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# Examining Public Acquisition of Science Knowledge From Social Media in Singapore: An Extension of the Cognitive Mediation Model

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## Abstract

This study extends the cognitive mediation model (CMM) by examining the role of social media in cultivating public science knowledge. A sample of 901 Singaporeans was collected through an online survey panel. The results showed that the CMM could be applied to a social media context with a focus on science literacy. Specifically, the findings indicated that people with higher levels of surveillance gratification and social utility motivations tended to pay more attention and to elaborate more about science news that they encounter on social media. Likewise, people with greater social utility motivation tended to engage in greater interpersonal discussions on social media. Notably, attention to news on social media had an indirect association with science knowledge through news elaboration and interpersonal discussion on social media. Implications for theory and practice for science communication were discussed.


*Keywords:* Cognitive mediation model; social media; motivation; information processing; science knowledge

**Examining Public Acquisition of Science Knowledge From Social Media in Singapore: An Extension of the Cognitive Mediation Model**

In the past decades, many countries have witnessed rapid economic development due to the advances in science and technology. Singapore, a city nation with little land and few natural resources, has utilized its technological and entrepreneurial approaches to become economically successful at the international level. Science literacy plays a crucial role in promoting Singapore's technological and economic development. In response to the development, cultivating public science literacy has become an important agenda in Singapore. For example, science curriculum remains a core subject throughout the compulsory education in Singapore. Although school-based education can shape public interest and knowledge about science and technology, the contribution of formal education to individuals' long-term public understanding of science is very limited (Falk, Storksdieck, & Dierking, 2007).

A growing number of evidence supports the notion that the public learns about science and technology development through informal learning rather than formal education in schools (Anderson, Lucas, Ginns, & Dierking, 2000; Falk & Dierking, 2002). Among them, media are the main information source for the general public (Nelkin, 1995; Nisbet et al., 2002). As news about science and technology are often reported in the media, it has become the most readily available sources for most of the public to acquire information about updates on scientific research and discoveries (LaFollette, 1990; Nelkin, 1995). Moreover, the expansion in online and social media information sources makes it easier for people to access content about science and technology development (Cacciatore et al., 2012). Individuals are increasingly turning to online environments to find information about science and to follow scientific developments (Runge et al., 2013). Meanwhile, scientists are increasingly producing and disseminating their research findings to the lay audience on social media (Brossard & Scheufele, 2013). Younger scientists support direct communication with unspecialized ‘lay’ audience and discuss scientific findings outside of their specific spheres, on the online platform, without any intermediary (Colson, 2011). Thus, it can be seen that social media is transforming the way in which science knowledge is produced and disseminated.

With the highest global ranking for smartphone penetration, Singapore’s social media landscape is evolving at a fast pace. A recent report on social media landscape in Singapore indicated that 74% of Singaporeans use social media regularly, and an individual on average spends 2.1 hours daily on social media (Hashmeta, 2014). Singaporeans are regarded among the most active users of social media in the world. The escalation of social media has reshaped the way Singaporeans consume information (Tey, 2015). Moreover, social media has increasingly been used to cultivate science literacy among the public in Singapore. Particularly, scientific institutions in Singapore, such as the Science Center Singapore and the Agency for Science, Technology and Research, are turning to social media to communicate with the public about science and technology development. Hence, Singapore, which is well-known for its world-class infrastructure in science, technology, research, and development, is an appropriate context to examine the role of social media in science communication.

Specifically, this study utilizes the cognitive mediation model (CMM) (Eveland, 2001) to explore the underlying process of learning from social media about science and technology. The CMM has been widely applied to examine the effects of traditional media (e.g. newspaper, television) on knowledge acquisition, whereas few studies have shed light on its applicability to social media. Thus, this study will examine the role of social media and how it could potentially mediate the relationships between motivation, information processing, and knowledge. Theoretically, we aim to extend the CMM in two ways: (1) by extending the CMM to the context of social media and (2) by examining the applicability of the CMM in the area of public science literacy. Figure 1 shows the hypothesized paths in the model.

[Insert Figure 1 about here.]

**The cognitive mediation model**

The CMM was developed by Eveland (2001, 2002) to explain how people process and learn from the news. The model posits that individuals are motivated to learn from the news, in which their self-imposed learning motivations encourage them to process news information, which in turn determine the amount of knowledge that they will acquire. Conceptually, the CMM is a synthesis of research in the fields of uses and gratifications research, news information-processing research, and cognitive psychology. Based on the uses and gratifications approach, the CMM posits that audiences take an active role in learning from the media depending on the gratifications they expect, and their active participation, in turn, shapes communication outcomes. Likewise, the information-processing approach highlights how people make sense of, attend to, and remember information in their daily lives. The CMM indicates that people are capable of processing information, and they develop different processing strategies to make sense of the diverse media messages.

Empirical studies on the CMM have demonstrated the strong theoretical underpinning of the model. For example, laboratory experiments have found that people's motivations drive knowledge gain, and those who pay attention to and engage in the elaborative processing of media messages would gain knowledge (Cowan, 1993; Craik & Tulving, 1975). More recent research has found support for the relationships predicted by the CMM, as motivations shape media attention and information processing, which was in turn positively associated with knowledge (Eveland, Shah, & Kwak, 2003; Ho, Peh, & Soh, 2013).

