



Usable News Authentication: How the Presentation and Location of Cryptographic Information Impacts the Usability of Provenance Information and Perceptions of News Articles

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ABSTRACT

Cryptographic tools for authenticating the provenance of web-based information are a promising approach to increasing trust in online news and information. However, making these tools' technical assurances sufficiently usable for news consumers is essential to realizing their potential. We conduct an online study with 160 participants to investigate how the presentation (visual vs. textual) and location (on a news article page or a third-party site) of the provenance information affects news consumers' perception of the content's credibility and trustworthiness, as well as the usability of the tool itself. We find that although the visual presentation of provenance information is more challenging to adopt than its text-based counterpart, this approach leads its users to put more faith in the credibility and trustworthiness of digital news, especially when situated internally to the news article.

CCS CONCEPTS

• **Security and privacy** → **Information-theoretic techniques; Usability in security and privacy; Authentication**; • **Human-centered computing** → **Empirical studies in HCI**; • **General and reference** → *Surveys and overviews*.



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KEYWORDS

Information Credibility, Usability and Human Interaction

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1 INTRODUCTION

Digital news consumption in the United States has steadily risen over the past twenty years, with just over half of US adults accessing news via digital devices at the end of 2020 [12]. Yet despite efforts to combat misinformation in recent years [34, 41, 53, 56], American adults' trust in news publishers and outlets continues to decline [11].

Prior work[22] suggests that adding provenance information to digital news has the potential to increase reader trust. Online news consumers place a high value in the ability to recognize false news, inconsistent news reporting, ghost edits, and improper source attribution. Implementing a provenance tool to detect these negative publishing behaviors and provide validation when publishers refrain from participating in these practices would go a long way toward increasing consumer trust in the content they receive. In this paper, we conduct usability tests of four tools designed to provide consumers with news provenance information, by adapting

the Technology Acceptance Model (TAM) [27] framework as well as web-based information retrieval and evaluation measures [19, 20] to assess users' perception of the following:

- (1) The *credibility* of a digital news article
- (2) Users' *trust* in the information presented
- (3) The *usability* of the provenance tool design

Previous research on authentication systems for digital news has shown the importance of both the presentation of authentication information provided to users—such as fact-checking, bias identification, and provenance authentication tools—as well as how authentication information is conveyed to users [32, 55]. As recent work indicates, cryptographically-verified information about news content is one of the few types of authentication information that may increase trust and credibility across the political spectrum [22]. Our study seeks to evaluate designs for a *usable* system that adds transparency to digital news via cryptographic measures.

Building on recent work, we develop mobile browser interfaces for surfacing cryptographically-authenticated information about a digital news article's original publication date, publishing organization, and its complete version history in an understandable way. Using this system, we explore the decision factors employed by news consumers in their evaluation of news provenance with and without the assistance of provenance tools. By conducting an online usability study using a representative sample of the US population, this study provides insights on the following three research questions:

- RQ1: Does the presentation and/or location of provenance information affect user reports of (a) the credibility of a news article or (b) trust in a news article?
- RQ2: Does the presentation and/or location of provenance information affect user reports of the usability of the provenance tool?
- RQ3: Does the presence of provenance information impact user self-reported trust in a news article?

Our research makes a foundational contribution to a rising area of research on digital provenance tools for news and other online information. We provide fundamental insights into how the presentation (visual v. hash-based) and location (within publisher's site v. on third-party site) of provenance information may influence the credibility and trustworthiness that users assign to that content, which can be used to design future systems. This higher-level understanding of how users perceive and interpret authentication, transparency, and accountability signals on digital content can also be used to inform future work on the credibility and trustworthiness of specific pieces of media and of digital media more generally, as users may begin to interpret not just the presence of provenance indicators, but their *absence* as well. As such, this work provides valuable insight into design and development priorities for secure and trustworthy digital publishing more generally.

To summarize, we make the following contributions related to the way that provenance information impacts users' perceptions of the credibility and trustworthiness of digital news:

- **Contribution 1:** We find a **statistically significant effect** on the perceived *accuracy* of digital news when provenance authentication *fails* and the failure indicator is displayed to users graphically (visual).

- **Contribution 2:** We find **significant interaction effects** between the location (internal/external) and presentation (blockchain/visual) on the perceived *trustworthiness* of digital news when provenance authentication *fails* when the failure indicator is presented graphically (visual) within the article website (internal).
- **Contribution 3:** Our findings highlight the nuanced impact that interactions between the presentation and location of provenance information have on the perceived accuracy and trustworthiness of digital news articles, offering actionable insights to designers of such systems.

2 RELATED WORK

2.1 User Assessment of Digital News Credibility

As news consumers navigate the constantly evolving digital journalistic landscape, the task of distinguishing credible information becomes increasingly complex. Beyond the traditional markers of source reputation, the information's accuracy and transparency contribute significantly to the overall assessment of credibility [1, 2]. The credibility of news sources relies on the users' perception of the source, the content, and the context in which the information is presented [20]. Researchers have extensively explored various aspects of credibility to understand how individuals evaluate and perceive the trustworthiness of information sources [19, 23, 36]. Several studies have delved into the determinants of news credibility, the impact of digital platform design on credibility perceptions, and the effectiveness of credibility indicators in countering misinformation [4, 13, 16, 33, 34].

2.2 Identifying Misinformation in Digital Content

Research has highlighted the importance of designing against misinformation, emphasizing the need for user-centric approaches to counter these inaccuracies. A number of tools and technology-driven measures have been developed to evaluate misinformation in digital content. Current fact-checking labels and provenance tools utilize natural language processing, artificial intelligence, machine learning algorithms, or human expert evaluations to assess the credibility of source, text, and tone of news content [4, 16, 48]. Warning labels/messages or visual indicators are provided to help users assess the accuracy of claims presented in news content. Research exploring the impact of fact-checking warning labels on user perceptions of misinformation reveals a nuanced landscape. Findings show that the effects of fact-checking labels vary depending on the design, framing, exposure frequency, and contextual cues. For instance, [13] assessed general warnings and fact-check tags and found them to reduce users' belief in false stories. At the same time, [48] discovered that warning labels made users perceive stories as less accurate. [45] investigation into warning messages demonstrated that these labels had limited effectiveness in altering user perceptions of news stories, indicating that users may sometimes overlook or disregard such warnings. [40] introduced the concept of the "implied truth effect," revealing that the presence of warning labels on false news stories can inadvertently undermine the perceived accuracy of news without warning labels.

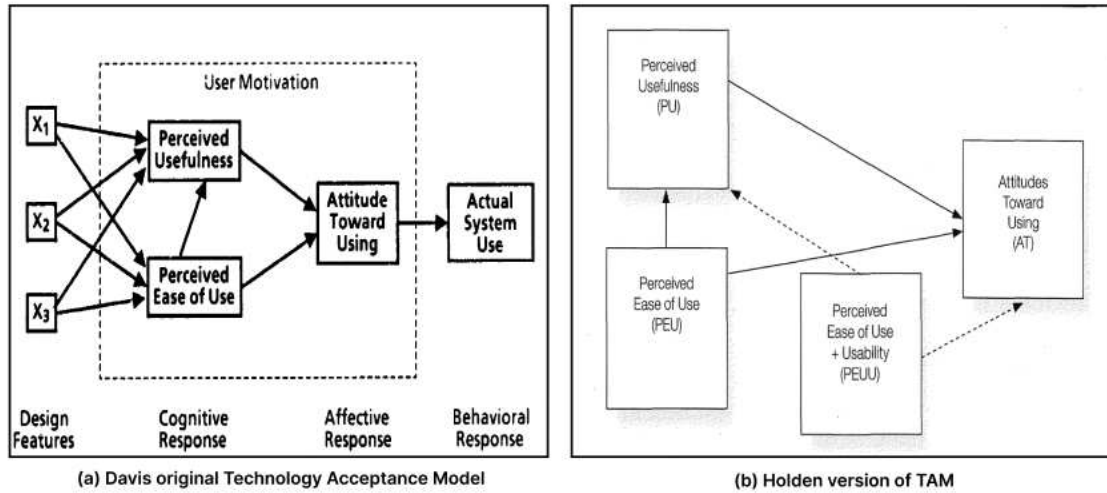


Figure 1: Comparison of the Technology Acceptance Model.

