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Abstract

Exposure to Inconsistent message has been demonstrated as a useful method to alleviate belief in false rumor. However, the data from previous research included unexplained variation in response to inconsistent message. Existing research also included the possibility that participants skipped out on reading and therefore they were not exposed to a message. We used an eye tracker to eliminate the possibility. Eye tracking data revealed that participants not only did not skip but they paid more visual attention to inconsistent messages comparing with consistent messages. Despite the overall effectiveness of inconsistent message, some responses showed continued belief in rumors even after the exposure. Eye-tracking analyses demonstrated that when participants had positive pre-belief for a rumor, more visual attention to inconsistent message predicted strengthened the belief. We discuss when exposure to inconsistent message does not work well as a way for harnessing belief in false rumor.

Keywords: rumor; belief change; eye tracking; social media

Introduction

The recent exponential growth of social media, such as Twitter and Facebook, has been affecting how rumors spread. Once a rumor is posted on social media, it can be shared widely in a very short time. In this sense, social media can be a salient rumor mill. Additionally, while prior eras included the spread of rumors by word of mouth, online rumors never go away completely online. Accumulation of rumors can increase the risk of misunderstanding, miscommunication, and potential social problems.

Several researchers have provided definitions for rumors. One popular definition is, "public communications that are infused with private hypotheses about how the world works" (Rosnow, 1991). Although other definitions emphasize aspects that include circulation in contexts of ambiguity, danger, or potential threat (e.g., DiFonzo & Bordia, 2007), we should not ignore the risk of spreading rumors within normal everyday interactions. As misinformation, propaganda, and "fake news" are diffused every day under the semblance of rumors, the risk for rumor belief should be acknowledged more broadly.

How we handle rumors in the digital age? Past studies have demonstrated that exposure to inconsistent messages, including denial, rebuttal, and criticism, was effective to mitigate belief in various types of rumors, such as an alleged misdemeanor (Koller, 1993), organizational rumors (DiFonzo & Bordia, 2000), disaster related rumors (Tanaka, Sakamoto, & Matsuka, 2013), ill effects of smoking (Iyer & Debevec, 1991), and a computer virus (Bordia, DiFonzo, Haines, & Chaseling, 2005). Bordia et al. (2000) revealed that exposure to a denial message mitigated belief in a rumor. In reality, recent studies have reported that while many people spread rumors through social media, others try to stop the spread of false rumors by posting inconsistent messages(Mendoza & Poblete, 2010; Starbird et al., 2016).

Despite the overall effectiveness of inconsistent message exposure, previous studies have shown the variation in the effect. For example, an experiment reported by Bordia et al. (2005) showed that an average belief in a rumor was reduced from 5.10 to 3.60 (1 = not at all believable to 7 = totally believable) after inconsistent message exposure. Although this is a significant belief reduction the result indicates that participants evaluate the rumor as moderately believable even after exposure to an inconsistent message. The same patterns emerged in another study by Tanaka et al. (2013) where some participants did not change their belief in rumor after they were exposed to an inconsistent message and even decided to spread the rumor. To consider the practical application of rumor control to real life, it is necessary to understand the responses of continual believing rumor despite inconsistent messages.

The present study examined the mixed effectiveness of inconsistent message exposure on belief change in rumors. We measured eye movements of participants when they were exposed to an inconsistent message with a rumor. The reason for this is to check whether participants are genuinely exposed to an inconsistent message. Even if a participant was asked to read an inconsistent message on a traditional

questionnaire or a computer screen, the possibility that he or she skipped reading the message still remains. Recent eye-tracking research demonstrated that people tend to skip reading posts on social media when they look uninteresting (Bode, Vraga, & Troller-Renfree, 2017). Thus, to examine the effect of inconsistent message exposure, it is important to eliminate the possibility of participants skipping out on reading and not actually being exposed to the message.

We focus on fixation duration and fixation frequency as eye movements. Fixation is defined as the periods when an eye is close to immobile and distinguished from rapid movement termed saccades (Rayner, Pollatsek, Ashby, & Clifton, 2012, p.91). A reader extracts printed visual information during fixation. Fixation duration tends to be longer when text becomes conceptually difficult (Rayner, 1998) and unpredictable (Ehrlich & Rayner, 1981; Rayner, Slattery, Drieghe, & Liversedge, 2011).