Moreover, the CMM has been examined in different contexts. Early studies conducted by Eveland and his colleagues focused on public learning from news on political issues (e.g. Eveland, 2001, 2002; Eveland et al., 2003). Subsequent research began to apply the CMM in other contexts, such as health (e.g. Ho et al., 2013; Jensen, 2011). For instance, Ho and colleagues (2013) examined an extended CMM with the inclusion of interpersonal communication as a systematic processing variable, in which the results showed that factual knowledge was positively associated with people's behavioral intention to engage in precautionary health measures against the H1N1 influenza. Similarly, Lo, Wei, and Su (2013) demonstrated that the CMM variables and self-efficacy were associated with factual knowledge about the swine flu. Recently, Lee, Shin, Kawaja, and Ho (2016) further explicated the distinct dimensions of media attention (i.e. attention to newspaper, television, and the internet) and knowledge (i.e. factual and structural knowledge) in the CMM to explain how women acquire knowledge about breast cancer.

Despite these contributions, there remain key gaps in CMM research. First, unlike health issues that are often considered as personally relevant to people, previous studies have not applied the CMM to science issues that are less personally relevant, as people might perceive science issues to pose less direct influence on themselves and on others as compared to health issues (Biek, Wood, & Chaiken, 1996; Merton, 1942; Tyler & Cook, 1984). Second, *media attention*, which is a key variable in the CMM, has not accounted for how news attention to social media relates to public acquisition of science knowledge. Unlike traditional media, social media has become a public sphere for people to share, discuss, and contribute to news, in addition to developing interpersonal relationships (Hermida, Fletcher, Korell, & Logan, 2012). In particular, social media provides a range of mechanisms for users to share and recommend online news content to others (Singer et al., 2011). Considering social media as a new form of news exposure and the different nature of science issues from health topics, it is reasonable to expect that the CMM may perform differently in this context. Therefore, this study aims to extend the CMM by examining the model in the social media context as well as its applicability to public science literacy.

***Linking motivations with attention to news on social media***

The uses and gratification studies have shown that motivations such as guidance, need for cognition, and personal identity affirmation are positively associated with individuals' attention to print and broadcast news (McLeod & McDonald, 1985), general television viewing (Rubin, 1983), and news media reliance (Beaudoin & Thorson, 2004). Research that examined motivations for the use of news media in information seeking, suggested that surveillance gratification and social utility functions are the most relevant in explaining discrepancies in learning (Beaudoin & Thorson, 2004; David, 2009; Rubin & Perse, 1987).

Surveillance gratification is defined as individuals' tendency to use the news media to gain information about their social environment (Eveland, 2001; Payne, Severn, & Dozier, 1988). Individuals who view news with a surveillance gratification objective tends to acquire more knowledge than those who do so for diversion or entertainment (McLeod & McDonald, 1985). Eveland (2001) demonstrated that surveillance gratification is a salient motivation in explaining individuals' learning from the news.

Likewise, Eveland (2001) suggested that to enhance the applicability of CMM, social utility motivation should be included to further extend the model. Social utility motivation refers to the gaining of information to connect interpersonally with family, friends, and others through making conversations with them (Eveland, 2004; McDonald, 1990; McQuail, 1983; Payne et al., 1988). Subsequent studies on the CMM demonstrated that both surveillance gratification and social utility were positively associated with media attention to print and television news (Beaudoin & Thorson, 2004; Ho et al., 2013). Moreover, Eveland (2001) suggested that future studies should focus on examining the role of different news mediums in the CMM. Therefore, in extending the CMM model, we propose to examine how motivations will be related to attention to news on social media.

Social media provides a wide range of mechanisms for many users to share and recommend news content to others in their online social network (Singer et al., 2011). Due to this reason, social media has become a rich repository of news and a platform that provides a large amount of information to its users (Lee & Ma, 2012; Purcell, Rainie, Mitchell, Rosenstiel, & Olmstead, 2010). Likewise, it has become a useful tool for individuals to acquire information about emerging science and technology developments (Kwak, Lee, Park, & Moon, 2010). Therefore, people with a high surveillance gratification motivation may have the tendency to turn to news on social media to fulfill their need to gain information about their environment. Moreover, social media connects people to their interpersonal contact online and offers interactive means that allows them to participate in online discussions with their contacts (Kim, Jeong, & Lee, 2010; Lerman, 2007). With the anticipation that discussions might ensue with their friends, family members, and colleagues on social media, people might be more inclined to pay attention to news that are circulated within social media. Hence, the following hypotheses are proposed:

*H1:* Surveillance gratification motivation is positively associated with attention to science news on social media.

*H2:* Social utility motivation is positively associated with attention to science news on social media.

***Linking motivations with elaboration and discussion on social media***

News elaboration is defined as the process of retrieving new information from the media and linking it with other extant concepts such as personal experiences and existing knowledge in people's mind (Eveland, 2001). In addition, news elaboration occurs when people associate and synthesize two new pieces of information which they gather from the media in novel ways (Eveland, 2001). Information-seeking motives, including surveillance gratification and social utility motivation, are associated with cognitive involvement that deals with thinking about and discussing news (Rubin & Perse, 1987).

