

Believe it or Not? Analyzing Information Credibility in Microblogs

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Abstract—This paper identifies and evaluates key factors that influence credibility perception in microblogs. Specifically, we report on a demographic survey (N=81) followed by a user experiment (N=102) in order to answer the following research questions: (1) What are the important cues that contribute to information being perceived as credible? and (2) To what extent is such a quantification portable across different microblogging platforms? To answer the second question, we study two popular microblogs, *Reddit* and *Twitter*. Key results include that significant effects of individual factors can be isolated, are portable, and that metadata and image type elements are, in general, the strongest influencing factors in credibility assessments.

Microblogs such as Twitter and Reddit are well established global sources of real-time news and information. As with all platforms that support user-provided content, they suffer from an abundance of noisy and unreliable data. With the emergence of microblog messages as serious sources for news, as indicators and early informers of natural phenomena such as earthquakes and severe weather, and even as medium for financial transactions (tweet-to-pay functionality was recently introduced by several banks), the importance of identifying credible information and information sources on microblog platforms continuously increases.

In recent years, microblogging services have transformed from online journal or peer-communication platforms [1] to powerful online information sources operating at a global scale in every aspect of society, largely due to the advance of mobile technologies. Today's technology enables instant posting and sharing of text and/or multimedia content, allowing people on-location at an event or incident to serve as news reporters. In fact, a recent study of traditional media journalist practice [2] shows that they rely heavily on social media for their information. Another study [3] reported that 53.8% of all U.S. journalists use microblogs to collect information and to report their stories. Several recent studies [4], [5] show how user-provided microblog content is an effective mechanism for understanding crisis situations such as earthquakes, hurricanes or political conflicts.

The mass proliferation of microblog usage also brought about a shift in the interaction mechanisms and information flow within them. In particular, a 2013 PEW research report [6] shows that an increasing number of users search microblogs by keyword or hashtag as opposed to the traditional content stream or message exchange practices. This means that a larger portion of information is coming from complete strangers, accessed via keyword matching than from sources that a user

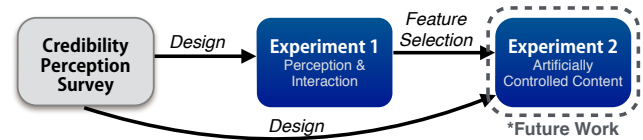


Fig. 1: Overview and dependencies between the initial survey (N=81), Experiment 1 (N=102) and Experiment 2 (Future work)

is actively following and are likely to be known by the user. This reduced window of information about the source presents a difficult challenge in assessing credibility of information, and requires a more comprehensive understanding of the components of a microblog message and their potential impact on the information consumer's assessment of information credibility. This is bolstered by the fact that the majority of users in Twitter (52%) and Reddit (60%) treat the system as their primary source of news information [6].

Recently there have been many efforts to study information credibility in microblogs, ranging from automated algorithms to model and predict credibility of users [7] and messages [8], [9] at general [8], [10] and topic-specific [9] levels, to visualization and interaction applications such as [11]. However, with the exception of [12], [13], little research has focused on the impact of individual microblog features such as profile images, links and other available metadata on perceptions of credibility—a problem that is increasingly important as a growing portion of news information gets produced by people the information consumer does not know. It is in view of this problem that we attempt to answer the following research questions:

- 1) What are the important cues that contribute to information being perceived as credible on microblogs.
- 2) To what extent is such a quantification portable across different microblogging platforms?

a) *Contributions*: Figure 1 shows a high level overview of the two key phases in this study, including the second experiment for future study, and the dependencies between them. First, a crowd sourced survey of 81 users was performed to assess patterns in users assessments of information credibility across different topics and for demographic groupings. From this survey, a large set of microblog features was analyzed and a subset was identified for further evaluation.

Second, a user experiment (N=102) was designed to place users in context across two microblog platforms and elicit a more refined set of salient factors that influenced their judgement of information credibility. To do this, heatmaps were computed from mouse click behavior in the microblog interfaces. To address the question of portability, we perform experiments across two of the most popular microblogs for news-consumption: *Reddit* and *Twitter*.