Based on earlier research, we hypothesize that exposure to an inconsistent message with a targeted rumor will cause belief change in the rumor by reducing pre-belief when compared with the control response to a targeted filler after consistent message exposure (Hypothesis 1). If an effect was found, eye movement record can help determine whether it was caused by exposure to, or skipping an inconsistent message. We expect that eye movement record will show that participants were exposed to an inconsistent message because belief change would not occur if they are skipping the inconsistent message (Hypothesis 2). As for eye movements, we expect that fixation duration will be longer when participants are reading an inconsistent message because the inconsistent message is not predictable based on prior experience of reading a rumor (Hypothesis 3). Predictability effect was observed not only in alphabetic scripts such as English but also in a logographic script (Rayner, Juhasz, & Yan, 2005), therefore, it is reasonable to apply this hypothesis to Japanese which uses logographic characters. This kind of research has implications for understanding what makes people stop believing or keep believing rumors.

Method

Participants

The participants were 46 college undergraduate and graduate students in Japan (32 males, 14 females, M_{age} = 20.8, SD_{age} = 1.89). They received 1,000 Japanese yen (about 9.00 USD) for their participation in an approximately 50-minute session. They all reported having Japanese as their native language and 72% reported attending a psychology class.

Materials

Stimuli For rumor tweets, 12 false rumors related to popular psychology topics were selected from the Japanese translation of Lilienfeld, Lynn, Ruscio, & Beyerstein (2010), including topics such as "*Subliminal messages can persuade people to purchase products*" and "*People use only 10 % of their brain power*" (see Appendix for stimulus materials). All rumors were written in Japanese horizontally and the number of characters was controlled to fall within the range of 46 to 48. Each rumor was transformed into a Twitter PNG image tweet. The user name associated with each tweet was randomly generated.

For each rumor, an inconsistent message with the rumor was developed based on the criticisms against the rumors (Lilienfeld et al., 2010). An inconsistent message was operationally defined as a message including inconsistent or contradictory information against a target rumor. For example, an inconsistent message for the rumor regarding "*subliminal messages*" mentioned above was "*An analysis of research from a Canadian television station revealed that the subliminal message 'please telephone us right away' was aired 352 times. However, there was no increase in the incoming telephone calls. Likewise, people cannot be made to buy things in this manner"*. For each of the 12 false rumors, an inconsistent tweet was developed. The number of characters was controlled to fall within the range of 70 to 75.

In order to prevent the participants learning the characteristics of the inconsistent message stimuli and acting strategically, filler stimuli were added. Twelve tweets were created from psychological knowledge based on textbooks and made into filler stimuli. For each filler, a consistent message was developed. There were no significant differences in the number of characters between rumor and filler tweets, and inconsistent and consistent messages.

Figure 1. A slide image on the eye-tracking computer. It presents a set of a rumor tweet (target: upper left) and its inconsistent message (bottom-left).

Apparatus

Eye movements were recorded only in the following inconsistent message exposure phase by a Tobii Pro Nano, which samples eye position at 60 Hz. All images were presented on a 17.3-inch display with a screen resolution of 1920 × 1080 pixels. Participants were seated ~60cm from the display. For each participant, the system was calibrated before the experiment using a set of 5 calibration points covering the whole screen area. Informed written consents

from participants were obtained. A 23.8-inch display was used except in the eye-tracking phase.

Procedure

Each participant was tested individually. Participants were told that the experiment concerned understanding students' knowledge about psychology, and it was not revealed that the research was interested in false rumors and the inconsistent message exposure until the debriefing period at the end of the experiment. The experiment was administered in the following order.

1. Pre-belief measurement The rumor tweets and the filler tweets were presented one at a time on a computer screen. Presentation of the stimuli was randomized for each participant. Participants were not informed that some stimuli were false. They were asked to answer the following three questions about each tweet: (1) Familiarity – How much do you know about this information? (*Well, Slightly, Not at all*); (2) Accuracy – How accurate do you think this information is? (1 *Not at all*, 5 *Highly accurate*); (3) Importance – How important do you think this information is? (1 *Not at all*, 5 *Highly important*).