In particular, studies on the CMM have demonstrated that surveillance gratification and social utility motivations are positively associated with elaboration of information on traditional media (Beaudoin, 2008; Ho et al., 2013). By providing timely news, social media is regarded as an important information source for individuals to keep themselves updated with their surroundings (Kwak et al., 2010). It is reasonable that to make sense of the updated information on science and technology development, people would connect the information they acquire from social media with their existing knowledge.

In addition to elaboration, interpersonal discussion has been incorporated into the CMM as a form of information processing. Kosicki and McLeod (1990) defined information processing as individuals' effort to reflect on as well as their attempts to discuss with others about the information that they get from media. Eveland (2004) indicated that communicating with others would enforce individuals to retrieve relevant information from their memory and connect the newly incoming information with their existing knowledge structure. Regarding the relationship between motivations and interpersonal discussion, Eveland (2002, 2004) pointed out that motivations would drive interpersonal discussion of news content. Subsequent studies on the CMM demonstrated that both surveillance gratification and social utility are positively associated with interpersonal discussion (Ho et al., 2013).

Discussion on social media can be a way for people to make sense of issues through exchanging ideas with others (Gil de Zúñiga, Jung, & Valenzuela, 2012). Unlike traditional media where sharing of news is limited due to the absence of effective diffusion channels, social media empower individuals to create, share, seek content, as well as to communicate and collaborate with one another (Kim et al., 2010). Such interactivity allows people to leave their comments and participate in both synchronous and asynchronous discussions. Since this interpersonal discussion can serve as a form of information-processing strategy, we expect that engaging in social media discussion would not only satisfy individuals' surveillance gratification motivation by allowing them to get the latest updates but also fulfill their social utility motivation by enabling them to talk to others on social media. Therefore, we put forth the following hypotheses:

*H3:* Surveillance gratifications motivation is positively associated with (a) elaboration on social media and (b) discussion on social media.

*H4:* Social utility motivation is positively associated with (a) elaboration on social media and (b) discussion on social media.

***Linking attention to news on social media with information processing***

Media attention, defined as the focus of mental effort on a given subject matter in the media, requires allocation of cognitive capacity (Chaffee & Schleuder, 1986; Kahneman, Ben-Ishai, & Lotan, 1973). In the CMM, Eveland (2001) proposed that media attention is considered antecedent to elaboration. Moreover, subsequent CMM studies have demonstrated that media attention is positively associated with interpersonal discussion. However, previous studies rarely examine the relationship between media attention and information processing in the context of social media. Thus, we propose to examine the effects of social media news attention on the two kinds of information-processing strategies.

***Attention and elaboration on social media***

Media attention is an important but insufficient condition for information processing, as information can only be processed after people consciously attend to it (Rigney, 1978). In other words, those who engage in information processing of incoming information must first pay attention to the content. Hence, a higher level of attention would make more information available for processing. Regarding the effects of media attention on elaboration, there is much evidence in the literature that media attention would motivate people to process information in an elaborative way (Beaudoin & Thorson, 2004; Eveland, 2001).

One defining characteristic of social media is that audiences have a great deal of control in choosing what they want to learn at their own pace (Leung, 2013). Giving people control over their own learning is thought to be beneficial for knowledge accumulation as they can organize and dictate their own learning based on the connections they make in their minds (Shin, Schallert, & Savenye, 1994). Hence, individuals' exposure to high-volume information on social media would motivate them to choose specific information that they are interested in, and process it in an in-depth manner. Besides, information on science and technology tends to be very specialized (Funkhouser & Maccoby, 1971). Thus, it would cost cognitive effort to process the information. The following hypothesis is proposed:

*H5a:* Attention to science news on social media is positively associated with elaboration on social media.

***Attention and discussion on social media***

Likewise, the relationship between media attention and interpersonal discussion has been extensively examined. The two-step flow communication model (Katz & Lazarsfeld, 1955) points out that mass media is expected to have its impact through interpersonal discussion. The communication mediation model also demonstrated the mediating role of interpersonal communication in media effects (McLeod, Scheufele, & Moy, 1999). Moreover, empirical studies have demonstrated that media attention is significantly associated with interpersonal discussion (Shah et al., 2007; Sotirovic & McLeod, 2001).

As we have highlighted, the increasing prevalence of social media is changing the nature of news by allowing the audience to actively engage with media sources (Hanna, Rohm, & Crittenden, 2011). Encompassing a wide range of online discussion forums and groups, social media encourage people to express their own opinions and participate in online discussion toward certain issues (Correa, Hinsley, & De Zuniga, 2010). For example, a recent study found that individuals' social media use for news is positively related to their discussion of political issues (Gil de Zúñiga et al., 2012). Moreover, the study indicated that social media facilitate not only the acquisition of information but also the discussion with other members of individuals' network, which may increase the reflection mechanism for an individual to make sense of what they were informed about (Gil de Zúñiga et al., 2012). Thus, we expect that attention to social media would prompt individuals to engage in discussion on social media. Hence, we propose the following hypothesis:

H5b: Attention to science news on social media is positively associated with discussion on social media.

***Linking attention to news on social media and information processing with knowledge***

By providing high-volume and almost real-time updated information, social media is becoming an important information source for the public (Westerman, Spence, & Van Der Heide, 2014). Given the diversity of sources in the new media environment, individuals are now shifting attention from traditional media to social media (e.g. Facebook, Twitter, YouTube) to acquire science-related information (Brossard, 2013). Due to the inherent participatory nature of social media platforms, people can share, discuss, and disseminate news about science and technology to others in the online community. This might, in turn, impact how people acquire science knowledge. Hence, we propose to examine the process underlying learning from social media about science and technology.