We further plan to conduct an experiment in which variables from phase 2 are experimentally controlled. This will allow us to assess the impact of each individual variable on credibility assessments in a range of contexts. We will briefly discuss this experiment in our Future work section.

Results of the two studies provide insight on the ways users evaluate and perceive information credibility in different contexts on microblog platforms.

I. RELATED WORK

Having described our experiment at a high level, we will now discuss it within the context of relevant related research, before detailing the experimental setup and results. We begin by defining credibility, and continue by comparing and contrasting different approaches for modeling information credibility in microblogs, at the computational and user-perception levels.

b) Credibility Definition: Information credibility is a concept that has received research attention from a variety of disciplines over many decades, and there are many conflicting definitions of the topic. A recent study by [14] provided a definition for credibility which has been frequently relied on by subsequent research. They describe credibility as “(a) a *perceived quality* (b) made up of multiple dimensions, mostly *trustworthiness* and *expertise*.”

[14] claim that credibility does not reside in an object, a person or a piece of information. Similarly in this work, we consider credibility as a function of *perception* including the person and the object being perceived. Many studies of credibility (e.g.: [15]) find that it is comprised of two primary dimensions—*trustworthiness* and *expertise*.

c) Credibility models: [16] studied how people evaluate information credibility online and proposed the idea of *Prominence-interpretation theory* which, as the name suggests, is comprised of the two values: “prominence” (important or distinct entities) and “interpretation” (user assessment of the entities). Following from this, other researchers proposed models or algorithms that either measure or predict credibility of users in different contexts. For example, [7] build a model of location and topic affinity to identify credible, relevant users in crisis situations. [8] and [9] both propose models for identifying credible sources of news information based on computational models. Going beyond theory, some researchers place a focus on empirical evaluation of credibility and the problem of ground truth. For example, [10] proposed a two pronged approach to gathering ground truth information on the credibility of microblog data by combining manually annotated scores with observed network statistics (e.g: retweets) from the data to achieve a “more stable” estimate of credibility.

d) Perceived Credibility: While there is much discord over a standard definition of credibility across different disciplines, most researchers agree that “credibility” that is inherent to an entity and perceived credibility of that entity are not necessarily equivalent. The latter could be viewed as a subjective function of the former. Perceived credibility can fluctuate from (inherent) credibility based on the way in which the entity is represented, and based on the characteristics of the person making the credibility assessment. Accordingly, numerous researchers from different disciplines have attempted to identify a set of salient factors that contribute to our perception process. Visual and textual components have been studied in the same vein [17] to reveal complex relationships between data, metadata and context that inform our perception of information credibility. Other researchers have studies influence at the network level, identifying trends and patterns that lead to tipping points of credibility and popularity [18] and surges in influence within the network [19].

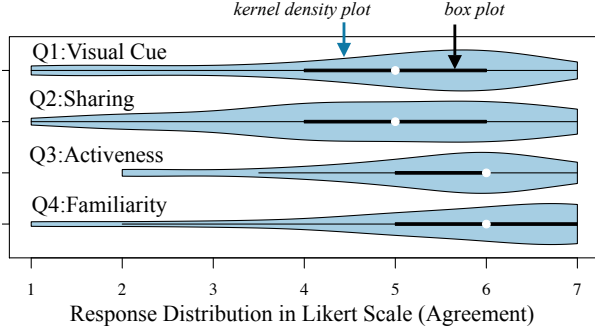
In recent years, features or cues that affect perceived credibility of information in microblogs have been studied [13], [20]. A common theme in these recent studies is to first select numerous candidate features that are likely to contribute to the assessment processes, and then analyze them in both qualitative and quantitative ways through online surveys or user studies. For example, [20] found disparity between the features considered for evaluating information credibility between search engines and Twitter. Morris also reported a controlled experiment that revealed the features through which users assess information credibility on Twitter. Their study also provided insight and suggestions for interface design to improve credibility perception from the end-user perspective. Perceived credibility has also been compared across different cultural settings by [13]. Their study reports on experimental and survey data that compares and contrasts the impact of several features of microblog updates (authors gender, name style, profile image, location, and degree of network overlap with the reader) on credibility perceptions among U.S.(Twitter) and Chinese(Weibo) audiences. Their goal was to design new user experiences which can maximize both *credibility* (as a property of entity) and *perception of credibility* (an end-user subjective function, to which the entity is an argument) of the contents on social media. Perceived credibility can be impacted by personality characteristics such as those modeled by [21].