2. Inconsistent/consistent message exposure Inconsistent message was a message including inconsistent or contradicting information. For example, the inconsistent message for the "*subliminal messages*" rumor refers to research which showed that the subliminal effect was not observed. On the other hand, consistent messages for fillers mentioned supportive examples and did not include any inconsistent or contradict information (see Appendix). After a five-point calibration for each participant using Tobii Pro Lab software (Tobii Technology), the 12 sets of a rumor tweet and an inconsistent message were presented one at a time mixing with the 12 sets of a filler tweet and a consistent message. The order of presenting the 24 sets was counterbalanced. Figure 1 shows a slide which presents one of the sets. Participants were instructed that each message was referring to the message of the target tweet. They were asked to read each set of tweets silently at their own pace and to judge the message interesting or not interesting. They were required to press 4 on the numeric keypad if the message was not interesting and 6 if the message was interesting.

3. Post-belief measurement The same set of target tweets from the pre-belief session were shown a second time. Participants evaluated accuracy and importance for each tweet.

After completing all tasks, participants were debriefed as to the purpose of the study. It was emphasized that some tweets were false. Participants provided another informed consent.

Data analyses

Eye-movement type and eye coordinates were recorded per millisecond (ms) with Tobii Pro Lab software throughout the message exposure phase. Direct visual attention (fixated) was extracted from the raw eye-tracking data using a minimum fixation duration of 100ms. To identify visual attention per tweet, we calculated fixation duration for target and message regions respectively. For each region, fixation frequency and total fixation duration were calculated. As the number of characters in each tweet was different between target tweets and messages, fixation duration rate was calculated per tweet, for both target tweet and message, by dividing the total fixation duration by the number of characters. We also calculated fixation frequency rate by dividing the total frequency of each tweet by the number of characters.

Results

Table 1 shows the means and standard deviations for pre-belief and post-belief. For pre-belief, there was a significant difference in accuracy perception between rumor and filler tweets. The accuracy perception for rumor tweets was lower than filler tweets, whereas there were no significant differences in importance between rumor and filler tweets.

Table 1. Pre- and post-beliefs for target tweets

Target Tweet	Accuracy		Importance	
	Pre-belief	Post-belief	Pre-belief	Post-belief
Rumor	3.14 (0.47)	2.67 (0.50)	3.52 (0.49)	3.23 (0.57)
Filler	3.53 (0.44)	3.46 (0.46)	3.56 (0.47)	3.57 (0.51)

Note. The numbers in parentheses are standard deviations.

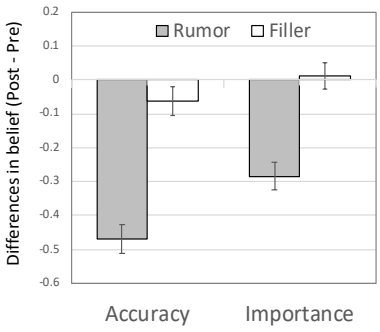

Figure 2. Means and standard errors for belief change after message exposure. Participants were exposed to inconsistent message for rumor and to consistent message for filler.

To test the effects of inconsistent message exposure, belief change after inconsistent message exposure was compared with the responses after the filler consistent message exposure. An analysis of variance (ANOVA) test with message type (inconsistent vs. consistent) was

conducted on belief change in accuracy of target tweets. The main effect of message type was significant, F (1, 45) = 24.28, $p < .001$, $\eta^2_G = .22$. The belief change in accuracy for rumor tweets exposure was bigger (M = -0.47, SD = 0.98) than that for filler tweets (M = -0.06, SD = 0.99) (Figure 2). We also performed a one-way ANOVA with message type on belief change in importance. Result showed a significant effect of message type, F (1, 45) = 12.26, $p < .005$, $\eta^2_G = .11$. The belief change in importance for rumor tweets exposure was bigger (M = -0.29, SD = 1.00) than that for filler tweets (M = 0.01, SD = 0.94) (Figure 2).