***Attention to news on social media and knowledge***

Attention is essential for knowledge gain as it enhances public learning (Chaffee, Zhao, & Leshner, 1994; Eveland, 2001; McLeod & McDonald, 1985). The effects of media attention on knowledge have been extensively examined across different mediums. For example, studies have shown that newspapers play a major role in informing the public about current affairs (Chaffee & Kanihan, 1997; Eveland, Marton, & Seo, 2004; Ho, 2012). People have the ability to learn from television programs (Atkin, 1982; Miller, Augenbraun, Schulhof, & Kimmel, 2006). Attention to Internet news is positively associated with individuals' knowledge (Kenski & Stroud, 2006; Lee & Ho, 2015a). Overall, there is much evidence to show that attention to news can be associated with knowledge. Furthermore, research indicated that social media could be a potential platform for individuals to acquire knowledge (Majchrzak, Faraj, Kane, & Azad, 2013). As people are increasingly turning to social media to seek information about science and technology developments (Runge et al., 2013), we anticipate that attention to science news on social media could help to increase individuals' science knowledge. Hence, we propose the following hypothesis:

H6: Attention to science news on social media is positively associated with the acquisition of science knowledge.

### *Elaboration on social media and knowledge*

In the CMM, elaboration is the antecedent to knowledge acquisition (Eveland, 2001). By engaging in elaborative processing, which is the inclination to think about an issue and integrate new information into existing knowledge structures (Eveland, 2001; Petty & Cacioppo, 1986), individuals can increase the strength of their stored memory and the number of mental pathways with which information can be accessed (Eveland, 2001). Many studies on the CMM have demonstrated the role of elaboration in learning from the print news, television news, and internet news (Eveland, 2001, 2002; Ho et al., 2013). Beaudoin and Thorson (2004) found that elaboration partially mediated the positive influence of news media on political knowledge. Besides, Eveland (2001) demonstrated that attention drives elaboration, and elaboration, in turn, promotes knowledge.

By paying attention to high-volume updates on social media, people with surveillance gratification and social utility motivations would consciously process the information. Thus, we expect that similar with elaboration on other mediums, making connections between the updated information on social media and existing knowledge would contribute to individuals' knowledge accumulation. Hence, we propose the following hypothesis:

H7: Elaboration on social media is positively associated with the acquisition of science knowledge.

### *Discussion on social media and knowledge*

Many communication theories support the notion that interpersonal communication enhances learning (Delli Carpini & Keeter, 1996; Eveland & Thomson, 2006; Holbert, Benoit, Hansen, & Wen, 2002; Scheufele, 2002). Recent studies on the CMM suggest that media attention would enhance learning through interpersonal discussion (Shah et al., 2007). Previous studies examined offline interpersonal discussion suggested that discussion within their social network would help individuals to obtain knowledge (O'keefe, Boyd, & Brown, 1998). By engaging in social media discussion, people would exchange opinions within their social network. Expounding various opinions and making an inference from the arguments relevant to science and technology facts may result in people becoming more knowledgeable about the issues. Therefore, we posit the following hypothesis:

H8: Discussion on social media is positively associated with the acquisition of science knowledge.

## Methodology

### Sample and data

Data for this study was collected through an online survey panel. The web-based questionnaire was administered via Qualtrics, an international research firm with extensive experience in academic and market opinion research. A pilot study was conducted before the actual fieldwork. The survey was in the field from 4 June 2015 to 2 July 2015. A sample of 901 respondents was randomly selected from the available pool of panelists on the file of Qualtrics. Attention filter questions were used within the survey questionnaire to ensure that respondents were actually reading each question and all associated response options before selecting an answer. Respondents who completed the survey were rewarded cash-equivalent points that can be redeemed for incentives.

To overcome the limitations of surveying Internet users only, and to assure national representativeness, a quota based on gender, age, and monthly household income was established so that the sample matches as much as possible to the distribution of these demographic variables in the Singapore census. Demographic variables showed that respondent aged between 21 and 76 years (*M* = 38.44, *SD* = 10.56). For gender, 54% of the respondents were female. The median education level was 'Degree.' The median monthly household income ranged from S$7001 to S$8000[1]. The response rate was 30%, as defined by the number of completed questionnaires divided by the number of qualifying panelists invited to participate. This response rate falls within acceptable parameters for online surveys (Bosnjak, Das, & Lynn, 2016; Iyengar & Hahn, 2009).

**Measures**

*Surveillance gratification motivation*. Adapted from Eveland's (2001) study, two 7-point items (1 ='strongly disagree,' 7= 'strongly agree') asked respondents to indicate their agreement with the following reasons behind keeping themselves informed about news related to science and technology topics: (a) 'To know about new updates on science and technology development;' and (b) 'To understand what is going on with science and technology development' (*M* = 4.99, *SD* = 1.12, *r* = .88, *p* < .01).