II. CREDIBILITY PERCEPTION SURVEY

To gather a fair assessment of candidate features to evaluate in our main experiments, and to gather insight about credibility decisions in microblogs, we conducted a crowd sourced study targeting Twitter users in late 2013 using Amazon’s Mechanical Turk (MTurk) platform. A total of 81 respondents were asked a series of questions to explore what information from microblogs they mostly consider when they need to search for credible information about particular events. The 59 male and 22 female participants were from different parts of the world, with a majority from the United States and India. Participant age ranged between 18 and 60 with an average of 28. 60% of the subjects used microblog on a weekly (22%) or daily (38%) basis. Participants reported basic information such as Twitter usage, educational and cultural backgrounds and yearly income.

TABLE I: Primary use of information on Twitter

Business	22(27.2%)	Information Sharing	21(25.9%)
Social Purpose	16(20.0%)	Information Search	15(18.5%)
Serendipitous Search	4(4.9%)	Other	3(3.7%)

**Fig. 2:** Survey responses for key questions (marked with * in Table II). Each line and enclosed curve shows the response distribution for questions in (1) a box-whisker-chart indicating medians and quartiles and (2) a kernel density plot, respectively. Responses are provided on a Likert scale (Strongly disagree (1) – Strongly agree (7)).

The overarching goal of the survey was to explore the following general hypothesis through self-reported metrics and to identify the set of Twitter features (E.g: links, profile images etc.) reported as most influential in credibility assessment. The two additional experiments in this paper expand the general hypothesis into 6 additional hypotheses, and were both designed based on analysis of the results from this survey. In the survey, 20% (16/81) of the participants reported that they consider visual cues as a major factor that affects their credibility assessments. Details of the resulting design decisions are discussed in Section III.

Research Question (RQ) 1: Does the display of metadata in microblogs influence perceived credibility of the associated content.

HYPOTHESIS. *Metadata display (textual or visual) influences perceived credibility of microblog content. The direction of influence is dependent on the specific content displayed.*

To gauge usage patterns and credibility perception, participants were asked 17 questions in a web survey, covering aspects such as activity rate, perceived impact of visual cues, and sharing frequency, among others. A selection of these survey questions are shown in Table II, and response distributions are shown in Figure 2. The results indicate that the majority of the participants consider themselves active information consumers on microblogs (79% for 'Activeness'). These users also share their own content frequently with their followers (57%, 'Sharing'). The most common usage reasons (Table I) were reported as business (27%) including online marketing, information sharing (26%) and social use (20%). Interestingly, 68% of participants reported that visual elements have significant impact on their credibility assessment in the microblog, as indicated by Q1 in Figure 2. Our population exhibited reasonably heavy use of Twitter (38% daily use) and a good standard of education across participants, with 67/81

Label	Questions
Activeness*	Do you consider yourself as an active online information consumer?
Sharing Freq*	Do you frequently share your information with the people in your network (followers)?
Primary Usage	What is your primary usage of information on microblogs?
Familiarity*	Are you familiar with microblog services?
1st Cred Factor	Which do you consider as a primary factor for measuring information credibility?
2nd Cred Factor	Which do you consider as a secondary factor for measuring information credibility?
Visual Cues *	Do you think that visual cues are important for judging credibility?
Url Relevance	Do you think that the presence of URLs in a tweet, which point to an external information source, can enhance information credibility?
In-Person Friends	About how many of your "friends" on Twitter have you met in person?
Non-Human Friends	About how many companies or organizations do you currently follow on Twitter?
Celebrity Friends	About how many celebrities do you currently follow on Twitter?
Time-On-Others	On Twitter, about how much time do you spend looking at what other users have posted?
Time-On-Me	On Twitter, about how much time do you spend posting tweets about yourself?