2.3 The Distinction of Provenance Focused Indicators

It's important to emphasize the difference between provenance and authentication. Provenance is the act of verifying the origin of news stories. On the other hand, authentication involves actions like fact-checking to ensure validity. Thus, although the body of existing research pertaining to digital news authentication has grown over recent years, the work pertaining specifically to the provenance of digital information is even more limited. Most recently, in [18] researchers examined the effect of a provenance user interface tool on social media posts. This work brought to light an added risk of introducing provenance tools to digital content: invalid states. Digital tools can still have difficulty producing accurate information at all times, and seeing inaccuracies can likely cause distrust in users. However, the correction or any change of provenance information garnered even more distrust, causing users to be skeptical when the provenance tool is activated with incomplete or invalid information. Conversely, some of the earliest work in news provenance systems dates to 2007 [46]. Researchers worked together to create a system that used artificial intelligence to help trace the source of a news article. After observing the many modifications to news articles that deviated from the original version, the study concluded that such provenance systems were critical to protecting consumers and the many organizations that rely on these sources.

2.4 Cryptographic Implementations of Provenance Indicators

Provenance systems need secure procedures in place to ensure the information being communicated to users is always correct. Our proposed tool designs use blockchain technology on the back end to achieve these assurances. Blockchain is a shared database that uses cryptography to store encrypted blocks of data and chain them together on a peer-to-peer network [5]. Although not commonly considered for use in digital news environments, recent work does suggest implementing blockchain can be beneficial for news consumers if done correctly [21, 42]. The process of verifying

provenance status becomes completely self-contained and can be easily integrated into existing systems. Additionally, it would offer unique transparency guarantees to news consumers.

However, usability is often a challenge when implementing blockchain technology [28]. When novel technology is designed improperly, it can be left unused. Thus, confirming provenance status is just as important as the user's experience interacting with the tool. Therefore, contrary to previous research, our work focuses heavily on the usability of the proposed provenance tools in addition to the effect the tools have on users' perceptions of digital news.

2.5 Measures of Usability in Technology Systems

Introducing provenance tools in digital environments is only helpful to news consumers if they are easy to use. To assess the usability of these systems, the proper measures must be used. The Technology Acceptance Model (TAM) is a widely recognized theoretical framework used to explain and predict how individuals come to accept and use technology systems. Based on the Theory of Reasoned Action (TRA), TAM argues that perceived usefulness and ease of use are two main predictors affecting users' attitudes toward using a technology [14, 15].

Perceived usefulness refers to the degree to which an individual believes the technology will enhance their performance. Perceived ease of use refers to the degree to which an individual believes the technology to be free of physical and mental effort. TAM has been used in numerous studies to understand user behavioral intentions towards various technologies. Over the years, TAM has evolved into various models. For example, Holden et al. extended the model's perceived ease of use factor to include usability measures [27]. The model used in this study adapted measures from Davis and Holden (see Figure 1) to specifically assess the perceived usability and understandability of the design features of our news provenance tools.

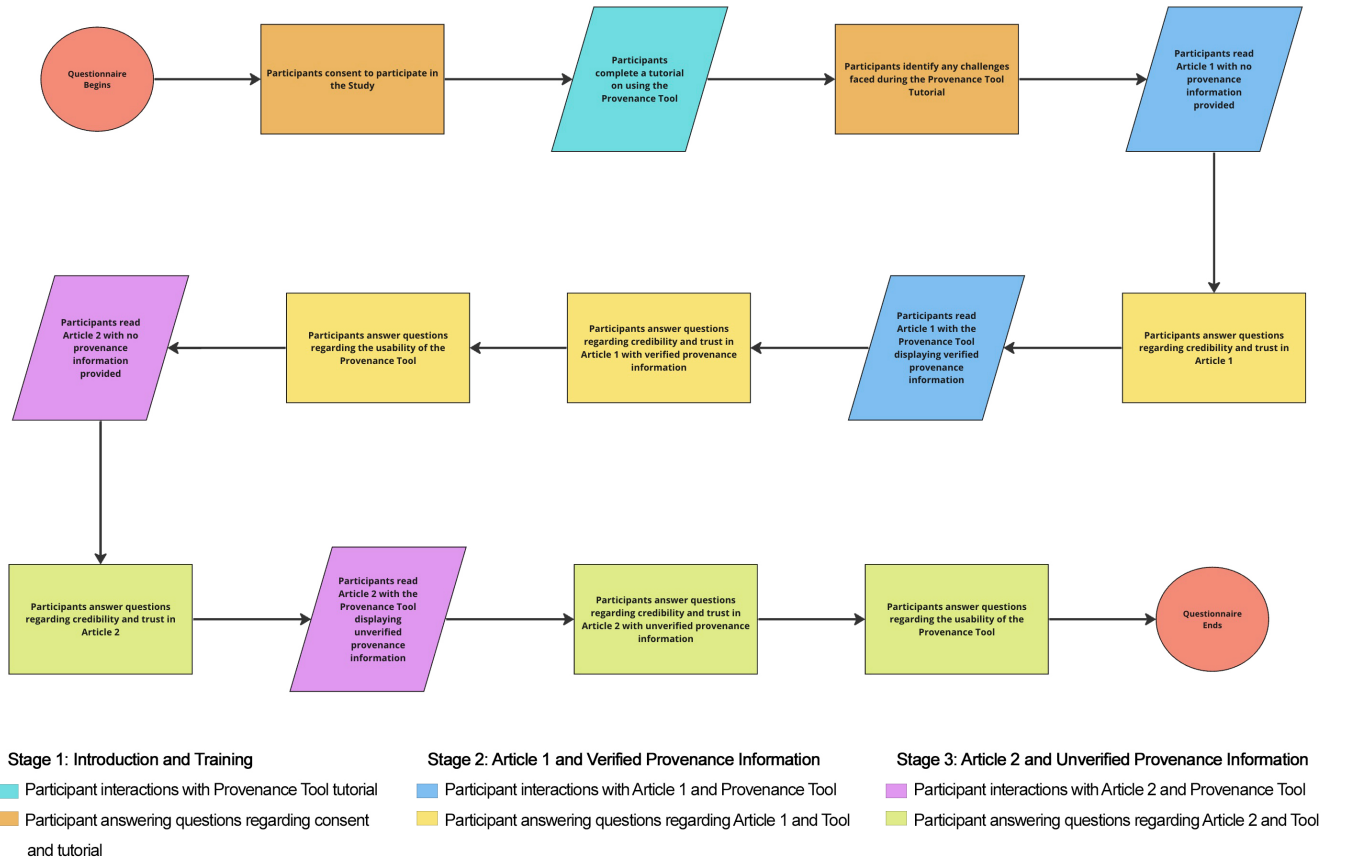


Figure 2: Flowchart illustrating the various steps and actions participants undertook while participating in the study

3 METHOD

Our study is a mixed-factorial experiment. To test RQ1 and RQ2 we use a 2x2 (*location* of provenance information: internal or external; *presentation* of provenance information: visual or “blockchain” hash-based log) between-subjects experiment. We tested the usability of a news provenance tool using each of these four possible location/presentation combinations, and evaluated the impact it had on users’ perceptions of the article’s believability and accuracy. To test RQ3 we also evaluated the impact of within-subjects factors on perceptions of article trustworthiness: the presence of provenance information (present v. absent). We used the Qualtrics survey platform and the Prolific recruitment platform to conduct the study remotely to increase the potential for participation and promote a representative sample. Our university’s institutional review board approved our study.

3.1 Study Procedures

Participants were invited to join the study via Prolific Academic¹, which has been shown to facilitate diverse, high-quality participant

samples [38, 39]. When participants began the study, they were assigned to one of the four between-subjects conditions shown in Table 1 and redirected to a Qualtrics survey. The full survey items are listed in Appendix A. Upon opening the survey, they received information about the study and indicated their consent to participate. During the study, participants engaged in a training session, two control interactions, and two interactions with the assigned news provenance tool, which were Figma prototypes embedded in the Qualtrics survey.

Participants began by completing a training session designed to familiarize them with the style of tasks present in the main experiment and to ensure there were no technical issues with the survey. (Figure 5 in Appendix A shows the training interaction). Next, participants interacted with a control-condition news article (no provenance information shown) on a simulated news website. After answering an attention-check question, they answered questions on the perceived credibility and trustworthiness of the article. Then, participants were presented with the same news article, but were prompted to turn on a news authentication tool extension and interact with the information from the tool while re-reading the same article content that had been presented in the control

¹<https://www.prolific.com/academic-researchers>

Location of Provenance Information	Internal to Publisher Website External to Publisher Website	Presentation of Provenance Information	
		Traditional Blockchain Log	Visual Blockchain Log
	Internal to Publisher Website	Internal Blockchain Tool	Internal Visual Tool
	External to Publisher Website	External Blockchain Tool	External Visual Tool

Table 1: The Four Between-Subjects Experimental Conditions

condition. The tool included the following provenance-related article metadata: publisher, version history, embedded materials, and edit history. After interacting with the article and provenance tool, participants once again answered an attention-check question, questions on the perceived credibility and trustworthiness of the article, and questions on the usability of the tool.