*Social utility motivation.* Adapted from Beaudoin and Thorson (2004), three 7-point items (1 = 'strongly disagree,' 7= 'strongly agree') measured respondents' motivation to gain information to connect interpersonally with others. Respondents were asked to indicate their agreement with the following reasons behind keeping themselves informed about news

[1] According to the Singapore National Census (Singapore Department of Statistics, 2010), the median age of Singaporeans is 37.4 years. The median monthly household income is S$8290. For gender, 49.11% are males and 50.88% are females.

related to science and technology topics: (a) ‘To find out interesting things to talk about;’ (b) ‘To pass on information to others;’ and (c) ‘To prepare for discussions’ (*M* = 4.65, *SD* = 1.14, *Cronbach’s α* = .88).

*Attention to science news on social media.* One 7-point item (1 = ‘no attention at all,’ 7 = ‘a lot of attention’) adapted from previous studies (Eveland, 2001, 2002) was used to ask respondents to indicate how much attention they paid to science and technology news on social media (*M* = 4.70, *SD* = 1.34).

*Elaboration on social media.* Modified from Eveland et al. (2004) and Ho, Scheufele, and Corley (2011), four 7-point items (1 = ‘strongly disagree,’ 7 = ‘strongly agree’) were used to measure respondents’ elaboration of information on science and technology. Respondents were asked to indicate their agreement with the following statements: (a) ‘When I encounter others’ opinions about science and technology on social media, I am likely to stop and think about it;’ (b) ‘When using social media, I carefully analyze the information shared by others about science and technology that are similar to my views;’ (c) ‘I often relate what I learnt from social media about science and technology to other things I know;’ and (d) ‘When using social media, I carefully analyze the information shared by others about science and technology that are dissimilar to my views’ (*M* = 4.45, *SD* = 1.23, *Cronbach’s α* = .93).

*Social media discussion.* Adapted from Eveland and Dunwoody (2002), two items were employed to measure respondents’ discussion of science and technology issues on social media. On a 7-point scale (1 = ‘never,’ 7 = ‘always’), respondents were asked to state how often they do the following activities on social media: (a) ‘Participate in discussions on science and technology issues;’ and (b) ‘Post your own thoughts or comments on science and technology issues’ (*M* = 3.34, *SD* = 1.64, $r = .82$, $p < .01$).

*Science knowledge.* To evaluate respondents’ knowledge on science and technology issues, eight questions were adapted from a number of sources (Australian Academy of

Science, 2013; Miller, 1998; National Science Foundation, 2006). For each of the statements, respondents were to answer if the following statements are 'true' or 'false' or 'don't know': (a) 'All radioactivity is man-made (F);' (b) 'Lasers work by focusing sound waves (F);' (c) 'Antibiotics will kill viruses as well as bacteria (F);' (d) 'Radioactive mill can be made safe by boing it (F);' (e) 'The earth takes a day to go around the Sun (F);' (f) 'Nanotechnology deal with things that are extremely small (T);' (g) 'Sunscreen protects the skin from infrared solar radiation (F);' and (h) 'Stem cells are different from other cells because they are found only in plants (F)' ($M$ = 0.56, $SD$ = 0.28, $KR\text{-}20$ = .73). 'T' or 'F' indicates the correct answer to the statements. The option 'Don't know' was recoded as an incorrect answer.

**Analytical approach**

The hypothesized model was tested using structural equation modeling, with maximum likelihood estimation in *Mplus 6* (Muthén & Muthén, 2012). Following a two-step analytical approach, we first estimated measurement model using confirmatory factor analysis and then tested the structural equation models (Anderson & Gerbing, 1988). Specifically, the CFA was conducted first to validate the measurement components, which provided foundation for structural model testing. Following this, we replaced the correlations between latent variables with hypothesized causal relationships and tested the structural model. In the hypothesized model, age, gender, household income and education were included as control variables.

Model fit was evaluated using the following goodness-of-fit indices: the maximum likelihood chi-square ($\chi^2$), relative chi-square ($\chi^2$/df), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA). A small ratio $\chi^2$/df indicates a good model fit. A ratio of between 1 and 5 is acceptable (Wheaton, Muthen, Alwin, & Summers, 1977). TLI over .95 and CFI that exceeds .95 are considered acceptable (Hu & Bentler, 1999). RMSEA value less than .08 indicates good fit (Hu & Bentler, 1999).

**Results**

Table 1 shows the descriptive statistics for our measurements and factor loading for each latent variable in our model. All factor loadings were over .40 and most exceeded .80. Factor loading for all latent variables were significant ($p < .001$). Our results show that both measurement model ($\chi^2$ = 651.12.76, df = 159, $p < .001$; $\chi^2$/df = 4.10; CFI = .95; TLI = .94; RMSEA = .060) and structural model ($\chi^2$ = 654.02, df = 222, $p < .001$; $\chi^2$/df = 2.95; CFI = .96; TLI = .95; RMSEA = .046) had acceptable fit. Table 2 shows the result of model fit indices.

[Insert Tables 1 and 2 about here.]

Regarding the hypothesized relationships between motivations and attention to social media news on science and technology issues, the results indicate that surveillance gratification was positively associated with news attention on social media (β = .19, $p <$ .001), supporting H1. Social utility motivation was positively associated with news attention on social media (β = .35, $p < .001$), which supported H2.

