negative social influence scores for false statements, consistent with the observed results.

### 3.2 Sharing

Our main interest is the effect of collective truthfulness judgment on reducing the sharing of false statements. H2 proposes that the presence of collective truthfulness ratings reduces the spread of false statements on social media.

As shown in Figure 4 and Table 2, people were statistically more likely to forward false information in the truthfulness condition than in the non-exposure condition, consistent with H2. However, people were statistically less likely to share false information in the truthfulness & sharing condition than in the non-exposure condition. Taken together, collective truthfulness rating and collective sharing decision displayed together could reduce the spread of false information on social media. Collective truthfulness evaluation plays an important role in impeding the spread of false information but not by itself, partially supporting H2.

We further analyzed the relationships between collective opinions on sharing decisions. In the non-exposure, truthfulness & sharing, truthfulness, and sharing conditions, subjects were more likely to share statements that they perceived as truthful. There was a positive correlation between perceived truthfulness in the non-exposure condition and the sharing decision in the non-exposure condition, $r = .80, p < .001$ as well as truthfulness & sharing condition, $r = .80, p < .001$, truthfulness condition, $r = .83, p < .001$, and sharing condition, $r = .7, p < .001$.

A 6 (statement: the six groups based on people’s perceived truthfulness) by 4 (exposure: non-exposure, truthfulness & sharing, truthfulness, and sharing) ANOVA, with sharing decision as a dependent measure, revealed that, collapsing across exposure, the proportion of responses indicating sharing for False (0.09), False-Weak (0.14), Debatable-False (0.24), Debatable-True (0.33), True-Weak (0.43), and True (0.56) differed statistically, $F(5, 114) = 114.5, p < .001$. Collapsing across statement, the proportion of sharing in the non-exposure (0.27), truthfulness & sharing (0.21), truthfulness (0.39) and sharing conditions (0.32) differed significantly, $F(3, 356) = 75.63, p < .001$, indicating that there was an effect of collective opinion. There was a statement by exposure interaction, $F(3, 342) = 2.34, p < .001$, indicating
that the effect of collective opinion resulted in different patterns across groups.

Given the significant interaction between statement and exposure, we further analyzed the effect of condition within each group using a one-way ANOVA, with exposure as an independent variable and sharing decision as a dependent measure. Within each group, the non-exposure, truthfulness & sharing, truthfulness, and sharing conditions differed statistically in the sharing decision: $F(3,57) = 17.83, p < .001$ for False; $F(3,57) = 32.58, p < .001$ for False-Weak; $F(3,57) = 28.63, p < .001$ for Debatable-False; $F(3,57) = 17.42, p < .001$ for Debatable-True; $F(3,57) = 8.86, p < .001$ for True-Weak; and $F(3,57) = 4.25, p < .001$ for True.

Taken together, Table 2 and Figure 4 reveal that people have a strong tendency to reduce their sharing of false statement when presented with both collective truthfulness judgment and collective sharing decision.

In the real twitter environment, Twitter does not provide collective truthfulness ratings but it provides collective sharing decision in the form of retweet count. According to Figure 4 and Table 2, with the presence of truthfulness rating alone, people accelerated the spread of false information relative to the non-exposure condition. Exposing people to collective sharing decision alone also accelerated the sharing of false information relative to the non-exposure condition. Developers of social media technologies should avoid these designs. Instead, exposing people to both collective truthfulness judgment and collective sharing decision seems to be effective in reducing the spread of false information.

Figure 5 shows the social influence score for each statement, computed in the same way as in truthfulness ratings. Social influence took place for False, True and Debatable statements.

![Figure 4. Exposure to collective decision (sharing)](image)