Participants repeated this article-then-article+tool process twice in the survey as depicted in the flow chart in Figure 2. In the first round, they read an article titled “California faces more torrential rain, high winds and flooding” and were shown a tool interface indicating the provenance of all the article metadata was successfully authenticated. In the second round, they read an article titled “Indonesia rattled by 7.6 quake, tsunami warning lifted” and were shown a tool interface indicating all the article metadata failed to be authenticated. Examples of the interfaces for success v. failed verification for each of the four tools can be found in Appendix B.

At the end of the questionnaire, participants were automatically redirected to Prolific where they received a completion code to use to receive compensation. Researchers manually reviewed each submission. Once approved, participants received 8.00 USD paid directly through Prolific. This was Prolific’s suggested compensation for a 40-minute survey, which was the maximum time allotted for the experiment (Average completion time during the pilot study was 26 minutes and 29 seconds). On average, it took participants 23 minutes and 9 seconds to complete the Qualtrics questionnaire. Recruited participants were allowed to begin the questionnaire at any time but were constrained to 40 minutes to complete the exercise once they began.

3.2 Research Materials

The primary research materials for this study are a Qualtrics survey and prototypes for four versions of a news provenance tool.

Development and Quality Checks of Research Materials. We used an iterative design process to construct our Qualtrics questionnaire and news provenance tool designs to ensure the quality of our research instruments. Our initial tool designs drew inspiration from existing research on news consumers’ needs for a news provenance tool (e.g. [22]), and were then revised following several rounds of feedback from user research experts. We also conducted walkthroughs of our questionnaire and prototypes with a lay audience and made additional changes. Finally, we conducted three pilot studies with eight Prolific participants each, in order to assess the clarity and perceived difficulty of the tasks, gauge completion time, and set a fair compensation rate. After each of the first two

pilot studies, minor design updates were made to the news provenance tools to improve user interactions and ensure high-quality data collection. In particular, we standardized the placement of the provenance button in both the blockchain and visual prototypes to be at the top of each article page (Figure 3). We also streamlined the steps necessary to access provenance information in the visual prototype to align with the blockchain prototype.

Qualtrics Questionnaire. The final Qualtrics questionnaire can be found in Appendix A. The survey consists of 64 questions, which vary between Likert Scales and free response text. Questions corresponded with three main categories: measuring perceived credibility of the news article, measuring perceived trustworthiness of the news article, and measuring usability of the prototype tool. All survey questions were created using adapted measures from previous studies (e.g., [19, 20, 27]). Despite the variety of media credibility scales available, they often measure similar fundamental dimensions of credibility. In our study, we employed Flanagin and Metzger’s [19] 5-item scale to evaluate participant’s perceived credibility of the news articles they interact with. This scale aligns with the traditional components commonly found in communication literature; perceived believability, accuracy, trustworthiness, bias, and completeness [29, 30, 50]. Notably, believability and accuracy consistently featured in scales accessing various media credibility, including online news sources [6, 31, 35, 49, 51]. Using both quantitative and free-response questions allowed us to obtain insightful data regarding the usability of the news provenance tools and their impact on users’ perceptions of the credibility and trustworthiness of the articles they interact with.

Provenance Tool Prototypes². Our experiment utilized four news provenance tool designs, the prototypes of which were created using the collaborative design tool Figma. Participants interacted with these prototypes using Figma’s “live preview” feature.

- **External Blockchain.** This tool uses a visual design similar to those typical of cryptocurrency blockchain logs for authentication and hosts the provenance information on a separate page external to the news article (Figure 3(a)).
- **External Visual.** This tool uses visual indicators to communicate cryptographic provenance information to the user; this information is hosted on a separate page external to the news article (Figure 3(b)).
- **Internal Blockchain.** This tool uses a visual design similar to those typical of cryptocurrency blockchain logs for authentication but the provenance information provided is hosted directly on the news article page (Figure 3(c)).

²The full designs for each news provenance tool can be found in Appendix B

- **Internal Visual.** This tool uses visual indicators to communicate cryptographic provenance information to the user and is interfaced directly on the news article page (Figure 3(d)).

News Article Selection. The two news articles participants interacted with were initially sourced from Reuters [3, 52]. Both articles are actual, weather-related events that occurred in early January of 2023. To avoid any affective responses that could impact participants' credibility assessment, we selected news stories that were similar in nature, not political, and which were intended not to interact with participants' direct knowledge or existing beliefs. We chose articles from Reuters rather than a more general interest US news media agency to help minimize the likelihood that participants had prior knowledge of the topic or opinion of the genuine news publisher.

3.3 Measures

For the main 2x2 between-subjects experiment, we test the impact of the location and presentation of provenance information—operationalized through four prototype conditions—on three dependent variables: perceived credibility and trustworthiness of the news article and tool usability.

3.3.1 Independent Variables.

Independent Variables - Between Subjects. The independent variables (IVs), location and presentation of provenance, each have two levels:

- Location of provenance information:
 - **External** - provenance information that must be viewed on a different page than the news article
 - **Internal** - provenance information that can be viewed on the same page as the news article
- Presentation of provenance information:
 - **Blockchain** - provenance information displayed as a traditional blockchain log
 - **Visual** - simplified visual indicators of provenance authentication outcomes

To test the 2x2 design shown in Table 1, four variations of a prototype news provenance tools were created, shown in Figure 3. Each participant was randomly assigned to one of these prototypes.

Independent Variable - Within Subjects. In addition to testing the comparative impact of where and how provenance information is displayed, we also tested the impact of the presence or absence of a provenance tool.

- Presence of provenance tool:
 - **Control Condition - News article with no provenance tool** - Before interacting with the provenance tools, participants were introduced to a control (Figure 4) mobile website titled News Authentication Network (NAN). This control condition does not contain any provenance information about the displayed article and was used to assess whether including provenance information at all impacts the perceptions of trust for the same news article. Users start on the home page where the title of three different news articles along with a picture related to the story or a

short description about the article (Figure 4(a)). After clicking on the top story, users are brought to a secondary page where they can read the article in its entirety (Figure 4(b)).

- **News article with provenance tool** - After interacting with the control version of the article, participants interact with the same article again, using their randomly assigned prototype (one of the four described above).

3.3.2 Dependent Variables - Between and Within. To test the between-subjects RQs (1(a), 1(b), 2) and the within-subjects RQ (3), we used the following dependent variables:

- **Perceived Credibility of the News Article (RQ1a)** - Users' perceptions of the believability and accuracy of the information provided in the news articles; measured using 1) "The information presented in the article was believable" and 2) "...accurate" [5-point Likert scale ranging from Not at all to Extremely] [19]
- **Perceived Trustworthiness of the News Article (RQ1b and RQ3)** - Users' perceptions of the trustworthiness of the news articles; measured using the item "The information presented in the article was trustworthy" [5-point Likert scale ranging from Not at all to Extremely] [19]
- **Usability of the Tool (RQ2)** - How well users can interact with the tool based on measures such as ease of use, flexibility, learnability, and functionality; measured using the 9-item adapted TAM used in [27] [5-point Likert scale ranging from Strongly Disagree to Strongly Agree; Cronbach's $\alpha = 0.94$].

3.4 Data Collection, Recruitment, and Screening

Data collection occurred in the summer of 2023. To ensure we had a representative sample and collected high-quality data, we implemented several strategies throughout each study stage.

Recruitment and Pre-Screening. An a priori power analysis, conducted using G*Power [17], indicated that we needed a minimum sample of 128 participants for a 2x2 between-subjects ANOVA to achieve 80% power for detecting a medium effect ($f = 0.05$) at $p < .05$. To account for data quality issues, we determined that 160 participants was an adequate sample size to test our study hypotheses. All participants were recruited through the online research recruitment platform Prolific. To recruit a sample representative of the US population for our study, we used Prolific's pre-screener settings to stratify participants across gender and race. We used data from the US census [8–10] and Gallup [24, 25] to define the quotas to stratify across race (simplified to majority or minority). Eight prolific studies were created to recruit participants from each gender and race to each news provenance tool prototype using the participants' prerecorded demographic information on Prolific. We used Prolific's new "balanced sample" feature to ensure each study recruited 50% male and 50% female participants. Pre-screeners for "Current Country of Residence", "Age", "Fluent Languages", "Approval Rate", and "Exclude Participants from Previous Studies" were used to ensure that only participants who resided in the U.S. that were over 18, fluent in English, have a study approval rating of 95 percent or higher, and had not participated in any of our previous studies were eligible to participate. This approach helped to ensure a more representative sample without overtly asking questions that could potentially prime participants.