TABLE II: Survey Questions. * denotes further detail in Figure 2

possessing at least a bachelor's degree.

e) Credibility Factors: The main section of the survey investigated what kinds of attributes participants consider as a primary factor when they search for credible information on microblogs. We can intuitively expect that both content and information source would be highly ranked and the results indeed support this. However, it is interesting to note that *visual cues* such as design and layout were also reported as influential in the process of credibility assessment. 10% of participants responded that design/layout was the primary factor (20% elected it a major factor) in their credibility assessments.

f) Correlation Analysis: People consider many different factors during credibility assessment with microblog information. Numerous researchers concluded that, ultimately, credibility can be perceived or measured in different ways based on the given context, cultural background, language, etc. [16]. We also find that many microblog users agree with this statement from pre-study offline interviews. Thus, we designed our questionnaire to find underlying correlation, if any, between demographic background and the question responses. Results are shown in Figure 3. Table II provides a full description of each element in the correlation plot of Figure 3. Some notable correlations include Twitter use and general information use. Predictably, there was a positive correlation between employment type and microblog content use—a major cause for this may have been a number of users stating they used microblogs for marketing purposes. There was a strong correlation between locality (size of city lived in) and amount of information shared on microblogs. People in larger cities shared more information than those in small cities and towns. We also find a correlation between gross income / ethnic origin and microblog usage, complementary to [22], who found strong correlation between these factors and browsing behavior. Demographic factors (both age and cultural background) correlated with usage rate, and with the impression of visual cues as an information credibility factor—younger people had higher usage rates and were more

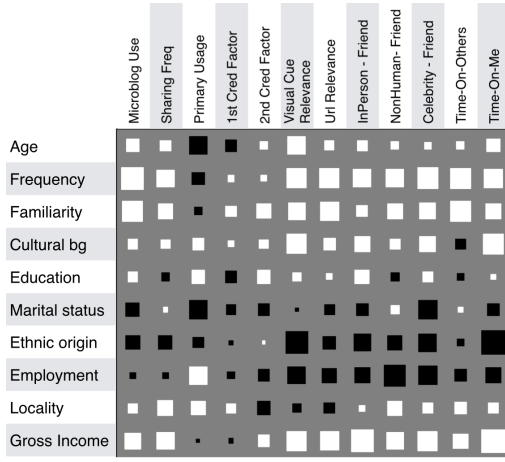


Fig. 3: Correlation matrix between the demographic information of the participants and the responses to the survey. The matrix is visualized in a Hinton Map (white and black squares represent positive and negative correlation, respectively. Square size is proportional to the absolute value of the score [0–1].)

influenced by visual cues.

In summary, the initial analysis from the survey highlights visual cues as a useful factor for further study, incorporating aspects of content, and metadata about the source/provenance of microblog messages.

III. EXPERIMENTAL SETUP

To further explore what factors influence credibility perception in microblogs, we designed and conducted a user experiment guided by insights from the credibility perception survey. The experiment was conducted on MTurk. In this section, we detail the design of the experiment and discuss a refined set of experimental hypotheses.

A. Experiment on Perception and Interaction

The initial survey highlighted that content (meaning) and sources (origin) of microblog posts are the most influential factors in credibility assessment. However, the representation of information such as metadata also plays a significant role in user perception of information credibility. According to these findings, we refine the initial research questions to include the following three questions/hypotheses.

RQ2: Do different features influence credibility by different amounts?

HYPOTHESIS. *Features have varying degree of influence over credibility perception*

RQ3: Can our models of feature influence be ported successfully to different microblogs?

HYPOTHESIS. *Influence of features is consistent across platforms*

To test these hypotheses, a study was designed to place users in a familiar/typical microblog context and provide them with a simple mechanism to highlight the specific features that they felt had an influence on their perception of content. To

address the last hypothesis, the study was designed to be cross-platform, comparing features from Twitter and Reddit. Figure 4 shows two example interfaces from the study (N=102). Users were requested to click on or close to items that they felt had *any* impact on their perception of information, positive or negative. They were given no a-priori information on specific feature lists. This mechanism for identifying influential features was used in an effort to avoid bias from manual or expert selection of a feature set. Domains (Twitter and Reddit) were a between-subjects variable, and only participants with significant prior experience with a domain were allowed perform the task.

