Knowledge Calibration for Science News: The Effects of Headlines and Full News Articles on Subjective Knowledge

Thesis

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By,

Timothy Salathiel O'Neil

Graduate Program in Communication

The Ohio State University

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Thesis Committee:

Jason Coronel, Advisor

Hillary Shulman

Abstract

Americans are increasingly exposed to information about science and technology in the news. These news stories are often presented with a brief headline that can be clicked to access a full-length article that provides a more detailed examination of the topic. Previous findings show a roughly even split between the number of people who read only headlines and full articles. This study examines the extent to which people report subjective knowledge after reading either (1) only headlines or (2) full-length articles about science issues, as well as the relationship between subjective knowledge and objective knowledge. Results showed that people feel more knowledgeable after reading full-length articles and a positive relationship between subjective and objective knowledge. These findings imply that people can accurately assess their knowledge for complex, unfamiliar topics.

Dedicated to mom, dad, and Mirranda.

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Vita

May 2017 …… B.A. Psychology, Wittenberg University

August 2018 to July 2020 ……... Researcher, Alion Science and Technology

August 2018 to July 2020 ……... Research Assistant, Human Neuroscience Lab, Wright State University

August 2020 to present ……... Graduate Teaching Associate, School of Communication, The Ohio State University

May 2021 to August 2021 ……..... Summer ORISE Research Intern, Centers for Disease Control and Prevention

Field of Study

Major Field: Communication

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Chapter 1: Introduction

The internet has made news increasingly accessible to Americans. Smartphones, news apps, and social media have made it possible for us to learn about the latest breakthroughs in science and technology within seconds. A recent survey from Pew Research found that 86% of U.S. adults get news from a smartphone, computer, or tablet (Shearer, 2021). Information about complex topics related to science (e.g., climate change, nontechnology, vaccines) is abundant online in the form of news articles, often shared on social media (Hitlin & Olmstead, 2018). An important feature of this online environment is that these articles appear only in the form of a headline, commonly as a link that can be clicked to access the entire article.

Complex scientific findings often cannot be summarized in the single sentence form of headlines, making reading an entire article necessary for comprehension, as they provide a more detailed examination of the topics. However, there is evidence that many people only read headlines, even for articles they share. Gabielkov et al. (2016) found that only 59% of links shared on Twitter had been clicked by the users who shared them. Though news content on social networking sites such as Facebook, Twitter, and YouTube can be personalized through algorithmic filtering based on user interests, Lee and Kim (2017) found that encountering news on social media depends less on individual interests and more on the structure of the online environment. Even though users with high news interest are especially likely to encounter the news online, all users are still likely to encounter news while using social networking sites.

If most people are exposed to headlines about science and technology online, and many users do not read the full articles that accompany them, it is important to examine how reading headlines differs from reading full articles and if these differences have an impact on knowledge about science. Headlines are defined here as the top-level headers on a full article that summarize

the article's content. Headlines are generally meant to highlight the main point of the article, letting readers decide if they want to continue reading the entire article. Therefore, a crucial difference between headlines and articles is length. It is important to establish that articles are not simply repeating information from the headlines without adding anything new. Headlines are specifically written to exclude some information from the articles they accompany (Gu et al., 2020). Therefore, articles about science and technology will contain more information than their headline counterparts and provide a fuller, more detailed account of the issues.

The paper will be organized as follows: first, I will review the current literature on subjective knowledge. Then, I will discuss competing predictions for how news presentation may influence subjective knowledge. This will be followed by an explanation of the methods used in the study. Finally, I will discuss the results and broader implications of this study, in addition to potential future directions.

Chapter 2: Literature Review

One consequence of only reading headlines about the same topic is that it may increase subjective knowledge, or a person's sense of how much they know about a topic, without accompanying gains in factual knowledge. This knowledge discrepancy has been found to influence decisions such as purchases (Aertens et al., 2011), where subjective knowledge better predicted outcomes than objective knowledge. Furthermore, subjective knowledge has been shown to influence attitudes about policies including foreign policy, taxes, healthcare, and climate change (Fernbach et al., 2013) and expression of minority opinions on political and social issues (Rios et al., 2018) even when objective knowledge is low. In these contexts, it is problematic for subjective knowledge to strongly influence behavior in the absence of objective knowledge, as it could lead to a decline in the quality around the public discourse for these topics.

Though reading multiple headlines has been shown to increase subjective knowledge without increasing objective knowledge (Shafer, 2020), the effects of reading multiple full body text articles (articles that contain both the headline and news story; hereafter referred to as a "full article") is not known. According to Gabielkov et al. (2016), an estimated 49% of people read full articles, not much lower than the segment of the population that only reads headlines. Indeed, I propose competing predictions on how reading full articles on the same science issue will influence people's subjective knowledge on the science issue. One theoretical view, which I refer to as the *accurate estimation account* (Ackerman et al., 2002; Gignac & Zajenkowski, 2020), suggests that reading full articles will increase subjective knowledge on the issue, relative to headlines. In contrast, a different theoretical view, which I refer to as an *under-estimation*

account (Winkielman et al., 1998), suggests that reading full articles on an issue will decrease subjective knowledge on the issue, relative to headlines.