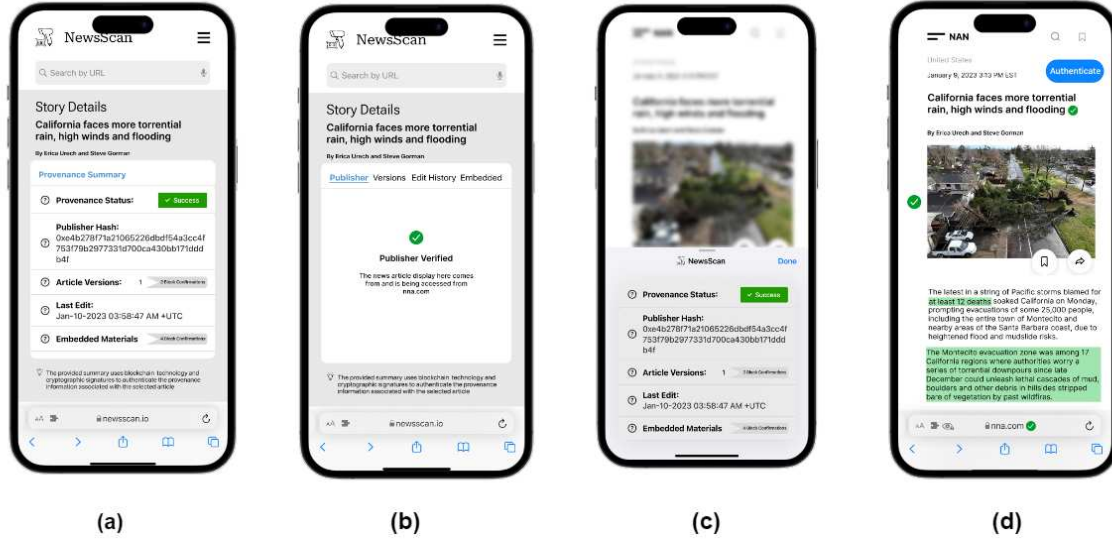


Figure 3: Participants were selected to interface with one of four news provenance tool prototypes: (a) External Blockchain, (b) External Visual, (c) Internal Blockchain, or (d) Internal Visual

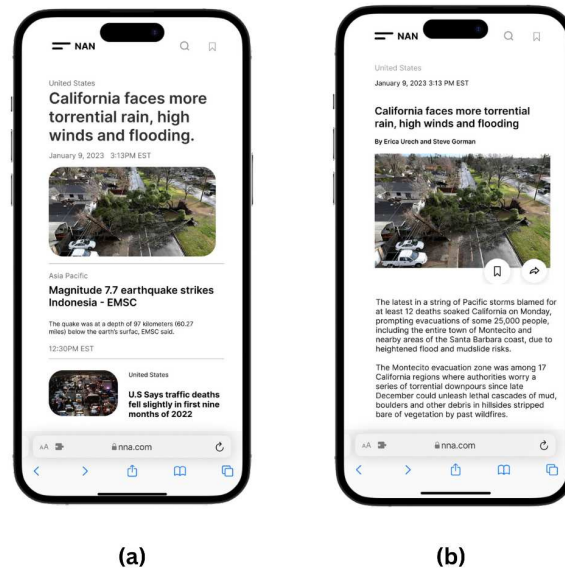


Figure 4: Participants were shown a control prototype before interacting with the provenance tools. (a) shows the home page of the control prototype and (b) displays the full article page.

Quality Checks and Screening During Data Collection. Attention check questions were used throughout the Qualtrics questionnaire to ensure only high-level data was collected. After completing the initial training section, participants were asked if they had successfully completed the activity before continuing. Although

this was not a screen-out question, it allowed us to understand better how many participants successfully completed the training before beginning the study. After the training section, participants had to answer four more attention-check questions throughout the experiment—one after each condition. The first attention check

Participant Demographics			
Characteristics	Number	Percentage	2020 US Census Data
Gender			
Male	77	48.1%	49.1%
Female	83	51.9%	50.9%
Race/Ethnicity			
Asian	9	5.6%	6.0%
Other	7	4.4%	9.8%
Mixed	19	11.9%	10.2%
Black	29	18.1%	12.4%
White	96	60.0%	61.6%
Age			
Under 20	1	0.6%	25.9%
20 - 29	54	33.7%	13.4%
30 - 39	49	30.6%	13.3%
40 - 49	30	18.7%	12.0%
50 - 59	15	9.4%	12.5%
60 - 69	6	3.8%	11.8%
70+	5	3.1%	11.2%

Table 2: The demographics of the 160 survey participants broken down by gender, race/ethnicity, and age.

asked for the title of the previous article; the second asked for the author; the third asked about the location where the article was written; and the final attention check question asked what month the article was written.

3.5 Participant Demographics

We received 171 survey responses from participants; only 160 were included in the final analysis (11 were returned because participants did not meet the survey criteria, or chose to stop the study). Table 2 summarizes the demographic responses from the final sample and shows participants reflect a diverse range of ethnic and racial backgrounds. Additionally, the sample is balanced across male and female participants. Similarly, our participants represented a wide range of ages, with the youngest being 19 and the oldest being 75. Overall, we recruited a diverse, well-balanced sample, which is vital to promoting more inclusive, nuanced findings for human-centered computing research.

3.6 Analytical Approach

We used the R [43] statistical environment, leveraging the `pastecs` [26], `psych` [44], and `ggplot2` [54] packages. Before conducting any analyses, we performed thorough data pre-processing to ensure data quality and integrity, including obtaining descriptive statistics for all variables. To test the impact of the presentation and location of provenance information on perceived credibility and trustworthiness of digital news articles and the usability of provenance tools, we used 2x2 between-subjects ANOVAs with an interaction term and Tukey’s post hoc tests. To test the role the presentation and location of provenance information has on changing trust in digital news articles, we used a series of dependent samples t-tests.

4 RESULTS

In this section, we present the results of both our 2x2 usability study, in which participants interacted with control-condition digital news articles (no provenance information), as well as news articles that contained provenance information located either within news site or a third-party site (internal vs. external), and presented either visually or textually (visual vs. blockchain). We report our findings as they relate to the perceived credibility of and trust in digital news articles and their perceived usability of the provenance tool. We also detail the results of the within-subjects measure change in trust that participants reported with each tool design.

4.1 Perceived Credibility of Digital Articles Displaying Provenance Information

To test RQ1(a), we perform a two-way ANOVA to analyze the effect of the presentation and location of provenance information on user reports of a news article’s credibility, as measured by perceived believability and perceived accuracy. The means and standard deviations for credibility are presented in Table 3.

4.1.1 Perceived Article Believability. The results of the two-way ANOVA revealed no statistically significant interaction between the location and presentation of provenance information with respect to the content’s perceived believability in the “authentication success” condition (that is, when the provenance was authenticated successfully) ($F(1, 156) = 2.07, p = 0.15$). Similarly, there was no statistically significant interaction in the “authentication fail” condition (when provenance information could not be verified) ($F(1, 156) = 3.74, p = 0.06$).

A simple main effects analysis in both the authentication success and fail conditions showed that the presentation of provenance information did not have a statistically significant effect on the article’s perceived believability ($p = 0.28$ and $p = 0.75$, respectively).

DV: Content Credibility RQ1(a)								
Condition (location/presentation)	Believability Authentication Success		Believability Authentication Fail		Accuracy Authentication Success		Accuracy Authentication Fail	
	M	SD	M	SD	M	SD	M	SD
External/Blockchain	4.15	0.88	3.72	1.10	3.97	0.932	3.10	1.14
External/Visual	4.42	0.64	3.42	1.20	4.10	0.78	3.08	1.16
Internal/Blockchain	4.47	0.60	3.75	1.26	4.22	0.86	3.00	1.30
Internal/Visual	4.44	0.55	4.15	0.94	4.17	0.54	3.80	0.98

Table 3: Descriptive Data for RQ1(a)

4.1.2 Perceived Article Accuracy. A two-way ANOVA revealed no statistically significant interaction between the presentation and location of provenance information on perceived accuracy in the authentication success condition ($F(1, 156) = 0.52, p = 0.47$). **In the authentication fail condition, however, there was a statistically significant effect on perceived article accuracy** ($F(1, 156) = 5.23, p < .05$). The Tukey HSD post-hoc test revealed Internal Visual Tools are statistically different from External Blockchain Tools ($p < .05$), External Visual Tools ($p < .05$), and Internal Blockchain Tools ($p < .05$).

Likewise, simple main effects analysis showed that the presentation of provenance information did not have a statistically significant effect on an article's perceived accuracy in the authentication success condition ($p = 0.78$). **In the authentication fail condition, however, the presentation of provenance information had a statistically significant effect on perceived article accuracy** ($p < .05$).