First, participants were asked 6 general questions about their microblogging practice. Then they were shown 3-4 screenshot images of the microblog (3 for Reddit and 4 for Twitter). To capture the aforementioned features avoiding possible bias, we let participants select three visual elements instead of having them rank an arbitrary selection of features we provide. On each click, a slider selector was shown below the image to record the amount of impact the element that the user clicked on has on her credibility assessment. We collected coordinates of each click and its corresponding score in likert scale (0 for no effect to 5 for major effect).

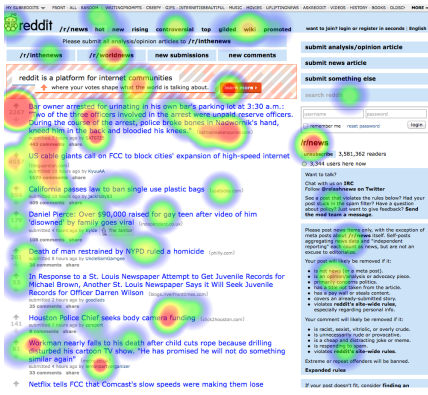
g) Feature extraction: In order to extract meaningful features from this experiment, we analyzed the results from a heatmap visualization (Figure 4) and statistical analysis using five-number summaries (Figure 5). As can be seen in Figure 5, there is overall similarity in credibility ratings on different elements for both Reddit and Twitter users. However, users of Reddit express higher priority on both information sources and textual elements for their credibility assessments. This observation may be due to small differences between two social platforms: For example, most of the posts in Reddit are directly connected to external webpages and this makes the source (URLs) more important during credibility assessments. Additionally, posts in Reddit are longer than in Twitter, which could account for the higher text credibility score for Reddit. Although the metadata scores are similar in Figure 5 for both platforms. Twitter does provide a richer set of metadata (e.g. classifications, hashtags, retweet counts etc.) on their page layouts, and this is evident from the increased number of clicks on metadata components in the heatmap (Figure 4(b)).

IV. RESULTS AND DISCUSSION

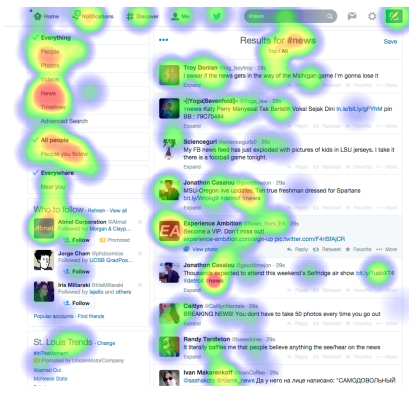
In this section, we provide the findings from our main user experiment. This section provides an overview of participant statistics, and following that, is organized around the four research questions and hypotheses posed earlier.

A. Study Participants

Our experiment had 102 participants. The average interaction time for both Twitter and Reddit users was 5 minutes. Users annotated three items each for a total of 306 annotations. Most reported that they were active daily on the platforms (Twitter and Reddit) and had been active for more than a year. Most used the official application, on a combination of mobile and desktop platforms.



(a) News subreddit page in Reddit



(b) A search result page with 'news' keyword in Twitter

Fig. 4: Heatmap visualization of the user annotations for Exp1, where clicks on an entity indicate perceived credibility.

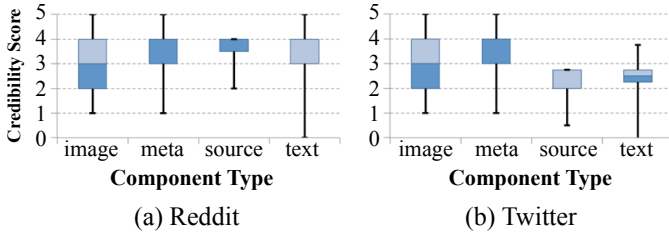


Fig. 5: Degree of impact on perceived credibility by UI component type for (a) Twitter and (b) Reddit

B. Influence of Metadata

RQ1: Does the display of metadata in microblogs influence perceived credibility of the associated content?