Distinguishing between these possibilities is important due to the distinct implications suggested by each account. Both predictions assume that objective knowledge will be greater for people who have read full articles about the topics. If the effect of reading full articles on subjective science knowledge aligns with the prediction of the accurate estimation account, an implication of this finding is that an information environment that involves exposure to longer, more in-depth information in the form of articles can help people accurately report their knowledge about science. These individuals would possess levels of subjective knowledge that predict engagement as well as appropriate objective knowledge to better inform discussions about science.

If the effect of exposure to full articles on subjective science knowledge aligns with the prediction of the under-estimation account, an implication of this finding is that an informational environment that only provides brief, incomplete summaries of scientific findings better facilitates subjective knowledge than one that provides more detailed information. Here, less knowledgeable individuals are potentially leading discourse around scientific issues, while more knowledgeable individuals feel poorly equipped to discuss and engage with science.

Hypotheses

My proposed study will test the following competing hypotheses:

Prediction of the accurate-estimation account

H1a: Individuals who read full articles will possess greater subjective knowledge than those who only read headlines about the same topics.

Why should reading articles increase subjective knowledge relative to headlines? Ideally, the more information people read about an issue, the more informed they should feel. In this context, people will likely read about multiple aspects of a given science issue and become exposed to several viewpoints (Oskamp, 1965). Two aspects of increased information may result in higher subjective knowledge: effort and redundancy.

One way that reading articles could increase subjective knowledge is by inducing effort. If people perceive reading full articles about scientific topics to be an effortful experience, they may feel more knowledgeable about the issues (Chaiken et al., 1989; Paese & Sniezek, 1991; Shaw & Zerr, 2003) due to self-perception processes. Bem's (1967, 1972) theory of self-perception posits that people infer their beliefs and attitudes by observing their own behavior, especially when internal cues are weak or ambiguous. Here, people may infer that by expending extra effort to read and understand articles about complex scientific issues, they are more knowledgeable about them. Internal cues to signal knowledge should be weaker for unfamiliar and complex topics related to science because people will be unaware of contextual information and instead look to their perceived effort as a cue for knowledge.

More information may also increase subjective knowledge through redundancy. Though reading more information will expose people to more aspects of the issues, some information will be repeated. Tsai et al. (2008) found that more information increased subjective knowledge, theorizing that people may perceive each new piece of information as valid individually, even if that information is redundant or irrelevant. This has been demonstrated in decision making contexts, where people prefer more information even if the added information does not benefit their knowledge or ability to make relevant decisions (Bastardi & Shafir, 1998; Schwartz, 2004). More information cues feelings of expertise that allow people to feel more confident in their

domain-specific knowledge (Heath & Tversky, 1991). Here, more information about a complex scientific topic will serve as a cue for subjective knowledge such that it is higher compared to when less information is available, in the form of a headline.

The knowledge structures created by the increased depth of information should allow people to make appropriate calibrations of their knowledge when they have read entire articles (Chandler, 1994). There may be a limit to how willing people are to indicate high levels of subjective knowledge based on reading headlines alone. This limit could be overcome by the increased information present in full articles, resulting in higher subjective knowledge for those who read many articles in their entirety.

Prediction of the under-estimation account

H1b: Individuals who read headlines about scientific topics will possess greater subjective knowledge than those who read full articles about the same topics.

Why would reading headlines alone increase subjective knowledge compared to reading full articles? This phenomenon may be due to fluency brought on by the reduced amount of information people are required to take in. Fluency is the subjective experience of ease with which information is processed. Fluency can be either perceptual or conceptual. Factors that can increase perceptual fluency include readability and auditory clarity. Conceptual fluency relates to how easily the semantic meaning of a message or stimulus is understood.

Fluency is generally understood to be a positive experience (Winkielman et al., 2003) that increases confidence in one's memory (Winkielman et al., 1998). Therefore, reading headlines should increase conceptual fluency for scientific issues, as they provide a positive experience by simulating the availability of appropriate knowledge structures needed to

understand the issues (Ramachandran & Hirstein, 1999). This positive experience may consequently influence people's judgments related to their knowledge of these issues.

According to the feelings-as-information theory (Schwarz, 2012), people attend to their feelings and metacognitive experiences as a source of information, which they use like any other information. Feelings-as-information theory asserts that these metacognitive experiences emerge as information sources due to naïve theories people hold about their own thoughts and knowledge. Here, fluency serves as a metacognitive cue for how well people have learned information. Consequently, people may mistake the fluency that comes with reading headlines about a topic with for their own personal knowledge about the topic. This is supported by findings suggesting that subjective experiences of fluency do not always line up with objective knowledge (Kornell & Bjork, 2008; Koriat, 1993).

It is worthwhile to address the role of content in fluent or disfluent experiences. If scientific topics are unfamiliar or complex, they may create disfluent experiences regardless of the amount of information presented. Previous findings demonstrate that subjective fluency experiences serve as a source of information that is distinct from the content itself (Schwarz, 1998). Knowledge assessments have been impacted by fluency manipulations when content is held constant (Stepper & Strack, 1993), and when content and fluency experiences suggest different conclusions, findings show a greater reliance on fluency cues (Schwarz et al., 1991; Winkielman et al., 1998). Therefore, it is reasonable to assume that, holding content constant (e.g., scientific topics) and manipulating fluency via amount of information, differences in subjective knowledge are due to fluency rather than content effects.