To examine eye movement, we performed a one-way ANOVA with message type on fixation duration rate on target tweets and messages, respectively. There were no significant differences in fixation duration rates between rumor and filler target tweets. However, the result of a one-way ANOVA on fixation duration rates on the message region showed that the main effect of message type was significant, F (1, 45) = 38.77, $p < .001$, $\eta^2_G = .04$. The fixation duration per character on inconsistent message (M = 85.76, SD = 64.14) was longer than consistent message (M = 71.30, SD = 50.40)(Figure 3, left figure). The same pattern emerged for fixation frequency rate. There was no significant difference between rumor and filler target tweets, whereas the result of a one-way ANOVA revealed a significant main effect of message type, F (1, 45) = 33.67, $p < .001$, $\eta^2_G = .04$. The fixation frequency rate on inconsistent message (M = 0.34, SD = 0.21) was higher than consistent message (M = 0.29, SD = 0.18) (Figure 3, right figure).

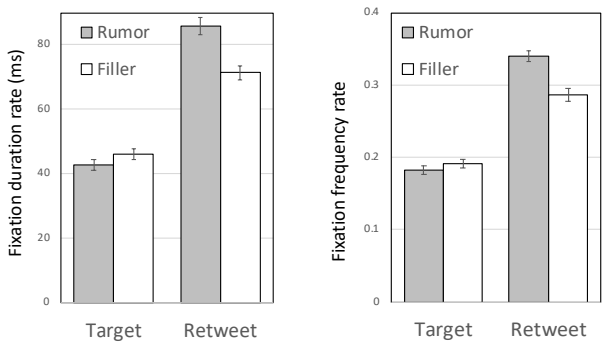

Figure 3. Means and standard errors of fixation duration rate and fixation frequency rate (per character).

To examine the relationship between eye-tracking data and belief, we used 'lme4' package (Bates, Maechler, Bolker, & Walker, 2015) in R (R Core Team, 2012). As fixed effects, we entered tweet type (inconsistent vs. consistent), pre-belief on accuracy and importance into the model. As random effects, subjects and multiple stimuli for each tweet type were added into the model.

We constructed a generalized linear mixed model (GLMM) of fixation duration rate. The inconsistent message affected fixation duration rate ($\chi^2(1) = 31.36$, $p < .001$), increasing it by about 14.5 ms ± 2.56 (standard errors)[95% CI: 9.44, 19.48]. Pre-belief and post-belief in a target tweet were not related to fixation duration rate on the message. As for fixation frequency rate, a GLMM revealed the same pattern. The inconsistent message affected it ($\chi^2(1) = 34.15$, $p < .001$), increasing it by about 0.05 ± 0.01 (standard errors) [95% CI: 0.04, 0.07]. There were no other factors related to fixation frequency rate.

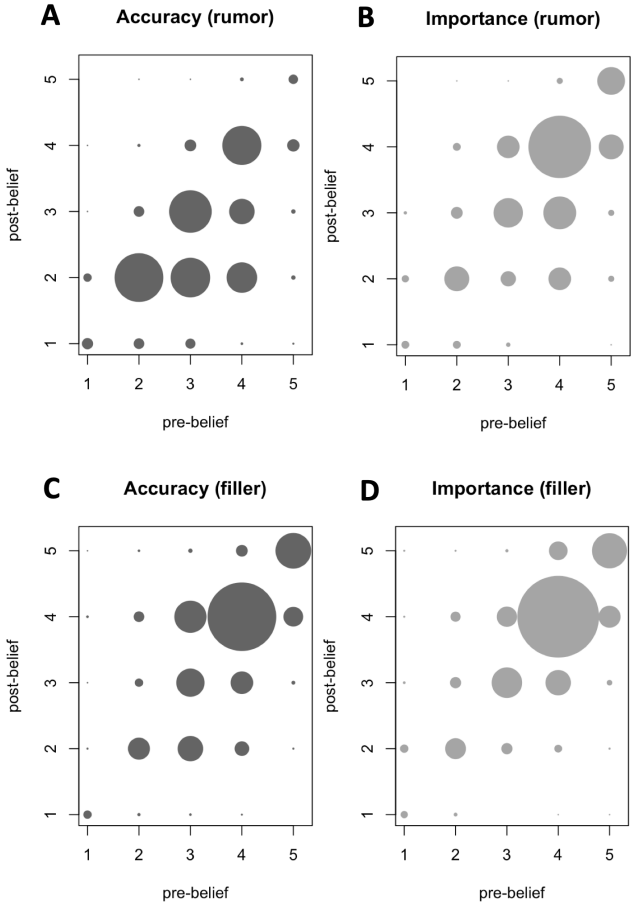

Figure 4. Belief change after exposure to inconsistent message associated with rumor tweets. The circle size represents the number of data points. Belief changes on rumor tweets in accuracy (A) and importance (B) after inconsistent message exposure. Belief changes on filler tweets in accuracy (C) and importance (D).