### Table 2. Post-hoc results for sharing decisions against the non-exposure condition

<table>
<thead>
<tr>
<th>Exposure &amp; Sharing</th>
<th>False (Games-Howell)</th>
<th>False-Weak (Games-Howell)</th>
<th>Debatable-False (Games-Howell)</th>
<th>Debatable-True (Tukey)</th>
<th>True-Weak (Games-Howell)</th>
<th>True (Tukey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truthfulness</td>
<td>$t = 3.250$</td>
<td>$t = 5.230$</td>
<td>$t = 3.761$</td>
<td>$t = 1.663$</td>
<td>$t = 0.288$</td>
<td>$t = 0.297$</td>
</tr>
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<td></td>
<td>$p &lt; .001$</td>
<td>$p &lt; .001$</td>
<td>$p &lt; .001$</td>
<td>$p &lt; .001$</td>
<td>$p = .992$</td>
<td>$p = .991$</td>
</tr>
<tr>
<td>Truthfulness</td>
<td>$t = 4.523$</td>
<td>$t = 2.594$</td>
<td>$t = 4.299$</td>
<td>$t = 4.170$</td>
<td>$t = 4.052$</td>
<td>$t = 2.107$</td>
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<td></td>
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<td>$p &lt; .001$</td>
<td>$p &lt; .001$</td>
<td>$p = .160$</td>
</tr>
<tr>
<td>Sharing</td>
<td>$t = 2.213$</td>
<td>$t = 2.120$</td>
<td>$t = 0.854$</td>
<td>$t = 2.543$</td>
<td>$t = 0.309$</td>
<td>$t = 1.477$</td>
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<td></td>
<td>$p &lt; .001$</td>
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<td>$p &lt; .001$</td>
<td>$p &lt; .001$</td>
<td>$p = .990$</td>
<td>$p = .456$</td>
</tr>
</tbody>
</table>

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4. General Discussion

Varieties of information are available on social media, including inaccurate information. In the research reported here, we investigated a method to reduce the spread of false information on social media and consequently improve the quality of information on social media. The method was to crowdsource the evaluation of veracity of information and to display it as collective truthfulness judgment.

We found that this method alone could not reduce the forwarding of false health-related information. On the contrary, it increased the forwarding of false information relative to a condition, in which no collective opinion was present. One speculation is that, when people are aware that others think the information is false and know how many have already shared the information, they hesitate to forward it because they do not want to spread false information, but, when they are not exposed to the number of people who have already shared the information, they may not be thinking about spreading false information and thus they may not hesitate as much. The results from the work presented here suggest that the designers of social media technologies should not display collective truthfulness ratings alone.

We also tested the effect of collective sharing decision on reducing the forwarding of false health-related information on social media. This is akin to retweet counts. As in the case of displaying collective truthfulness ratings alone, displaying collective sharing decision alone accelerated the forwarding of false information relative to a condition with no collective opinion. Thus the current design of Twitter may not be optimal for reducing the spread of inaccurate tweets. In fact, consistent with our results, in some cases the retweet function can speed up the spread of inaccurate information [16].

In our experiment, the optimal way to combat the spread of false information was to display both

Figure 5. Social influence scores for sharing decisions
collective truthfulness judgment and collective sharing decision. In this condition, the collective opinion reduced the spread of false information and also lowered the truthfulness ratings. When people are aware that others think the information is false and retweet count is small, they refrain from forwarding it. These findings suggest that social media technologies should collect and display collective truthfulness ratings in addition to retweet counts in order to reduce the spread of inaccurate information.

5. Limitations and Future Directions

In the real social media environments, collective opinion is not constant. It keeps changing. For example, in Twitter, the retweet counts change as more users retweet. We want to extend our research to examine how dynamic collective opinion influences people’s information sharing decisions.

In the experiment reported here, we used ‘share’ or ‘not share’ to collect people’s information sharing decision. This is different from the retweet button in Twitter. We are currently making the interface closer to the real world settings so that in the future we can simulate the real environments more closely.

The work presented here did not consider social network structures. To simulate the real social media environments, one needs to know users’ connections to others. Without such information, we cannot translate the reduction in the spread of false information into the number of people who will not receive the false information. Adding a social network component is in our future plan.

6. Conclusions

Many people take to social media sites to share information with others. Well-intentioned users can spread rumors that are later found to be false. To improve the quality of information in social media, we study crowd-based techniques to minimize the spread of false information and support the discovery of relevant information. In the current paper, we presented some results from our research suggesting that crowdsourcing credibility evaluation and displaying it together with retweet counts can be effective in reducing the spread of inaccurate information on social media.

Through researching crowd-based methods to improve the quality of information on social media, we want to help increase people’s intelligence by directing their computer-mediated interactions. In this way we wish to contribute to society.

7. Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. IIS-1138658 and Grant No. BCS-1244742. The work reported here is part of HL’s doctoral dissertation at Stevens Institute of Technology.

8. References


eliminate the continued influence of misinformation. Memory & Cognition, 38, 1087-1100.