People may feel that learning about a new topic was easy, leading them to overestimate their knowledge. Conversely, if people have a disfluent experience while learning about a new

topic, they may underestimate their knowledge on that topic. Winkielman et al. (1998) found that a disfluent experience impacted knowledge judgments such that people who had recalled more information were less confident in their knowledge than people who had a fluent experience and recalled less information. This suggests that fluency is a powerful cue for assessing knowledge and may distinguish between how knowledgeable people feel after reading headlines compared to articles. The hypotheses presented in this study address the competing predictions of the under-estimation and accurate-estimation accounts by testing subjective knowledge after reading full articles or headlines.

Prediction for objective knowledge

H2: Individuals who read full articles about scientific topics will possess greater objective knowledge than those who only read headlines about the same topics.

This hypothesis is important to test because it demonstrates that people who have read multiple full articles do have a better objective understanding of these topics that holds up under knowledge testing. Through exposure to different full articles, people should accumulate knowledge of the topic over time that cannot be achieved through the superficial information provided in headlines (Borer, 2007).

This finding is also important because it clarifies whether people who have read multiple full articles or only headlines are more accurately calibrating their knowledge. One possibility is that the more information people read, the more they will learn, and feel they have learned, about the issues. This possibility is supported by Sundblad et al. (2009), who found that groups of people were able to accurately report their factual knowledge of climate change based on the amount of information they had learned about it. Another possibility is that the fluent experience of reading short headlines led people to believe they know more than they do. Carpenter et al.

(2013) found that a fluent classroom experience increased perceptions of learning without increasing actual learning. Testing objective knowledge in comparison to subjective knowledge provides support for either the accurate-estimation or under-estimation account.

Chapter 3: Methods

Participants

A total of 157 participants were recruited from a large midwestern public university in the United States. Each participant was compensated with course credit in return for taking part in the study. Seven participants were excluded for finishing the study under 5 minutes, a cut-off determined to signal a lack of proper attention to the stimuli. Once these participants were excluded, I analyzed data from the remaining 150 participants. Sixty-seven percent of participants were female, and thirty-three percent were male. The sample had a mean age of 20.50 years (M = 20.50, SD = 3.94, range = 18 – 54).

Materials

The stimuli for the study consisted of 32 news items, including 16 headlines and 16 full articles. The topics discussed in the news items are biochar, the Orca, thorium, and ocean alkalinity enhancement. These issues were selected because they have not been widely discussed in mainstream news and were unfamiliar to most participants during pilot testing, reducing the potential influence of prior knowledge about these topics. This assumption was validated by asking participants at the end of the study how familiar they were with these topics prior to participation in the study. Participants were asked about their prior familiarity with the issues presented in the stimuli on a scale of 1 (*very familiar*) to 6 (*very unfamiliar*) to establish baseline knowledge of the science issues presented in the study. Familiarity with biochar (M = 5.35, SD = 1.28), orca (M = 5.27, SD = 1.29), ocean alkalinity enhancement (M = 5.41, SD = 1.05), and thorium (M = 5.28, SD = 1.17) were low, establishing that participants were not already familiar with these issues prior to their participation in the study.

See Table 1 for example stimuli from the headline and full article conditions.

Procedure

To test my hypotheses, I used a between-subjects experimental research design. My independent variable was news item type (headline vs. full article) and my dependent variable was subjective knowledge. News item type was manipulated between subjects to avoid the potential for participants to compare their reported knowledge between the headline and article conditions. Participants came into the lab and completed the survey in-person.

First, participants read 8 total news items, either headlines or full articles. There were two news item type conditions. In the first condition, participants read 8 total headlines. In the second condition, participants read 8 total full articles, including the headlines given in the headline condition. Participants were able to control how much time they spent reading each headline or article. Two of the four science topics (biochar, orca, thorium, ocean alkalinity enhancement) were randomly selected for presentation. For example, participants may see four headlines about biochar and four about ocean alkalinity enhancement. Throughout these conditions, news item type was consistent. For example, participants would not see four headlines about thorium and four full articles about biochar. Articles were written to be consistent in their suitability for a general audience to eliminate confounding effects of jargon or difficulty between articles. Each article was submitted to an online text analysis software program to determine general audience suitability. All articles received a suitability score of 90 to 95 on a scale of 0 to 100.

After reading the 8 news items, participants reported their level of knowledge for each issue based on a four item scale: *I could describe what [issue] is to someone who has never heard of it*, *I know enough about [issue] to feel pretty confident when speaking about it*, *I do not feel very knowledgeable about [issue]* (reverse scored), and *I know enough about [issue] to be*

able to understand future articles about it. This scale is adapted from a scale of subjective knowledge by Flynn and Goldsmith (1999), which showed high internal consistency (0.93), test-retest reliability after a four-week period (0.79), and appropriate validity. The wording of the items was adjusted to match the construct of interest (scientific issues). Items related to comparing participants' knowledge to the knowledge of others were removed due to feedback from pilot testing that suggested these questions induced demand characteristics. Participants will answer these four items on a 7-point, Likert-type scale from 0 (*strongly disagree*) to 7 (*strongly agree*). Subjective knowledge was measured based on the average response to these questions.