For the relationships between surveillance gratification and information processing on social media, surveillance gratification motivation was positively related with elaboration on social media (β = .27, $p < .001$), which supported H3a. However, H3b was not supported as no significant relationship was found between surveillance gratification motivation and discussion on social media.

H4a and H4b contended that social utility motivation is significantly and positively associated with social media elaboration and discussion. Social utility motivation was positively associated with elaboration on social media (β = .41, $p < .001$), supporting H4a. In addition, H4b was supported, as the social utility was significantly associated with social media discussion (β = .57, $p < .001$).

H5a and H5b hypothesized that attention to science news on social media is positively associated with elaboration and discussion on social media. They were both supported, as social media news attention was positively associated with elaboration on social media (β = .20, $p < .001$) and discussion on social media (β = .16, $p < .001$).

H6, which held that social media news attention had a positive association with science knowledge, was not supported, as no significant association was found. Elaboration on social media was found to be positively associated with science knowledge (β = .25, $p < .001$), which supported H7. Besides, media discussion was found to have a negative relationship with science knowledge (β = −.23, $p < .05$), hence, failing to support H8. The model explained 27% of the variance in science knowledge (see Figure 2).

[Insert Figure 2 about here.]

## Discussion

This study has demonstrated some important findings by extending the CMM to the social media platforms. The results showed that surveillance gratification and social utility motivations regarding science and technology issues were related positively with attention to science news on social media and social media elaboration. These information processing are in turn positively related to science knowledge. While surveillance gratification showed a positive relationship with social media discussion, social utility motivation had no association with social media discussion. Moreover, discussion of science issues on social media was found to have a negative association with science knowledge. Overall, our study demonstrated that the CMM theory is applicable to the context of science in social media.

As expected, surveillance gratification motivation could promote attention to science news on social media. This is expected as social media provide much information about science and technology development (Brossard, 2013). Moreover, social media, compared with traditional media, is a timely real-time platform for people to get the most updated information to keep up with the world around them (Sundar, 1999). Besides, previous studies have demonstrated that social media provides information that can be used in discussion with others (Kaplan & Haenlein, 2010). Thus, it is unsurprising that people with the motivation to interact with others about science issues would pay attention to science news on social media.

Surveillance gratification and social utility motivations spur individuals' elaboration of science and technology information on social media. It is plausible that the same motivation that steered respondents to pay attention to science news on social media would also motivate them to consciously process this news to acquire knowledge. This could be supported by the literature, as previous studies on the CMM have demonstrated that these motivations can function as salient predictors of elaboration (Beaudoin & Thorson, 2004; Eveland, 2002). Besides, we found that people with social utility motivation tended to engage in discussion of science and technology issues on social media, given that social utility refers to the motivation of seeking information to engage in conversation, which encourages individuals to interact with others. Surveillance gratification motivation on the other hand steers people to get information about the world around them, which is a kind of individual behavior and may not require individuals to interact with others, showed no significant relationship with social media discussion. As such our findings demonstrated that different motivations have unique effects on information processing on social media. Therefore, it is worthwhile for future studies to identify other motivations that may potentially affect social media elaboration and discussion in various science-related topics.

Consistent with past CMM studies (Eveland, 2001; Ho et al., 2013; Lee et al., 2016), news attention on social media could encourage individuals to elaborate on the information. Science and technology issues usually involve very specialized knowledge, such as nanotechnology or genetically modified food. To make sense of information on these domain-specific topics, individuals need to spend extra cognitive effort to process it. We also found that the more people pay attention to social media news on science issues, the more likely they would engage in science discussion on social media. Previous studies have demonstrated that people are compelled to retrieve information from their memory and to connect the new information with the existing knowledge in the process of their discussion with others (Eveland, 2004; Ho et al., 2013; Lee & Ho, 2015b). In other words, to find arguments that can be used in the discussion, people would consciously analyze the information. Therefore, discussion on social media could be a useful way to make sense of the science and technology information. Besides, social media is a platform promoting interpersonal communication (Kaplan & Haenlein, 2010). Thus, it is unsurprising that people would engage in social media discussion after they get information about science and technology issues on social media.

News attention on social media exhibited no direct relationship with science knowledge. This could be explained by the features of social media. As a platform for networking and communicating (e.g. Facebook, LinkedIn, and Twitter) with friends, colleagues, and acquaintances, people may focus more on the recreational functions of social media. Therefore, the information they get from social media may not be directly transformed into knowledge accumulation. Although paying attention to science news on social media could not directly contribute to science knowledge accumulation, our results showed that attention to news on social media had an indirect association with knowledge through elaboration and discussion on social media.

However, elaboration and discussion on social media had different relationships with science knowledge. In line with previous studies, people who actively process the information would learn more about the given topic (Craik & Tulving, 1975; Eveland, 2001), this explains how elaboration on social media has a positive association with science knowledge. However, social media discussion of science issues showed negative effects on science knowledge. The attributes of social media may account for this finding. Due to a lack of social context cues and the provision of anonymity to the participants, interpersonal communication on social media is not as formal as face-to-face communication (Brown, Broderick, & Lee, 2007). It is possible that people get distracted from relevant topics during the discussion on social media. This distraction may, therefore, impair the process of learning. Besides, people usually use social media for the purpose of entertainment, thus, their discussions on the platform may not be learning oriented. Moreover, what people talk about on social media may not be factually true. For instance, people frequently discuss science-themed movies or fictions on social media, which may generate misunderstanding toward certain scientific facts and ultimately decrease their science knowledge.