Figure 4 shows the distributions of the relationship between pre-belief and post-belief in rumors and fillers. Comparing with pre-belief in fillers that tended to be stable after consistent message exposure (Fig.C and D), pre-belief in rumors tended to be weakened after inconsistent message exposure (Figure A and B). However, the distributions of rumor tweets include not a few responses that did not change their belief and kept believing rumors after inconsistent messages.We examined predictor of the

difference in responses after inconsistent message exposure. As our focus here was especially on the belief change in the responses which had positive pre-belief (rated 3, 4, or 5) for rumor tweets, other responses which had negative pre-belief (rated 1 or 2) were excluded from the following analysis. This is an attempt to avoid a floor effect. That is, there is very little or no room to show a decrease in belief after inconsistent message exposure for the responses which had negative belief towards the bottom of the graph. Among all 552 responses associated with rumors (46 participants × 12 rumor tweets), 396 (71.7%) and 439 (79.5%) responses were analyzed in terms of accuracy and importance, respectively.

We constructed a GLMM to predict belief change (pre – post) in accuracy on the rumor with the responses with positive pre-belief. Fixation duration rate on inconsistent message increased belief change of accuracy positively ($\chi^2(1) = 4.91$, $p = .03$), that is, strengthening pre-belief of accuracy by about 0.002± 0.001 (standard errors) [95% CI: 0.0002, 0.003]. Fixation frequency rate on inconsistent tweet also affected belief change in accuracy ($\chi^2(1) = 3.85$, $p = .05$), strengthening pre-belief of accuracy by about 0.47± 0.23 (standard errors) [95% CI: 0.005, 0.92]. A GLMM to predict belief change of importance for rumor tweet revealed no significant relationship between eye movements and belief change.

Discussion

The present study investigated the effects of inconsistent message exposure on belief change in rumor and relationship between the belief change and eye movement.

First, we examined whether inconsistent message exposure changes the belief in rumor target message. Results showed that inconsistent message exposure tends to reduce pre-belief associated with rumors. Both perceived accuracy and importance associated with rumors were significantly reduced after inconsistent message exposure, whereas pre-belief of filler target did not significantly change after consistent message exposure. Thus, Hypothesis 1 was supported. These results support previous findings on the exposure of readers to denial messages being helpful to mitigate their false belief in rumors (Bordia et al., 2005; Bordia, DiFonzo, & Schulz, 2000; Koller, 1993).

Eye tracking data demonstrated that participants paid more visual attention to inconsistent messages associated with rumors than consistent message associated with fillers. Both fixation duration rate and fixation frequency rate associated with inconsistent messages were higher than consistent messages. This result provides support for Hypothesis 2, eliminating the possibility that participants skipped reading an inconsistent message. This result indicates that the inconsistency of the message attracted visual attention. These results provide support for the literature indicating that fixation duration becomes longer when text becomes more unpredictable (Rayner et al., 2011) and when it includes inconsistency (Rayner, Chace, Slattery, & Ashby, 2006). When people encounter inconsistent message, they need to consider the relationship between pre-belief and the inconsistent message and to update the pre-belief if needed. This cognitive procedure could result in longer visual attention. Taken together with a rumor study which demonstrated that people tend to spread false rumors because of novelty (Vosoughi, Roy, Aral, 2018), one explanation is that inconsistent messages were unpredictable and novel, thus, resulting in a relatively decrease in the novelty of rumors. This explanation is corroborated by the result that there were no significant differences in visual attention to the target tweets between rumor and filler. Participants have read the target tweets prior to eye measurement, that is, both types of target tweets were predictable. This prior experience resulted in no significant differences in eye movements between rumor and filler.