HYPOTHESIS. *Metadata display (textual or visual) does influence perceived credibility of microblog content. The direction of influence is dependent on the specific content displayed.*

Both the credibility perception survey and user experiment indicate an impact of metadata on perceived credibility in microblogs. The subjective results in Survey 1 show a strong (but self-reported) indication that Content of a message and Origin (author) of a message are the strongest influencing factors. This is followed by visual features, including components such as profile pictures and other metadata. The discussions that follow here further illuminate and reinforce this basic result.

C. Cross-Feature Analysis

RQ2: Do different features influence credibility by different amounts?

HYPOTHESIS. *Features have varying degree of influence over credibility perception*

Figure 5 shows perceived credibility score distributions of different feature types. As can be seen, impact on perceived credibility varies across different types of features. This supports our initial hypothesis on RQ2. All feature types have considerable impact on credibility judgment. In particular,

image type features show a wide distribution of credibility impact. This pattern is consistent over different microblog platforms in the experiment. In terms of click frequency, the metadata feature accounts for 73.5% of the total clicks. This is followed by the image feature with 18.6% of the clicks.

D. Cross-Platform Analysis

RQ3: Can our models of feature influence be ported successfully to different microblogs?

HYPOTHESIS. *Influence of features is consistent across platforms*

To recap, the experiment evaluated self-reported importance of microblog features across two platforms: Reddit and Twitter, allowing users to place simple clicks in context of the actual interface. Figure 5(a) and (b) show the results for Reddit and Twitter respectively. Our results disprove our initial hypothesis that feature ratings are invariant, since the text features achieved a higher credibility rating in Reddit. This is likely to be related to the fact that there is significantly more text per post allowed in Reddit. Image features appeared to garner similar ratings across the two platforms, which is a meaningful finding, especially coupled with the fact that the Visual/Image-based features are the strongest influences on credibility perception. It is interesting to note that both metadata and image garnered the majority of clicks in both platforms. This finding is somewhat in conflict with regard to the results of the survey, which stated that content and source of information were seen as the most important factors for perceived credibility.

V. FUTURE WORK

Based on the reported studies, we will aim to answer a more specific research question in future work: Can we separate the cues from the content and quantify their influence on credibility perception? More specifically, from the credibility perception survey and the experiment, we will select a set of features on which to base our evaluation for a follow-up experiment. By artificially controlling values for each target feature, we can assess the directional effect of metadata content on credibility perception. Furthermore,

to avoid topic-specific biases in assessing the stability of feature influence on credibility perception across topics, we can incorporate a variety of common topics into the evaluation. This systematic and controlled experiment will allow us to reveal different insights across feature types and topics, and to design prediction models that can be used for intelligent user interfaces, with the particular goal of predicting indicators of credibility such as retweets, up-votes or shares from real world data. A second thread of future work will examine the potential of combining eye-tracking technologies such as Tobii EyeX¹ with EEG sensors to detect concentration and distraction with respect to eye gaze pattern while users interact with social media data.

VI. CONCLUSIONS

To conclude, in this set of interlinked studies we evaluate ways in which individual components of microblogs can influence end-user perceptions of information credibility. In particular, an initial survey provided general insight into a candidate set of factors that influence credibility most; a second study (N=102) examined these factors in the context of two microblog domains, Reddit and Twitter, to allow real users to communally identify the most influential factors.

Three hypotheses related to the impact of different types of microblog elements (features) on human-provided assessments of credibility were tested and the results were discussed in detail. Key findings from the study show that 1) metadata features, in general, have a strong effect on perceived credibility, followed by image features. 2) Factors that influence perceived credibility did not remain constant across platforms. Text-based features scored higher on Reddit while the impact of visual features did remain constant.

Future work will apply findings from this experiment to the design of a systematically controlled experiment in order to improve prediction models from real world data such as [8], [9], predicting newsworthiness, credibility, or actions such as retweets, up-votes, or shares.

VII. ACKNOWLEDGMENT

This work was partially supported by the U.S. Army Research Laboratory under Cooperative Agreement No. W911NF-09-2-0053; The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of ARL, NSF, or the U.S. Government. The U.S. Government is authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation here on.

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¹<http://www.tobii.com/>