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The Perceived Familiarity Gap Hypothesis: Examining How Media Attention and Reflective Integration Relate to Perceived Familiarity With Nanotechnology in Singapore

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Abstract

Public level of familiarity with nanotechnology partly determines their acceptance or rejection of the technology. This study examines the differential influence of public attention to science news in the media, interpersonal communication about science, and reflective integration on perceived familiarity with nanotechnology among people in the higher and lower socioeconomic status (SES) groups in Singapore. Significant three-way interactions among education, science news attention, and reflective integration variables were found. Attention to television science news narrowed the level of perceived familiarity with nanotechnology between the higher and lower SES groups for those who engaged in high elaborative processing. Science newspaper attention on the other hand, widened the familiarity gap between the higher and lower SES groups among those who engaged in high elaborative processing. Two-way interaction among education and elaborative processing were found—elaborative processing closed the familiarity gap between higher and lower SES groups. Theoretical and practical implications were discussed.

Keywords: knowledge gap; perceived familiarity; nanotechnology; mass media; reflective integration.

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Introduction

Nanotechnology, the science of the very small, is framed to be the defining technology of the 21st century (Anderson et al. 2009; Kjærgaard 2010; O'Mathúna 2009). With promises of revolutionary breakthroughs such as advancing cancer detection and treatment, ensuring affordable and efficient manufacturing and fostering growth in business opportunities, nanotechnology has received a considerable amount of attention from scientists, political leaders and technocrats (Mansoori et al. 2007; O'Mathúna 2009; Powell 2007). Despite the promised benefits, there are concerns in the scientific community about the potential negative effects of exposure to nanoparticles on health and environment (Cacciatore et al. 2011; Maynard 2006). Even with the many rigorous debates generated among scientists and researchers, the public seems to be largely unaware of nanotechnology, its application and the its potential risks (Anderson et al. 2005; Cobb 2005; Cobb and Macoubrie 2004; Retzbach et al. 2011).

This low level of awareness of nanotechnology is startling; in order for people to make informed decisions about sciences, there is a need for a minimum level of scientific knowledge (Su et al. 2014). The focus on how much people know—*science literacy*—is often a concern for scientists and communication scholars; for any technology to receive widespread acceptance, the public first must be engaged (Mielby et al. 2013; Petersen 2009). Past studies have found a positive, albeit small, relationship between individuals' knowledge level and their attitude toward science, and a negative association between knowledge and reservations about science (Allum et al. 2008; Nisbet et al. 2002).

The knowledge gap hypothesis is one of the widely used theoretical frameworks to understand science knowledge acquisition (Cacciatore et al. 2014; Su et al. 2014). It posits that information flow in society is unequal and as such, people in the higher socioeconomic status (SES) group will acquire knowledge at a faster rate than those in the lower SES group (Tichenor et al. 1970). However, much of the existing knowledge gap studies primarily focused on *factual knowledge* (Hwang and Jeong 2009), while research on how information flow influences other dimensions of knowledge is scarce.

Knowledge is a multi-faceted concept and it includes other dimensions such as structural knowledge, belief knowledge, and perceived familiarity (Hwang and Jeong 2009; Jonassen et al. 1993; Ladwig et al. 2012). The predominant focus on factual knowledge is partly driven by the belief in the knowledge deficit model (Ladwig et al. 2012; Lee and Scheufele 2006), which assumes that higher factual knowledge will equip people with the competency to separate good science from bad science (Bodmer 1985). However, empirical evidences have shown mixed findings, where the effects of factual knowledge on people's attitude toward scientific developments were small and almost negligible (Allum et al. 2008).

In recent years, scholars have downplayed the role of factual knowledge and focused their attention on the cognitive miser model (Brossard and Nisbet 2007; Scheufele and Lewenstein 2005). The model suggests that judgments toward science are made based on limited information without maximizing cognitive effort. It is impossible for people to get their facts right in the light of competing daily demands (Brossard and Nisbet 2007), and thus people will need to turn to alternative shortcuts for attitudinal formation. If attitudes toward science are formed without much factual knowledge, it may be more pertinent to examine gaps in familiarity than gaps in factual knowledge (Cobb 2005; Cobb and Macoubrie 2004).

Perceived familiarity has often been used as a proxy for concepts such as factual knowledge, self-reported knowledge, or perceived knowledge (Kahan et al. 2009; Satterfield et al. 2009). Ladwig et al. (2012) examined conceptual distinctions between perceived familiarity and factual knowledge, and concluded that the two concepts are not the same as they do not have the same underlying knowledge structures. For instance, Su et al. (2014) found differential effects of individual's attention to media on factual knowledge and perceived familiarity. As such, several scholars have argued that it is important not to conflate the two variables as both have different bearings on science policy outcomes (Bauer and Petkova 2000; Ladwig et al. 2012). Examining perceived familiarity as an outcome variable is especially important for emerging sciences such as nanotechnology as the it is at the infancy stage where news coverage and public awareness of the technology are low (Satterfield et al. 2009).

This study aims to examine how scientific information flow through the media can be associated with discrepant gaps in perceived familiarity with nanotechnology. We propose a perceived familiarity gap hypothesis—an alternative but complementary model to the original conception by Tichenor et al. (1970). We argue that information flow through the media will accentuate the level of perceived familiarity with nanotechnology between the higher and lower SES groups. In addition, to understand how differential attention to science news may influence perceive familiarity, this study also examines how reflective integration—people's processing of information through interpersonal communication and elaborative processing (Liang et al. 2013)—are related to familiarity. Past studies have highlighted interpersonal communication and elaborative processing as potential antecedents of knowledge in various science contexts (Condit et al. 2002; Stamm et al. 2000).