Next, we focused on the variation in the effect of inconsistent message exposure. Although the exposure to inconsistent message tends to devalue the accuracy and importance of rumor, the distribution of the relationship between pre- and post-belief in rumor showed that some responses showed a continued belief in rumors even after the exposure to inconsistent messages. Further examination focusing on the belief change of the responses with positive pre-belief in rumor tweets demonstrated that the belief change of accuracy was predicted by eye movement. Longer fixation duration and higher fixation frequency on inconsistent message predicted that the accuracy of rumors would be strengthened. These results can be interpreted in line with the previous findings (Espino, Santamaria, & Garcia-Madruga, 2000; Masson, 1983; Rayner et al., 2006): that the difficulty of text can lead a longer reading duration. Our findings indicate that the effect of inconsistent message exposure became limited for the participants having positive pre-belief in a rumor when they did not fully comprehend the inconsistent message.

There are some limitations in the current study. This study did not measure the level of comprehension of inconsistent messages. It is unclear whether longer fixation was related directly to low comprehension. Additionally, fixation predicted belief change in accuracy but it was not related to belief change in importance. Further research is needed to clarify these relationships.

In conclusion, the current study demonstrated the overall effect of exposure to inconsistent messages to reduce false belief in rumors, supporting previous research on rumor control. Our findings demonstrated the relationship between eye movement and belief change after inconsistent message exposure. The effectiveness of inconsistent message exposure was limited when the inconsistent message was difficult to process, resulting in as slightly strengthened pre-belief.

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Appendix

Example of stimulus set (translated from Japanese into English). The numbers in brackets under each rumor or filler are means and standard deviations for pre- and post-belief of accuracy.

Rumor #1 The brain weighs approximately 1.2-1.5 kg, but in actual fact, most of us use only 10% of that. [M_{pre} = 3.41 (0.96), M_{post} = 2.85 (1.19)]

Inconsistent message for Rumor #1 When even a part of the brain is damaged by an accident or illness, it affects physical exercise, perception, language, and thought. These kinds of effects would be strange if 90% of the brain was not being used.

Rumor #2 People can be broadly divided into left-brained and right-brained, where left-brained people are logical and

analytical, while right-brained people are artistic. [M_{pre} = 3.30 (1.05), M_{post} = 3.07 (1.10)]

Inconsistent message for Rumor #2 Language is necessary for both logical and artistic activities, but both sides of the brain are working when language is used. The left side of the brain is superior in producing grammar and vocabulary, and the right side of the brain, responsible for intonation.

Rumor #3 Because one's personality appears in their handwriting, experts can understand a person's character by judging their letters and lines. [M_{pre} = 3.35 (1.06), M_{post} = 2.63 (1.01)]

Inconsistent message for Rumor #3 Handwritten application documents include information like one's work experience and criminal record in addition to just handwriting. When these indirect clues were regulated, handwriting analysts' predictive abilities were at coincidental levels.

Filler #1 Comics are funnier read when holding a pencil between your teeth so as not to touch your lips than when holding a pencil between puckered lips. [M_{pre} = 2.70 (1.11), M_{post} = 3.15 (1.23)]

Consistent message for Filler #1 When you hold a pencil in your teeth without touching your lips, your mouth spreads from side to side and makes an expression like when laughing. The laughing expression influences the way you read or perceive the comics.

Filler #2 When people repeatedly experience that their situation does not improve whether they work hard or resist, they learn the feeling of powerlessness. [M_{pre} = 3.96 (1.07), M_{post} = 3.96 (0.99)]

Consistent message for Filler #2 People must be tormented by feelings of powerlessness in companies where they are scolded "not to do whatever they feel like" if they independently think and take action, but scolded "not to be passive and to think for themselves" if they wait for instructions.

Filler #3 As in the case of things studied at home being easier to remember at home than in the classroom, circumstances influence memory. [M_{pre} = 4.07 (0.93), M_{post} = 3.80 (1.07)]

Consistent message for Filler #3 I have heard the same kind of thing about feelings — it is apparently easier to remember sad events when feeling sad and easier to remember happy events when feeling happy.