Next, participants answered objective knowledge questions about the articles from the news items they viewed. Each question was true or false. True or false questions were used to obtain quick assessment of knowledge for the content in the articles, rather than open-ended questions to assess knowledge of brief articles. The multiple-true-false format has been demonstrated to assess mastery and thought processes more accurately than multiple-choice questions (Couch, Hubbard, & Brassil, 2018; Brassil & Couch, 2019).

Participants answered 16 objective knowledge questions, two for each of the 8 news items. One of the two questions could be known from reading only the headline, but the other question was based on information that could only be known by reading the entire article in an attempt to mirror the real-life consequences of skipping articles in lieu of headlines: crucial information for understanding the topic is lost. Here, objective knowledge was measured by simply tallying the number of correct answers. Directly under each objective knowledge question, participants reported their confidence in each answer from a scale of 1 (*very unsure*) to 4 (*very sure*). This objective knowledge test also served as a manipulation check to determine if

participants who were presented with entire articles actually read them. Lastly, participants provided demographic information, including interest in science, age, gender, race, education, and income.

Table 1

Example news items for scientific topics by condition

Headline condition	Headline plus full article condition
Leading scientist claims biochar's potential to solve climate change may be exaggerated, despite its ability to create energy and improve soil.	Leading scientist claims biochar's potential to solve climate change may be exaggerated, despite its ability to create energy and improve soil. Dr. Roger Goodman, Associate Professor of Environmental Science at University of San Francisco has spent his career developing sustainable climate solutions. He has seen various green technologies fail over the years, leading to a healthy sense of skepticism. The latest potential answer to climate woes? Biochar. Biochar is a type of charcoal, different from what you might find on a grill. This organic material is cooked through a process which uses high temperatures and low oxygen levels to create charcoal. Biochar facilitates a lot of fungi and bacteria by providing a home for soil organisms, nutrients, water, and air. Some scientists have compared this environment to that of a coral reef. The process of creating biochar has gained much attention for its potential to solve problems related to climate change. Some companies use the excess heat from this process to dry wood for timber. Here, the trees capture the carbon, and the biochar stores it, capitalizing on the capture, stabilize, and store method. Many in science and industry believe this could be a huge step towards solving climate change. Also, companies that create biochar could employ hundreds of people, creating green jobs. Dr. Goodman, however, has taken a more cautious approach to biochar. His message is firm, but simple: biochar is helpful, but will not completely solve the climate crisis. "It's only part of a set of solutions required to create a truly sustainable environment," Dr. Goodman stated. "It's crucial to make sure our message to the public is truly supported by science. Otherwise, people may become disappointed and discouraged." He believes that it is more important now than ever to communicate realistic expectations about climate solutions to the public. "People want quick and easy solutions, but there is no one simple solution when it comes to solving this complex problem," he said in a recent interview. Other scientists find Dr. Goodman's take to be overly pessimistic. Dr. Francis Beeman, Professor of Agricultural and Biological Engineering at Purdue University stated, "People should get excited about the potential impact of biochar on our climate. When we find opportunities to improve the situation, it's a cause for celebration. Biochar won't solve our problems overnight, but the science supports moving forward with it in a big way." Studies have consistently shown that biochar can create energy, store carbon, and improve soil. This has generally been seen as a net-win among scientists who study climate related issues. With every new technology comes a trade-off. Though there is some debate over how big a role biochar will play in improving our climate, there is a lot of support surrounding its use. It's important not to hype biochar beyond its capabilities, but if used wisely, it can make an impact.

Chapter 4: Analytic Strategy

To distinguish between the competing predictions of H1a (Individuals who read full articles will possess greater subjective knowledge than those who only read headlines about the same topics) and H1b (Individuals who read headlines will possess greater subjective knowledge than those who read full articles about the same topics), I conducted a series of independent sample t-tests. The independent variable in my analyses was the news item type (headline vs. article) and the dependent variable was subjective knowledge. I used an independent samples t-test to examine differences between the average subjective knowledge for those who read headlines compared to those who read full articles.

A result consistent with H1a would be a finding that subjective knowledge is higher on average for those who read full articles than those who read only headlines. A result consistent with H1b would be a finding that subjective knowledge is higher on average for those who read only headlines than those who read full articles.

I tested H2 (Individuals who read full articles will possess greater objective knowledge than those who only read headlines about the same topics), with an independent samples t-test, where news item type (headline vs. article) is the independent variable and objective knowledge is the dependent variable. I used an independent samples t-test to compare objective knowledge for both the headline and article condition. A result consistent with H2 would be a finding that objective knowledge is higher on average for those who read entire full articles than it is for those who only read headlines.

Chapter 5: Results

Results supported the accurate-estimation account (H1a): people who read full articles in addition to headlines reported higher levels of subjective knowledge ($M = 4.59$, $SD = 0.99$) than people who only read headlines ($M = 3.52$, $SD = 1.03$), $t(148) = -6.49$, $p < .001$, $d = -1.06$. These results are visually depicted in Figure 1. This finding held up when broken down by issue (all ps $< .001$). Overall, people felt significantly more knowledgeable about science and technology issues when they read entire articles compared to people who read only headlines, thus support was not provided for H1b (the under-estimation account).