The present study has several limitations that should be addressed in future research. First, the online survey panel employed in this study would limit the generalizability of our findings. However, by making sure that our data matches the demographics of the census population in Singapore, we minimize the limitation caused by using an online panel. Second, we used a cross-sectional sample that does not allow us to infer causality. To alleviate this, we made an extension to the CMM by highlighting the relationships in its original theoretical model. Specifically, we examined the relationships between motivations, media attention, and information processing, and how these factors are associated with science knowledge.

Previous studies suggested that knowledge about a certain topic could give rise to individuals' discussion on it (Galston, 2001; McClurg, 2006). To rule out potential rival hypotheses regarding the causal direction of the relationships between discussion and knowledge, we ran a *post hoc* analysis to test a rival causal model. The results yielded poorer fit as compared to our original model[2]. However, this finding merely implies that our proposed model yielded a better fit to the data. Future studies should consider using

[2] When we tested the alternative model by reversing the causal relationship between social media discussion and science knowledge, the model produced a poorer fit in comparison to our original model ($\chi^2$ = 1220.36, df = 240, $p$ < .001, $\chi^2$/df = 5.08, RMSEA = .07, CFI = .90, TLI = .89). Thus, our post hoc analysis suggests that our proposed hypothesized model is better than the rival model.

longitudinal data to verify our proposed direction of the relationships between social media discussion and science knowledge.

This study has made a number of important theoretical contributions. First, we show that the CMM is suitable for non-political and non-health-related contexts, thus extending the applicability of the theory by making an extension of the CMM into the public science literacy context. Second, we demonstrated that surveillance gratification and social utility motivations were associated with attention to news on social media, elaboration, and discussion, thus extending the applicability of the theory in the context of social media. This has enabled us to extend and build the original CMM into a stronger theoretical model. Next, our findings have shown that attention to science and technology news on social media would not directly contribute to individuals' knowledge but has an indirect association with science knowledge through the mediating effects of information processing. Moreover, we proposed the elaboration of social media information and the discussion on social media as two different information-processing strategies and demonstrated that they could work differently shaping individuals' science knowledge acquisition. Besides, our study demonstrates that the CMM can be used to explain the public acquisition of science and technology-related knowledge in a Southeast Asian population. It is clear that this opens up new research trajectories for science communication scholars as it highlights that more studies should be conducted in different parts of Asia to assess whether the CMM is applicable cross-culturally.

For practical implications, the findings from our study advance the necessity of rethinking the relationship among social media, the public, and science communication. Considering the findings of this study that social media plays a role in increasing public science knowledge, it is important that future decision-making which aims to achieve science literacy to take social media into account. The results of this study point to one interesting distinction of social media in promoting public understanding of science and technology.

Since there is no direct relationship between attention to news on social media and science knowledge, policymakers should not simply shift news about science and technology from mass media to social media when communicating with the public. Instead, government and practitioners should focus on the role of news attention, elaboration, and discussion on social media to develop effective information dissemination strategies about science and technology. Creative strategies should be developed to induce audience's elaborative processing, and conducive platforms should be developed to encourage the public to engage in constructive discussions of science and technology issues on social media. For instance, the creation of an online science discussion forum under the moderation of a neutral facilitator may be a means to encourage constructive discussions. The facilitator can provide evidence to help the public to determine the accuracy of news coverage (e.g. links to original scientific publication). This will value-add and advance the conversation around science topics (e.g. science journalism, curation, and critical analysis). Such practices will also help the public to build an understanding and engagement with science in their own way. Overall, understanding the mechanisms behind the CMM in the context of social media can help science communication professionals to effectively disseminate information and engage the public in the era of social media.

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## Tables

**Table 1.** Summary of measurement items.

| Variable | *Factor loading* | *M* | *SD* |
|---|---|---|---|
| Surveillance gratification | | | |
| gratification1 | .93 | 5.00 | 1.14 |
| gratification2 | .95 | 4.98 | 1.16 |
| Social utility | | | |
| utility1 | .82 | 4.83 | 1.23 |
| utility2 | .89 | 4.74 | 1.24 |
| utility3 | .84 | 4.39 | 1.34 |
| Elaboration | | | |
| ela1 | .88 | 4.43 | 1.34 |
| ela2 | .89 | 4.45 | 1.38 |
| ela3 | .85 | 4.45 | 1.33 |
| ela4 | .87 | 4.48 | 1.37 |
| Social discussion | | | |
| dis1 | .92 | 3.35 | 1.71 |
| dis2 | .90 | 3.32 | 1.73 |
| Science knowledge | | | |
| know1 | .54 | 0.58 | 0.49 |
| know2 | .49 | 0.52 | 0.50 |
| know3 | .46 | 0.46 | 0.50 |
| know4 | .50 | 0.63 | 0.48 |
| know5 | .50 | 0.55 | 0.50 |
| know6 | .40 | 0.81 | 0.39 |
| know7 | .47 | 0.36 | 0.48 |
| know8 | .69 | 0.61 | 0.49 |

*Note*: For reference, items appear in this table in the same order as in the Method section.