Simple main effects analysis showed that the location of provenance information did not have a statistically significant effect on perceived accuracy in either the authentication success ($p = 0.20$) or the authentication fail ($p = 0.08$) condition.

4.2 Participant Trust in Digital Articles Displaying Provenance Information

To test RQ1(b), a two-way ANOVA was performed to analyze the effect of presentation and location of provenance information on user reports of trust in a news article. The means and standard deviations for trust are presented in Table 4.

A two-way ANOVA revealed that there was not a statistically significant interaction between the effects of presentation and location of provenance information in the authentication success condition ($F(1, 156) = 1.53, p = 0.22$). **However, there was a statistically significant interaction in the authentication fail condition** ($F(1, 156) = 8.99, p < .01$). The Tukey HSD post-hoc test revealed Internal Visual Tools are statistically different from External Blockchain Tools ($p < .05$), External Visual Tools ($p < .01$), and Internal Blockchain Tools ($p < .01$).

Simple main effects analysis showed that the presentation of provenance information did not have a statistically significant effect on trust in either the authentication success ($p = 0.24$) or the authentication fail ($p = 0.06$) conditions.

Simple main effects analysis showed that the location of provenance information did not have a statistically significant effect on trust in the authentication success condition ($p = 0.12$). **In the authentication fail, condition, however, simple main effects analysis showed a statistically significant effect on participant trust in the article content** ($p < .05$).

4.3 Usability of Provenance Tool Designs

To test RQ2, a two-way ANOVA was performed to analyze the effect of the presentation and location of provenance information on user reports of the provenance tool's usability. The means and standard deviations for usability are presented in Table 5.

While a two-way ANOVA indicated a statistically significant interaction between the effects of presentation and location of provenance information on tool usability in the authentication success conditions ($F(1, 156) = 5.09, p < .05$), the Tukey HSD post-hoc test revealed no statistically significant differences. Similarly, although there was a statistically significant interaction in the authentication fail condition ($F(1, 156) = 6.80, p < .05$), the Tukey HSD post-hoc test revealed no statistically significant differences.

Simple main effects analysis showed that the presentation of provenance information did not have a statistically significant effect on usability in either the authentication success ($p = 0.22$) or the authentication fail ($p = 0.78$) condition.

Simple main effects analysis showed that the location of provenance information did not have a statistically significant effect on usability in either the authentication success ($p = 0.39$) or the authentication fail ($p = 0.40$) condition.

4.4 Change in Evaluation of Trust in Digital Articles Displaying Provenance Information

To test RQ3, we ran a series of dependent samples t-tests comparing participants' ratings of the trustworthiness of the control version of the news article to the condition where the tool showed the provenance of news article elements was successfully verified.

For the traditional blockchain versions of the tool, the internal ($t(39) = -2.68, p < .05$, Cohen's $D = -0.42$) resulted in increased perceptions of trust when the article content was authenticated while the external tool ($t(38) = 0, p = 1$, Cohen's $D = 0$) had no influence on perception.

DV: Trust in Content RQ1(b)				
Condition (location/presentation)	Trustworthiness Authentication Success		Trustworthiness Authentication Fail	
	M	SD	M	SD
External/Blockchain	3.90	1.05	3.00	1.24
External/Visual	4.20	0.72	2.78	1.19
Internal/Blockchain	4.25	0.74	2.82	1.39
Internal/Visual	4.24	0.58	3.78	1.15

Table 4: Descriptive Data for RQ1(b)

DV: Usability of Provenance Tool				
Condition (location/presentation)	Usability Authentication Success		Usability Authentication Fail	
	3.55	0.75	3.57	0.77
External/Blockchain	3.99	0.86	3.98	0.92
External/Visual	3.73	0.81	3.82	0.90
Internal/Blockchain	3.60	0.81	3.50	0.97
Internal/Visual	3.55	0.75	3.57	0.77

Table 5: Descriptive Data for RQ2

For the visual blockchain versions of the tool, both the internal ($t(40) = -1.40$, $p = 0.17$, Cohen's $D = -0.22$) and external tool ($t(39) = -2.93$, $p < .01$, Cohen's $D = -0.46$) resulted in increased perceptions of trust when the article content was authenticated.

To explore how the tools could impact perceptions of trust when content could not be verified, we ran a series of dependent samples t -tests comparing participants' ratings of the trustworthiness of the control version of the news article to the condition where the tool showed the provenance of news article elements failed verification.

For the traditional blockchain versions of the tool, both the internal ($t(39) = 4.73$, $p < .001$, Cohen's $D = 0.75$) and external tool ($t(38) = 4.90$, $p < .001$, Cohen's $D = 0.78$) resulted in decreased perceptions of trust when the article content was not authenticated.

For the visual version of the tool, both the internal ($t(40) = 1.90$, $p = 0.06$, Cohen's $D = 0.30$) and external tool ($t(39) = 5.56$, $p < .001$, Cohen's $D = 0.88$) resulted in decreased perceptions of trust when the article content was not authenticated.

5 DISCUSSION

In this section, we discuss the implications of our results for designing provenance tools for online articles and information. Specifically, we examine how the location and presentation of provenance information affects user perceptions of the credibility and trustworthiness of digital content. We also evaluate the usability of the tool. Finally, we explore how including provenance information affects users' trust.

5.1 Presentation of Provenance Information and Perceptions of Credibility

When we examine the influence of presentation of provenance information on users' evaluations of digital news content and provenance tool usability, we find that we only observe one statistically significant effect: when the provenance information cannot be verified. Therefore, although we witness interesting relationships between the presentation of provenance information and elements such as perceived believability and trustworthiness, we cannot know for certain if an effect exists between them. Of particular interest is that while we observed presentation had a statistically significant effect when provenance failed, we did not detect an effect when provenance status was successfully verified. At a high level, these results align with prior work suggesting that trust and distrust are distinct constructs with respect to online information and interactions (e.g. [37, 47]), and that negative indicators reduce trust more than positive indicators enhance it.

Moreover, the effect we could observe shows that Blockchain Tools are less effective in influencing participant's perceptions of a news article's accuracy than their Visual counterparts when provenance status is uncertain. This suggests that customary blockchain-based adoptions of provenance verification cannot perform at the same level as new innovative visual methods mended together with cryptographic approaches to communicating provenance status when the goal is to improve perceptions of digital news accuracy.

This is an important implication for scholars in the field. Most recent works (e.g. [21, 42]) adopts traditional blockchain methods for communicating provenance status. There needs to be a significant shift in future research to adopt and implement more visual based methods for the best chance of improving users' perceptions of the credibility of digital news.

5.2 Presentation of Provenance Information and Perceptions of Credibility and Trust

We only observe two statistically significant effects when we examine the influence of the location of provenance information on users' evaluations of digital news content and provenance tool usability. Once again, both effects occur when the provenance tool cannot provide verified information. Our first key takeaway from the results is that External Tools are less effective than Internal Tools at influencing participants' perceptions of believability. This finding underscores the importance of clearly indicating provenance status and providing relevant context within the information environment. Simply put, users are likelier to believe provenance status updates that appear in the same environment as the story they are reading.

Our second key takeaway from these results is that External Tools play a more minor role in participants' decision to trust digital information than Internal Tools. Users are more likely to trust digital news when provenance information is seamlessly integrated within the same ecosystem rather than relying on external sources for verification. These findings align with prior work suggesting the limited value of third-party seals or assurances in increasing users' trust in websites and information (e.g., [7]). Future designers of these systems must ensure when provenance information is presented to the reader, it is well-integrated and contextually relevant if they hope to positively impact users perceptions regarding the credibility of—and their trust—in digital content.

5.3 Presentation and Location of Provenance Information and Perceptions of Credibility, Trust and Usability

We observe numerous significant effects when we examine the influence of the presentation and the location of provenance information on credibility, trust and usability. Of the four tools, the Internal Visual Tool was the most effective at influencing participant's perceptions of believability, accuracy, and trust in digital news when provenance cannot be verified. These findings also align with prior work in the relative importance of graphic elements and complexity (e.g. [47]) in users' (dis)trust determinations. In the broader context of news authentication, these findings hold important implications. Visual cues that present provenance information on the same page as the news source are extremely influential in shaping users' perceptions. However, although this unique combination of blockchain technology and interactive visual aids can enhance user perceptions of the news article, its effectiveness may vary depending on the content of provenance information. Nevertheless, future strategies must consider adopting this approach for the best chance of helping users to perceive news as authentic and trustworthy.