There was also support for H2: objective knowledge was higher for participants who read full articles in addition to headlines ($M = 11.32$, $SD = 2.66$) than those who only read headlines ($M = 10.41$, $SD = 2.30$), $t(148) = -2.23$, $p = .03$, $d = -.37$. People who read entire articles generally performed better on an objective knowledge test on these issues. Beyond providing support for H2, this also serves as evidence that participants assigned to the article condition were likely reading the entire articles presented to them.

Exploratory Analyses

In addition to the confirmatory analyses above, it is worthwhile to explore differences in reported subjective knowledge based on individual characteristics to inform future research directions. There was some tendency for males ($M = 3.79$, $SD = 0.72$) to report higher subjective knowledge than females ($M = 3.37$, $SD = 1.12$) in the headline condition. Both groups reported increased knowledge in the article condition, and there was no significant interaction between gender and condition. This may simply reflect a tendency for males to report higher subjective knowledge than females, due to confidence. This assumption can be supported by the result that

males (M = 2.92, SD = .50) reported higher confidence in their objective knowledge answers than females (M = 2.69, SD = .60), $t(146) = 2.30$, $p = .01$, $d = .40$, despite the fact that males' objective knowledge scores (M = 11.33, SD = 2.66) were similar to females' objective knowledge scores (M = 10.65, SD = 2.46), $t(146) = 1.54$, $p = .13$, $d = .27$.

It is also worthwhile to determine which factors influence objective knowledge. Objective knowledge scores were best predicted by condition ($\beta = .91$, $p = .03$, $R^2 = .03$) and interest in science and technology ($\beta = .61$, $p = .001$, $R^2 = .07$). Predictably, being in the full article condition resulted in increased objective knowledge compared to being in the headline condition. This is likely because participants were getting more information from the articles to answer the objective knowledge questions correctly. More interestingly, interest in science and technology resulted in increased objective knowledge scores. This may be due to participants with higher interest in science paying more attention to the news items, leading to better recall of information in the objective knowledge test.

There was a moderate, but highly significant positive relationship between subjective knowledge and objective knowledge, $r = .24$, $p = .003$, see Figure 2. In addition to the finding that both subjective and objective knowledge were higher for those who read entire articles, this correlation provides support for the claim that people can fairly accurately report how knowledgeable they are on issues related to science and technology. There was also a moderate positive correlation between objective knowledge and confidence in objective knowledge answers, $r = .36$, $p < .001$, supporting that people are accurately reporting their knowledge.

Furthermore, it is worthwhile to determine whether the correlation between subjective and objective knowledge remains significant for each condition. In the article condition, there is still a slightly moderate positive correlation between subjective and objective knowledge, $r = .22$,

$p = .06$. This relationship does not hold up in the headline condition, where there is a weaker, non-significant positive correlation between subjective and objective knowledge, $r = .14$, $p = .23$. This suggests that people are less adept at gauging their level of knowledge when they have only read headlines about issues related to science and technology. This may be due to the high performance of males on the objective knowledge test in the headline condition, though gender is not a statistically significant predictor of subjective knowledge when objective knowledge is controlled ($\beta = -.354$, $p = .19$).

A multiple linear regression model determined that condition ($\beta = .51$, $p < .001$), interest in science and technology ($\beta = .20$, $p = .005$), education level ($\beta = .29$, $p < .001$), and age ($\beta = -.15$, $p = .04$) all significantly predicted reported subjective knowledge, $R^2 = .33$. People who read full articles, were more interested in science and technology, were more highly educated, and were younger tended to report higher subjective knowledge.

It is possible that people who are more interested in science feel more confident in their knowledge when learning about new scientific topics. Highly educated people may also feel more confident, as they are more likely to have experience learning about new topics and having their knowledge formally tested. Finally, there may be a tendency for younger people to feel more confident in their knowledge about these topics as they are related to environmental or technological issues that younger participants may have more exposure to than older participants. It is important to note that this sample was relatively homogenous in terms of age ($M = 20.5$, $SD = 3.94$) and education ($M = 2.99$, $SD = 0.89$). A more diverse sample may better shed light on the strength of these relationships.

Chapter 6: Discussion

The goal of this study was to examine whether people feel more knowledgeable about science and technology issues when they read entire articles or only headlines and to determine whether there was a relationship between objective knowledge and subjective knowledge. The main finding of this study is that people feel more knowledgeable about science and technology issues when they have read entire articles than when they only read headlines. Also, there is a positive relationship between how much people know and how much they think they know about these issues after reading either type of news item.

Implications

The main finding of this study supporting the accurate-estimation account implies that exposure to longer, more in-depth information about science better facilitates both actual and perceived knowledge. Here, people can report their knowledge of science issues well based on the information they've been provided and are not over-confident. Subjective knowledge is predictive of engagement with and willingness to discuss science. An implication of our finding is that people who are more informed about these issues will also be the most likely to engage with and discuss science, ideally facilitating more accurate, informed discussions around scientific topics. Additionally, these findings imply that longer news articles can provide fluent experiences, potentially by inducing effort and providing redundant information. Future studies may test this mechanism directly in the context of science communication.

Limitations

Our findings may not be generalized to science topics that people are already familiar with. One strength of the study design is that people were mostly unfamiliar with the given

topics, eliminating a confound of prior knowledge. It would be beneficial to understand how prior knowledge or exposure may serve as a moderator in this context. For instance, people may have been exposed to topics like nanotechnology or CRISP-R in the news, making them more likely to report greater subjective knowledge after reading a few headlines about them. It is still possible that their objective knowledge would be low under testing, the opposite of the results from this study. Future studies should examine the moderating role of prior knowledge using both familiar and unfamiliar science issues.