**Table 2.** Measurement and structural model fit indices.

| Model | $\chi^2$ | *df* | $\chi^2/df$ | CFI | TLI | RMSEA (*p* close) |
|---|---|---|---|---|---|---|
| Measurement | 651.12 | 159 | 4.10 | .95 | .94 | .060 (1.00) |
| CMM | 654.02 | 222 | 2.95 | .96 | .95 | .046 (1.00) |

**Figures**

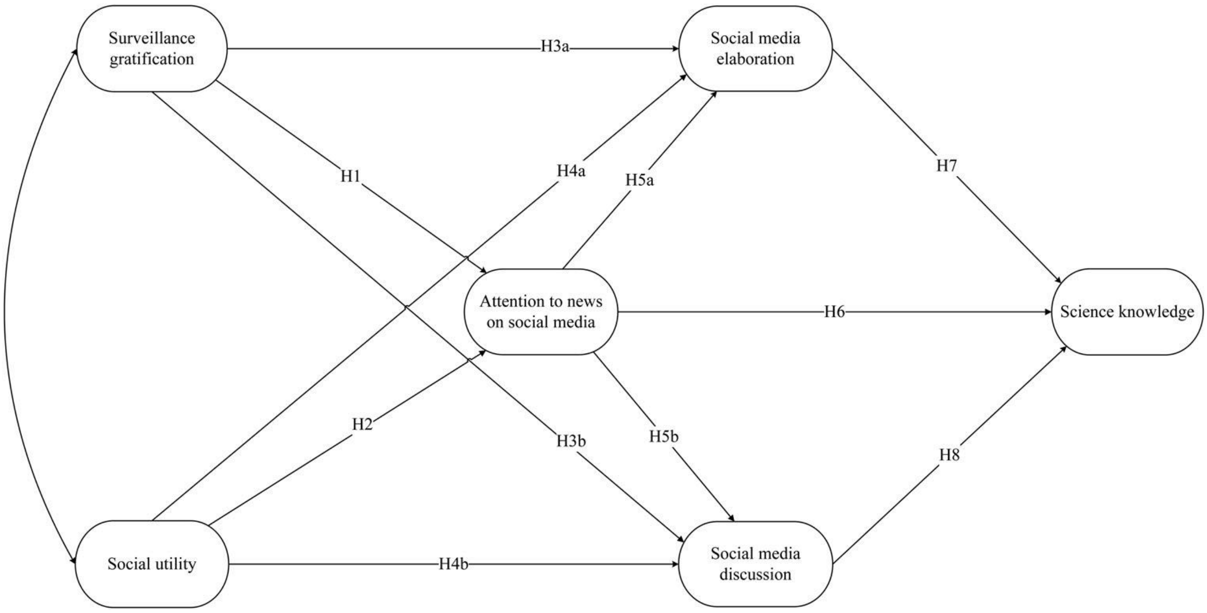


Figure 1. Hypothesized model.

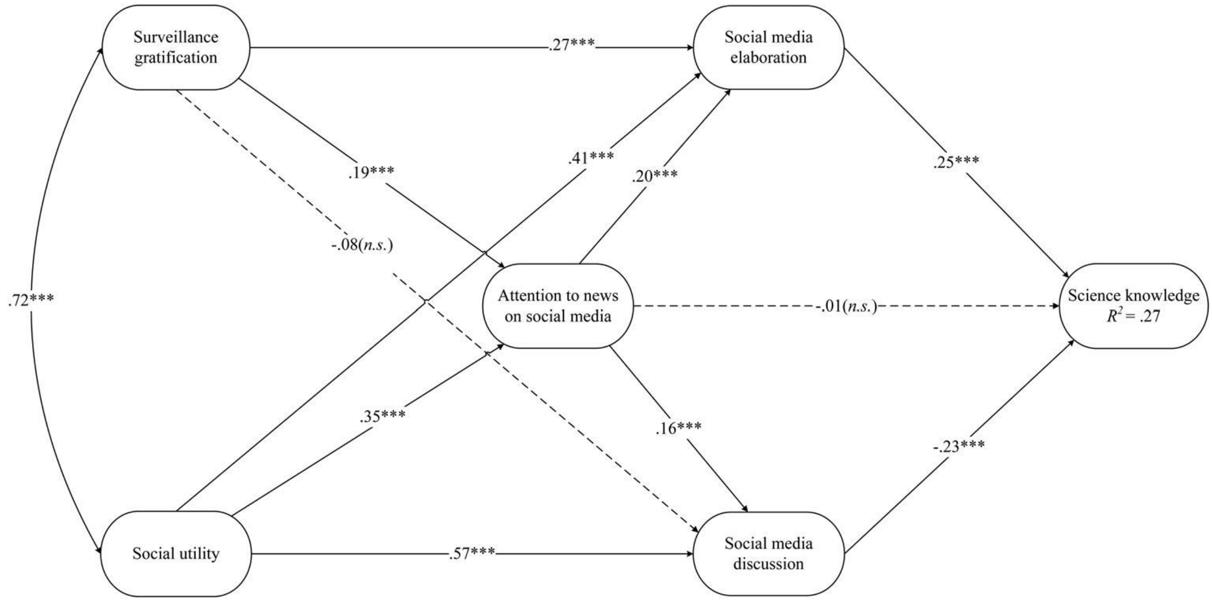


Figure 2. Structural equation model with standardized coefficients ($N$ = 901).