A closer examination of users perceptions of trust reveals a statistically significant effect on participants perception of trust

after the presentation of provenance information. When the news article's provenance status was successfully verified, users who interacted with the Internal Blockchain and External Visual Tools put significantly more trust in the news article considering the information. However, when the provenance status of the article could not be verified, users of the External Blockchain, Internal Blockchain, and External Visual Tools saw a significant decrease in the amount of trust they placed in the article. This implication presents a challenge for future tool designers. While the Internal Visual Tool has the most influence in participants initial perceptions of trust, it is the Internal Blockchain and External Visual Tools that are the best positioned to incite a change in perception of trust amongst users. Designers will have to choose which measure of trust is the most important when building a provenance tool

Our analysis also reveals a significant interaction between the presentation and location of provenance information on the perceived usability of the tool, both in cases where the data is successfully verified and when it cannot be verified. Interestingly, our post-hoc analysis found no significant differences between conditions. This highlights the nuanced relationship between how provenance information is presented and where it is located, which plays a pivotal role in consumers' evaluation of the tool's usability. Although we cannot say what conditions the effect exists between, examining our descriptive data provides essential information. Users considered the External Visual Tool the most usable when provenance information could and could not be verified. This suggests presenting provenance information using graphical representations in an external visual format enhances user experience. The interactive nature of the External Visual Tool is likely the driving force behind its effectiveness. Rather than just being told the provenance information is verified, users can take action to learn more about what encompasses said verification and learn more on their own accord.

6 LIMITATIONS

The empirical findings presented in this work should be viewed in light of certain limitations. These limitations are discussed here, as well as how they might be remedied in future studies.

6.1 Recruitment and Participant Overlap

An initial limitation of our study was the recruitment process on Prolific. We initially attempted to recruit participants for each experimental condition simultaneously, but this approach introduced the possibility of the same individuals participating in multiple conditions. While we can screen out participants who participated in our past recruitments, we cannot prevent Prolific users from seeing our other live studies upon completing the questionnaire. This means participants could participate in the study multiple times by interfacing with different conditions. Our short-term solution was to recruit participants for each condition one at a time. This way, we could prevent old participants from seeing the new studies we launched and thereby ensure the internal validity of our results. Future research should consider finding a tool that allows for random selection via an online questionnaire, so only one Prolific recruitment needs to be posted and all desired data can still be collected.

6.2 Lack of Screening for Technological Experience and News Consumption Behavior

While our sample successfully represents a diverse range of demographic backgrounds, we did not screen participants for their technological experience or news consumption behavior. Consequently, there is no assurance that our sample accurately represents the average news consumer. Variations in participants' familiarity with technology and their news consumption habits may impact their interactions with the news interface and subsequent feedback. This also limits our ability to generalize our findings to the broader population of "typical" news consumers. Future research should incorporate a screening process considering participants' technological proficiency and news consumption habits. This will ensure the desired demographic of news consumers and a sample representative of the US population is recruited.

6.3 Confines of the Figma Prototyping Tool

Our use of Figma to develop and evaluate the interactive news interface introduced another limitation. Figma's "Live Feature" functionality exhibited divergent behaviors across different web browsers. For instance, it may operate smoothly in Safari but experienced responsiveness issues in Google Chrome. Additionally, variables such as participants' web browser cookies also had the potential to affect their experience on Figma. As participants were free to choose their preferred web browsers during the study, the browser-dependent performance discrepancies may have influenced the user experience and potentially skewed the results. Future studies can explore cross-browser compatibility testing or utilize web-based tools and frameworks that ensure consistent performance across major browsers. Additionally, providing participants with guidelines or recommendations for browser usage may help standardize their experiences and minimize browser-related variability.

All participants in our study were required to follow predetermined paths within the Figma mockup to understand the application's key features. This approach may have influenced participants' perceptions of the tool's efficiency and effectiveness. It could also have limited the ability to assess how easily users could learn to use the device, as they received a guided walkthrough of the Figma prototype. To address this limitation, future researchers can employ a mixed-methods approach. In addition to guided walkthroughs, researchers can incorporate open exploration sessions, allowing participants to interact with the prototype freely. This would provide a more comprehensive usability assessment, encompassing initial learning and task efficiency. Furthermore, validated usability assessment methods and surveys can help capture participants' perceptions accurately while controlling for potential biases introduced by guided paths.

7 CONCLUSION

This work provides valuable insights into the impact of the presentation and location of provenance information on user perceptions of credibility and trust in digital news, in addition to the usability of provenance tools. First and foremost, we learn that the introduction of cryptographic provenance tools in digital news environments

is warmly welcomed by consumers. Using visual cues to highlight provenance information as users interact with online news strongly impacts their perceptions of the content they read. This finding highlights the importance of implementing an intuitive, user friendly-design that takes advantage of visual prompts to communicate provenance information. Additionally, users stand to see the most benefit from provenance tools when the veracity of the news in front of them is in question. Specifically, internal tools, i.e., those situated in the same ecosystem as the digital news article, do an excellent job of engaging with the news consumer. These tools encourage the user to carefully consider the credibility and trustworthiness of the article before continuing to read. Ultimately, future adoption of an internal visual provenance tool design is recommended.

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A STUDY MATERIALS

Note: The study measures (all items and response options) are listed below in the order they appeared in the online survey.

Informed Consent:

RESEARCH STUDY KEY INFORMATION

[Anonymized] is inviting you to volunteer for a research study. The HATLab is a research group at Clemson University.

Study Purpose: The purpose of this research is to gain insight into how users evaluate the design and effectiveness of mobile news provenance tools in order to inform future development of effective user interfaces for conveying the meaning of the cryptographic assurances our publishing framework provides.

Voluntary Consent: Participation is voluntary, and the only alternative is to not participate. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.

Activities and Procedures: Your part in the study will be to participate in a research experiment using a Qualtrics questionnaire.

Participation Time: The experiment should take you approximately 40 minutes to complete

Risks and Discomforts: The only risks that you may face are those that you face in assessing the effectiveness of the design of mobile news provenance tools.

Possible Benefits: You may benefit from the shared expertise of the researchers, who have specialties in user interface design, cryptography and digital publishing. Moreover, you - as a consumer of online news - may benefit from the custom design of a system that will help increase the credibility of news products and provide a higher-level understanding of the authentication, transparency and accountability of shared information. There is also monetary compensation for participating in and completing our research study.

Incentives: For your time, you will receive a \$8 reward upon completion of the experiment.

Exclusion/Inclusion Requirements: If you choose to participate in this study, you would be expected to engage in study tasks. Participants should be 18 years or older, currently reside in the United States, and must get news from the internet through a smartphone, computer, or tablet.

Protection of Privacy and Confidentiality: The results of this study may be published in scientific journals, professional publications, or educational presentations. Identifiable information collected during the study will be removed and the de-identified information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from the participants or legally authorized representative.

Contact Information: If you have any questions or concerns about your rights in this research study, please contact [anonymized]. [anonymized] will not be able to answer some study-specific questions. However, you may contact [anonymized] if the research staff cannot be reached or if you wish to speak with someone other than the research staff. If you have any study-related questions or if any problems arise, please contact [anonymized].

By clicking the "I consent" button below, you acknowledge: Your participation in the study is voluntary. You get news from the internet through a smartphone, computer, or tablet. You are 18 years of age or older. You currently reside in the United States. You are aware that you may choose to terminate your participation at any time for any reason. You have read the information written above. [I consent, begin the study; I do not consent, I do not wish to participate]

Prolific ID: Please enter your Prolific ID: _____

Figma Training Introduction: Please complete the brief tutorial using the interface below:

Figma Training Follow Up: After completing the task, please select one of the following options: [I've completed the task, I could not figure out how to complete the task, I experienced technical difficulties]

Article 1 Overview: *This prompt pertains to the interface below.*

It's another beautiful day, and you are interested in learning what is new and exciting in the world!

You take out your mobile device and open The NewsAuth News Network (NANN) website on your mobile browser to catch up on the latest world news. Upon entering the webpage, you are greeted by three of the most popular articles of the day and ultimately decide to read the first article on the webpage titled, "California faces more torrential rain, high winds and flooding"

Please continue to the bottom of the page to read the article. After reading the article, please move on to answer the questions on the next page.