Another limitation of this study is that the only explicit manipulation between news item conditions is the amount of information provided. In reality, there may be other features of full-lengths articles that could cause a disfluent experience for readers. For example, articles about science may contain a high amount of jargon or outline complex scientific findings. The articles used for this study were written such that jargon was controlled for to isolate the effect of length on reports of subjective knowledge. In everyday life, people are likely to encounter jargon in public science communication. Furthermore, jargon has been shown to disrupt processing fluency even when definitions for jargon terms are provided (Shulman et al., 2020). Future studies may directly examine the influence jargon has on subjective and objective knowledge in this context.

Future Directions

This study prioritized external validity by writing headlines and articles that attempt to mirror news items people could encounter in their daily lives. More controlled lab experiments may be able to disentangle features of news items that may influence subjective knowledge without adding the noise present in this manipulation. Though the stimuli in this study were written to control for as many factors as possible between headlines and articles (e.g., length,

jargon), some may have been more entertaining, informative, or interesting, as they varied in content and approach. Future studies could isolate specific features of the articles, such as jargon. This could be done by having participants read the exact same article, with a few jargon words in one version and the jargon words replaced with more colloquial terms. Similar studies could manipulate length or other characteristics of interest.

Conclusions

This research suggests that people can accurately report how much they know about scientific topics after being exposed to them in the news. The extent to which this is true may vary based on prior familiarity with the topics and other features of the news items. Future research should examine how these contextual factors influence both subjective and objective knowledge in the domain of science communication.

References

Ackerman, P. L., Beier, M. E., & Bowen, K. R. (2002). What we really know about our abilities and our knowledge. *Personality and Individual Differences, 33,* 587-605.

Baldiga, K. (2014). Gender differences in willingness to guess. *Management Science, 60*(2), 434-448.

Bastardi, A. & Shafir, E. (1998). On the pursuit of useless information. *Journal of Personality and Social Psychology, 75*(1), 19-32.

Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review, 74*, 183-200.

Bem, D. J. (1972). Self-perception theory. In L. Berkowitz (Ed.) *Advances in experimental social psychology* (Vol. 6, pp. 1-62). New York: Academic Press.

Borer, L. (2007). Depth of processing in private and social speech: Its role in the retention of word knowledge by adult EAP learners. *The Canadian Modern Language Review, 64*(2), 273-299.

Brassil, C. E. & Couch, B. A. (2019). Multiple-true-false questions reveal more thoroughly the complexity of student thinking than multiple-choice questions: A Bayesian item response model comparison. *International Journal of STEM Education, 6*(16), 1-17.

Carpenter, S. K., Wilford, M. M., Kornell, N., & Mullaney, K. M. (2013). Appearances can be deceiving Instructor fluency increases perceptions of learning without increasing actual learning. *Psychonomic Bulletin & Review, 20*, 1350-1356.

Chandler, C. C. (1994). Studying related pictures can reduce accuracy, but increase confidence, in a modified recognition test. *Memory & Cognition, 22*, 273-280.

Chaiken, S., Liberman, A., & Eagly, A. H. (1989). Heuristic and systematic information processing within and beyond the persuasion context. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 212-252). New York: Guilford.

Couch, B. A., Hubbard, J. K. & Brassil, C. E. (2018). Multiple-true-false questions reveal the limits of the multiple-choice format for detecting students with incomplete understandings. *BioScience, 68*(6) 455-463.

Fernbach, P. M., Rogers, T., Fox, C. R., & Sloman, S. A. (2013). Political extremism is supported by an illusion of understanding. *Psychological Science, 24*(6), 939–946. https://doi.org/10.1177/0956797612464058.

Flynn, L. R. & Goldsmith, R. E. (1999). A short, reliable measure of subjective knowledge. *Journal of Business Research, 46*, 57-66.

Gabielkov, M., Ramachandran, A., Chaintreau, A., & Legout, A. (2016). Social clicks: What and who gets read on Twitter? *Proceedings of the 2016 ACM SIGMETRICS International Conference on Measurement and Modeling of Computer Science*. doi:10.1145/2896377.2901462

Gignac, G. E. & Zajenkowski, M. (2020). The Dunning-Kruger effect is (mostly) a statistical artifact: Valid approaches to testing the hypothesis with individual differences data. *Intelligence, 80*, 1-9.

Gu, X., Liu, J., Yu, C., Mao, Y., Yu, H., Finnie, D., Zukoski, N., Han, J., Wu, Y., & Zhai, J. (2020). Generating representative headlines for news stories. In *Proceedings of The Web Conference 2020*, April 20-24, 2020, Taipei, ACM, New York, NY.

Heath, C., & Tversky, A. (1991). Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty, 4*(1), 5-28.

Hitlin, P. & Olmstead, K. (2018, March 21). The science people see on social media. https://www.pewresearch.org/science/2018/03/21/the-science-people-see-on-social-media/

Koriat, A. (1993). How do we know that we know? The accessibility model of the feeling of knowing. *Psychological Review, 100*(4), 609.