Attention Check What was the title of the previous article? [California faces more torrential rain, high winds and flooding, Portion of I-95 in Philadelphia collapses after vehicle engulfed by fire, US East Coast blanketed in veil of smoke from Canadian fires, Controlled burn and downed power line sparked Colorado's costliest wildfire, New England to have enough power for this summer, operator says]

Call to Action 1: Please indicate your level of agreement with the following statements:

Perceived Impact on Belief The information presented in the article was believable [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Accuracy The information presented in the article was accurate [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Trust The information presented in the article was trustworthy [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Bias The information presented in the article was biased [5-point Likert scale ranging from Not at all to

Please complete the brief tutorial using the interface below:

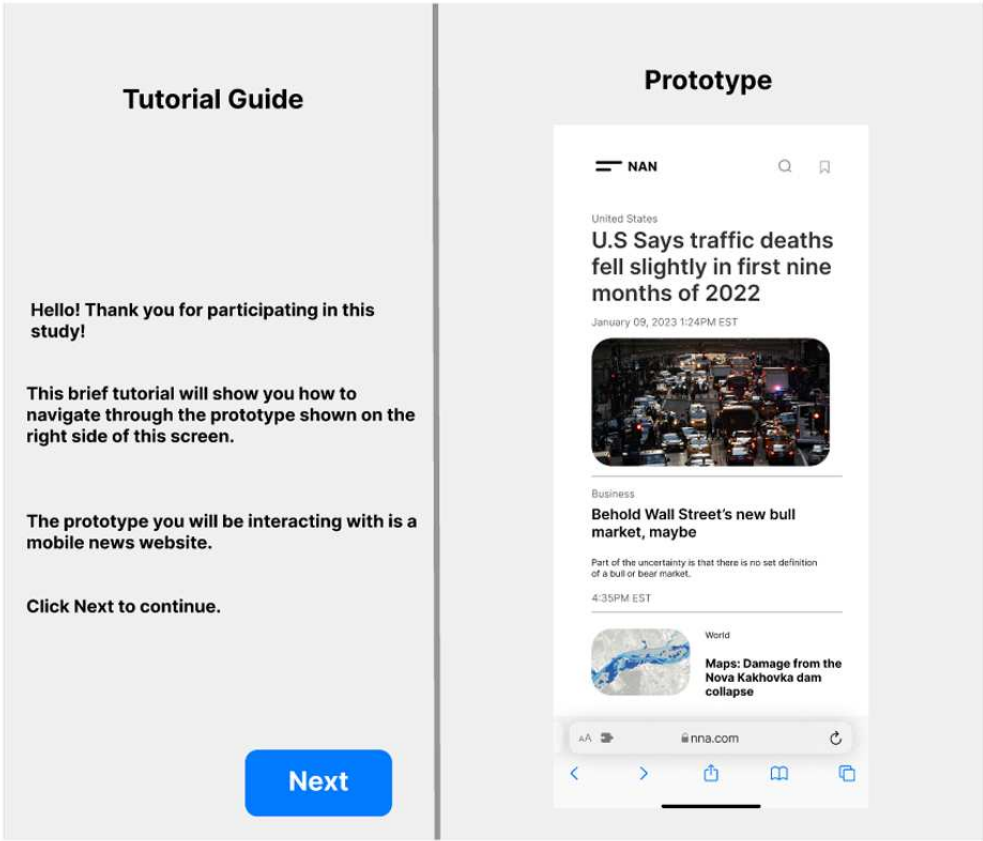


Figure 5: A screenshot of the training interaction from the survey.

Extremely]

Perceived Impact on Completeness The information presented in the article was complete [5-point Likert scale ranging from Not at all to Extremely]

Article 1 Provenance Introduction *This prompt pertains to the interface below.*
One day has passed since you last visited the NANN webpage. Once again you take out your mobile device and sign onto the website, but this time the page you are greeted with an exciting advertisement! This ad promotes a state of the art news authentication tool that you can add to your mobile device as a web extension. Eager to test

out the tool, you download the web extension and in a matter of seconds your page updates and the tool is ready to be used! You decide to revisit the article you read yesterday, "California faces more torrential rain, high winds and flooding," but this time you have the added guidance of the news authentication tool. Please continue to the bottom of the page to turn on the authentication tool then read the article. After reading the article, please move on to answer the questions on the next page.

Attention Check Who was the author of the previous article? [Erica Urech and Steve Gorman, Jarrett Renshaw, Tyler Clifford, Keith Coffman, Christina Anagnostopoulos]

Call to Action 2 Please indicate your level of agreement with the following statements:

Perceived Impact on Belief The information presented in the article was believable [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Accuracy The information presented in the article was accurate [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Trust The information presented in the article was trustworthy [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Bias The information presented in the article was biased [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Completeness The information presented in the article was complete [5-point Likert scale ranging from Not at all to Extremely]

Assessment of the Challenge in Tool Usage Overall how challenging was it to use the news provenance tool? [5-point Likert scale ranging from Not at all to Extremely]

Call to Action 3 Please indicate your level of disagreement or agreement with the following statements:

Assessment of the Frequency of Tool Usage I think I would use the tool frequently [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Complexity of Tool Usage I found the tool unnecessarily complex [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Tool's Integration of Functions I found the various functions of the tool was well integrated [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Tool's Ease of Use I thought the tool was easy to use [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Confidence in Tool Usage I felt very confident using the tool [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Learning Effort Complexity of the Tool I needed to learn a lot of things before I could get going with this tool [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Mental Effort Demand of the Tool Interacting with the tool does not require a lot of my mental effort

[5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Functionality of Tool I found it easy to get the tool to do what I wanted it to do [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Flexibility of the Tool I found the tool to be flexible to interact with [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Features of the Tool The tool has good functionality (features) [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Understandability of the Tool Overall, how understandable was the tool? [5-point Likert scale ranging from Not at all to Extremely]

Call to Action 4 Please indicate your level of disagreement or agreement with the following statements:

Assessment of Clarity in Tool Usage My interaction with the technology is clear and understandable [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Learnability of the Tool Learning how to perform tasks using the technology was easy [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Intuitiveness of the Tool Please indicate your level of disagreement or agreement with the following statement: I feel I have an intuitive sense on how to operate the technology. [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Recall in Tool Usage I find it easy to remember how to perform tasks using the technology [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Article 2 Overview: *This prompt pertains to the interface below.*
It is yet another great day, and you are ready to see what is the latest and greatest happenings of the world!
You take out your mobile device and open The NewsAuth News Network (NANN) website on your mobile browser to catch up on current events around the globe. Upon entering the webpage, you are greeted by three of the most popular articles of the day and ultimately decide to read the first article on the webpage titled, "Indonesia rattled by 7.6 quake, tsunami warning lifted"
Please continue to the bottom of the page to read the article. After reading the article, please move on to answer the questions on the next page.

Attention Check What was the location of the previous article? [Indonesia, California, Colorado, India, Canada]

Call to Action 5 Please indicate your level of agreement with the following statements:

Perceived Impact on Belief The information presented in the article was believable [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Accuracy The information presented in the article was accurate [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Trust The information presented in the article was trustworthy [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Bias The information presented in the article was biased [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Completeness The information presented in the article was complete [5-point Likert scale ranging from Not at all to Extremely]

Article 2 Provenance Introduction *This prompt pertains to the interface below.*

One day has passed since you last visited the NANN webpage. Once again you take out your mobile device and sign onto the website, but this time the page you are greeted with an exciting advertisement! This ad promotes a state of the art news authentication tool that you can add to your mobile device as a web extension. Eager to test out the tool, you download the web extension and in a matter of seconds your page updates and the tool is ready to be used!

You decide to revisit the article you read yesterday, "Indonesia rattled by 7.6 quake, tsunami warning lifted," but this time you have the added guidance of the news authentication tool.

Please continue to the bottom of the page to turn on the authentication tool then read the article. After reading the article, please move on to answer the questions on the next page.

Attention Check What month was the article written in? [January, June, March, May, July]

Call to Action 6 Please indicate your level of agreement with the following statements:

Perceived Impact on Belief The information presented in the article was believable [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Accuracy The information presented in the article was accurate [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Trust The information presented in the article was trustworthy [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Bias The information presented in the article was biased [5-point Likert scale ranging from Not at all to Extremely]

Perceived Impact on Completeness The information presented in the article was complete [5-point Likert scale ranging from Not at all to Extremely]

Assessment of the Challenge in Tool Usage Overall how challenging was it to use the news provenance tool? [5-point Likert scale ranging from Not at all to Extremely]

Call to Action 7 Please indicate your level of disagreement or agreement with the following statements:

Assessment of the Frequency of Tool Usage I think I would use the tool frequently [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Complexity of Tool Usage I found the tool unnecessarily complex [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Tool's Integration of Functions I found the various functions of the tool was well integrated [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Tool's Ease of Use I thought the tool was easy to use [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Confidence in Tool Usage I felt very confident using the tool [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Learning Effort Complexity of the Tool I needed to learn a lot of things before I could get going with this tool [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Mental Effort Demand of the Tool Interacting with the tool does not require a lot of my mental effort [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Functionality of Tool I found it easy to get the tool to do what I wanted it to do [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Flexibility of the Tool I found the tool to be flexible to interact with [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of the Features of the Tool The tool has good functionality (features) [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Disagree to Strongly Agree]

Assessment of the Understandability of the Tool Overall, how understandable was the tool? [5-point Likert scale ranging from Not at all to Extremely]

Call to Action 8 Please indicate your level of disagreement or agreement with the following statements:

Assessment of Clarity in Tool Usage My interaction with the technology is clear and understandable [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Learnability of the Tool Learning how to perform tasks using the technology was easy [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Intuitiveness of the Tool Please indicate your level of disagreement or agreement with the following statement: I

feel I have an intuitive sense on how to operate the technology. [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Assessment of Recall in Tool Usage I find it easy to remember how to perform tasks using the technology [5-point Likert scale ranging from Strongly Disagree to Strongly Agree]

Positive Feedback of the Tool What features of the tool did you appreciate the most? Why?