Kornell, N., & Bjork, R. A. (2008). Learning concepts and categories is spacing the "enemy of induction?" *Psychological Science, 19*(6), 585-592.

Kruger, J. & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134.

Lee, J. K., & Kim, E. (2017). Incidental exposure to news: Predictors in the social media setting and effects on information gain online. Computers in Human Behavior, 75, 1008–1015.

Oskamp, S. (1965). Overconfidence in case-study judgments. *Journal of Consulting Psychology, 29*, 261–265.

Paese, P. W., & Sniezek, J. A. (1991). Influence on the appropriateness of confidence in judgment: Practice, effort, information, and decision-making. *Organizational Behavior and Human Decision Processes, 48*, 100-130.

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science, 9*, 1, 45-48.

Rios, K., Goldberg, M. H., & Totton, R. R. (2018). An informational influence perspective on (non)conformity: Perceived Knowledgeability increases expression of minority opinions. *Communication Research, 2*(45), 241–260. https://doi.org/10.1177/ 0093650217699935.

Schwartz, B. (2004). *The paradox of choice: Why more is less*. New York: Harper Collins.

Schwarz, N., Bless, H., Strack, F., Klumpp, G., Rittenauer-Schatka, H., & Simons, A. (1991). Ease of retrieval as information: Another look at the availability heuristic. *Journal of Personality and Social Psychology, 61*, 195-202.

Schwarz, N. (1998). Accessible content and accessibility experiences: The interplay of declarative and experiential information in judgment. *Personality and Social Psychology Review, 2*(2), 87-99.

Shafer, S. (2020). Illusion of knowledge through Facebook news? Effects of snack news in a news feed on perceived knowledge, attitude strength, and willingness for discussions. *Computers in Human Behavior, 103*, 1-12.

Shaw, J. S., & Zerr, T. K. (2003). Extra effort during memory retrieval may be associated with increases in eyewitness confidence. *Law and Human Behavior, 27*(3), 315-329.

Shearer, E. (2021, January 12). *More than eight-in-ten Americans get news from digital devices*. Pew Research Center. https://www.pewresearch.org/fact-tank/2021/01/12/more-than-eight-in-ten-americans-get-news-from-digital-devices/

Shulman, H. C., Dixon, G. N., Bullock, O. M., & Colón Amill, D. (2020). The effects of jargon on processing fluency, self-perceptions, and scientific engagement. *Journal of Language and Social Psychology, 39*, 1-19.

Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology, 64*, 211-220.

Sundblad, E., Biel, A., & Garling, T. (2009). Knowledge and confidence in knowledge about climate change among experts, journalists, politicians, and laypersons. *Environment and Behavior, 41*(2), 281-302.

Tsai, C. I., Klayman, J., & Hastie, R. (2008). Effects of amount of information on judgment accuracy and confidence. *Organizational Behavior and Human Decision Processes, 107*, 97-105.

Winkielman, P., Schwarz, N., & Belli, R. F. (1998). The role of ease of retrieval and attribution in memory judgments: Judging your memory as worse despite recalling more events. *Psychological Science, 9*, 46-48.