Negative Feedback of the Tool What features of the tool do you think could be improved? Why?

Miscellaneous Feedback Is there any other feedback you would like to provide at this time?

B FULL TOOL DESIGNS

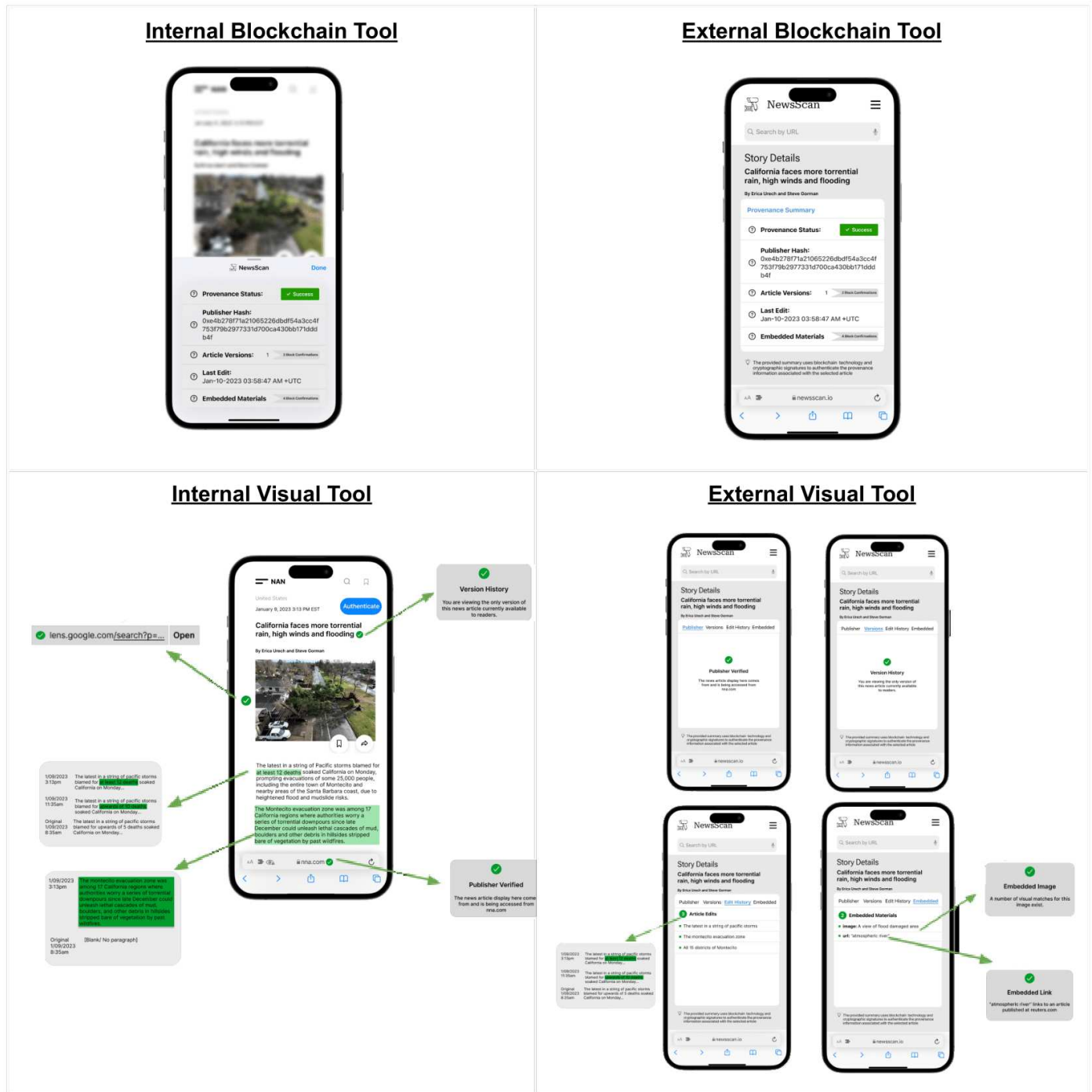


Figure 6: Comparison of all four provenance tool prototypes when information is successfully verified

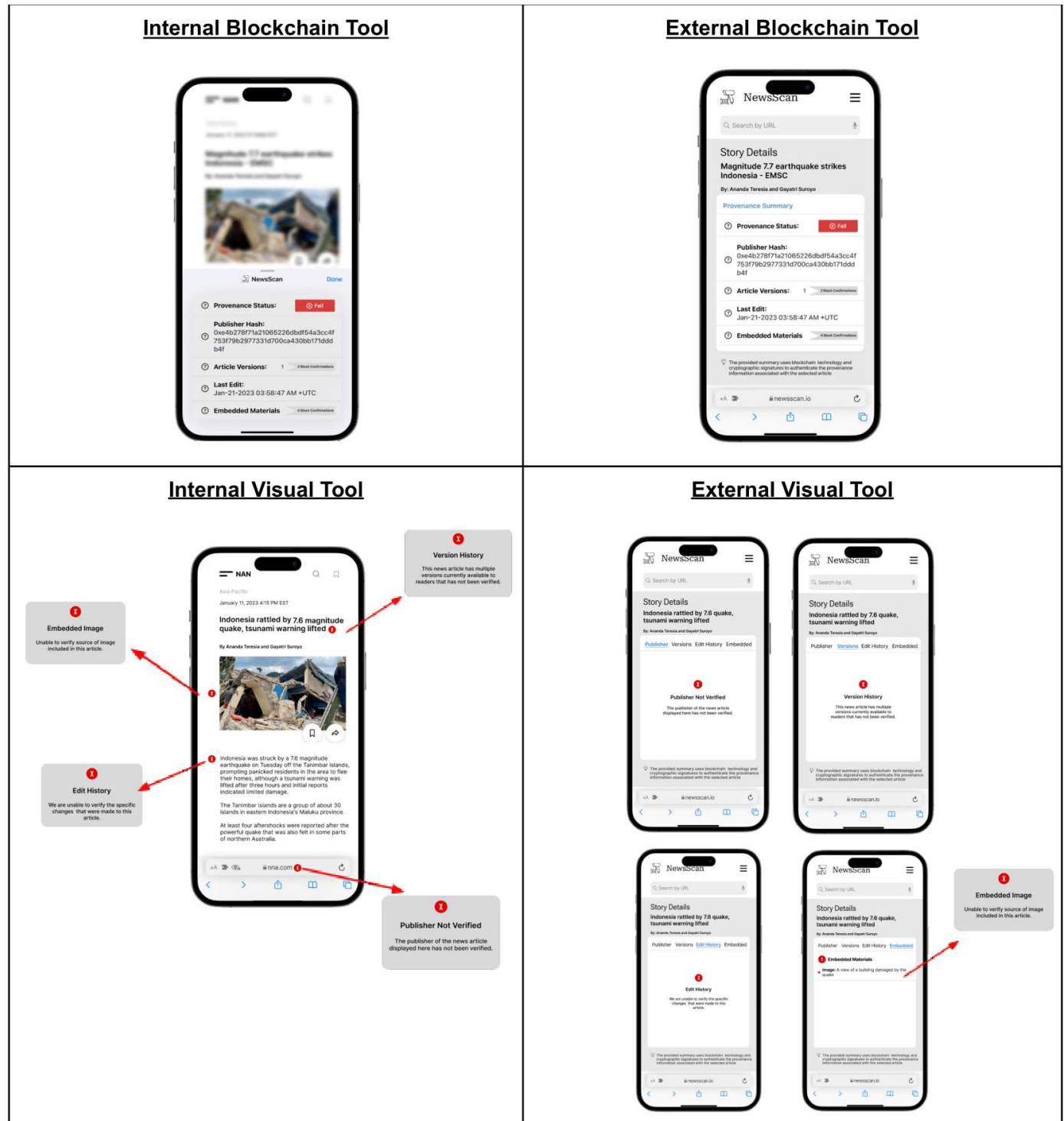


Figure 7: Comparison of all four provenance tool prototypes when information verification failed