Appendix A: Figures

Figure 1

Subjective Knowledge between Headline Condition and Article Condition

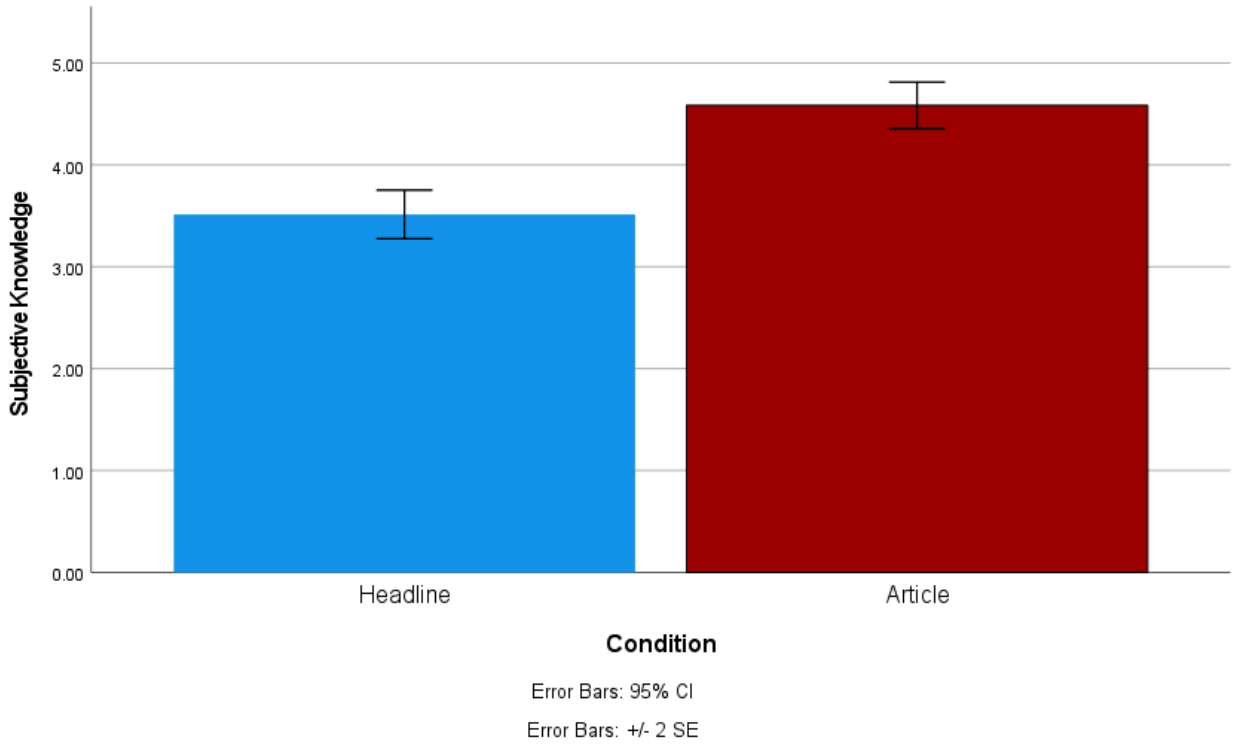
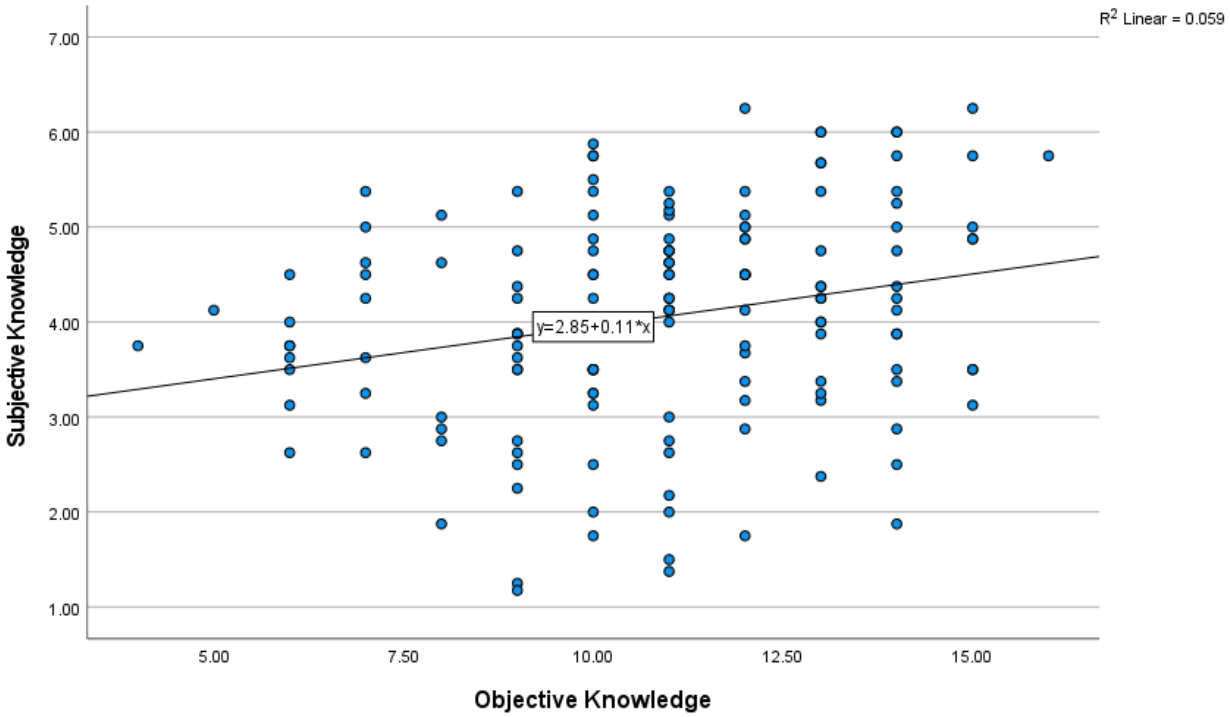


Figure 2

Positive Correlation between Subjective Knowledge and Objective Knowledge



Appendix B: Scales and Measures

Subjective Knowledge Scale: Responses are on a 7-point Likert-type scale and range from "strongly disagree" to "strongly agree."

Instructions: "You will now be asked about the issues from the news items. You will indicate how much you agree or disagree with each statement. Please keep in mind that there are no "right" or "wrong" answers in this task."

1. I could describe what (biochar/orca/thorium/ocean alkalinity enhancement) is to someone who has never heard of it.
2. I know enough about (biochar/orca/thorium/ocean alkalinity enhancement) to feel pretty confident when speaking about it.
3. I do **not** feel very knowledgeable about (biochar/orca/thorium/ocean alkalinity enhancement).
4. I know enough about (biochar/orca/thorium/ocean alkalinity enhancement) to be able to understand future articles about it.

Confidence Scale: Responses are on a 4-point Likert-type scale and range from "very unsure" to "very sure." This question was asked after each objective knowledge question.

1. How confident are you in your answer?

Familiarity Scale: Responses are on a 6-point Likert-type scale and range from "very familiar" to "very unfamiliar." This question was asked after completing the objective knowledge questions and prior to demographic questions.

1. Prior to taking part in the study, how familiar were you with (biochar/orca/thorium/ocean alkalinity enhancement)?

Science and Technology Interest: Responses are on a 5-point Likert-type scale and range from "not at all interested" to "very interested." This question was asked as part of the demographic questionnaire at the end of the study.

1. How interested are you in science and technology?