Apart from examining the main effects, this study seeks to examine potential two- and three-way interactions among education, science media use, and reflective integration on perceived familiarity with nanotechnology. The importance of knowledge gap does not merely lie in examining bivariate relationships, but a discovery of a multivariate phenomenon (Eveland and Scheufele 2000). Traditionally, knowledge gap studies that examined three-way interaction focused on how individuals' involvement or interest moderated media use on knowledge acquisitions (e.g. Kwak 1999). Kwak (1999) noted that it was useful to examine three-way interaction in a knowledge gap setting as it could bring out subtle roles of the media that a two-way interaction could not. We want to extend this reasoning to the interaction among education, science media attention, and reflective integration on perceived familiarity as it will give us a more holistic understanding of the phenomenon.

Past studies have shown that media and interpersonal communication about science were often viewed as having complementary roles. Studies have found significant interaction effects among media use and interpersonal discussion on behavior, participation, and knowledge (Eveland and Scheufele 2000; Lee 2010; Scheufele 2002). People who engaged in interpersonal discussion about the content they heard from the media often reported higher knowledge level (Eveland and Scheufele 2000). In our context, media use and interpersonal communication could interact and the level of perceived familiarity could differ across SES groups. In addition, similar interaction patterns could be observed for media use and elaborative processing (Ho et al. 2013). Despite some empirical evidences of interaction among education, media and reflection integration, there is currently no research on understanding how reflective integration may moderate the effects of media use on perceived familiarity across SES groups. As such, we posit these research questions:

RQ1: Does interpersonal communication about science moderate the effects of media attention and education on perceived familiarity with nanotechnology?

RQ2: Does elaborative processing moderate the effects of media attention and education on perceived familiarity with nanotechnology?

Context of study—Nanotechnology

Nanotechnology is deemed as a suitable context for testing the perceived familiarity gap hypothesis (Ladwig et al. 2012; Su et al. 2014) as the technology is not as prominent as sciences such as stem cell research or nuclear energy. These highly publicized sciences typically received large amount of press coverage due to their high level of controversy, thus it is likely that people would already have a degree of exposure to the issues, resulting in a stronger predisposed attitude. Nanotechnology, on the other hand, is in the early phases of the issue-attention cycle where public awareness is low (Ho et al. 2013; Retzbach et al. 2011). The issue-attention cycle describes a process where people's attention to scientific topics go through a cyclical process of wax and wane due to the amount of news coverage dedicated to it (Anderson et al. 2012). There are five stages in the issue-attention cycle of a scientific issue (Downs 1972). The first stage is known as the *pre-problem stage* which is characterized by three key features: low public awareness of the scientific issue, media's emphasis on the benefits of the science, and experts raising issues related to potential risks of the scientific issue (Ho et al. 2013). The second stage is known as *alarmed discovery* in which the public gains more awareness of the scientific issue due to coverage of problems associated with it, such as disasters or accidents. However, at this juncture, public sentiment remains largely positive with the belief that taking the right actions could curb the problems. At the third stage, the public realizes the enormous cost required for solving the problems associated with the scientific issue, which may be beyond their acceptable threshold. At the fourth stage, public attention starts to wane, until it enters the fifth stage, in which another issue dominates the attention of the public.

Nanotechnology is arguably at the initial stage of the issue-attention cycle because it fulfills the three criteria of low public awareness (Ho et al. 2013; Lin et al. 2013; Retzbach et al. 2011), dominant media emphasis on its benefits (Donk et al. 2012; Groboljsek and Mali 2012), and the presence of warnings issued from the scientific community about its potential risks (Handy and Shaw 2007; Wilkinson et al. 2007). Being in the early stage of the issue-attention cycle, people will readily depend on the media to provide them with heuristic shortcut for information processing (Scheufele and Lewenstein 2005). Since a good working knowledge of nanotechnology has yet to diffuse to all segments of the population, we will be able to test how gaps in familiarity between the higher and lower SES groups differ according to the influence of media and reflective integration variables.

Nanotechnology in Singapore

Singapore, like the U.S., places much emphasis on nanotechnology development and it is positioned to be a nanotechnology hub in Asia (Basu and Chang 2005). Much financial investments had been channeled to develop infrastructures to support nanotechnology research (Science and Technology Plan 2010; Science, Technology and Enterprise Plan 2015). The Agency for Science, Technology, and

Research (A*STAR), one of the top research centers in Singapore, has listed nanotechnology as a key area of focus (Ho 2010). In the Science, Technology and Enterprise Plan 2015, S$6.39 million will be devoted to research and development in which nanotechnology is one of the important initiatives. Though this amount is considerably less when compared to the spending in the U.S., it is reflective of the country's efforts in developing nanotechnology (Ho 2010; Liang et al. 2013). As momentum for nanotechnology research in Singapore grows, it is important to examine how nanotechnology information flow influence perceived familiarity as past research has shown that public level of familiarity with a technology determines how receptive they are to it—the more familiar they are with nanotechnology, the higher the perceived benefits and the lower the dread level (Finucane et al. 2000; Kahan et al. 2009; Loewenstein et al. 2001). As perceived familiarity plays an important role in attitudinal formation toward science, it is vital to examine the potential antecedents of perceived familiarity.

Perceived familiarity and Education

Education is a key determinant of differential knowledge gains among the higher and the lower SES groups in the knowledge gap hypothesis (e.g. Gaziano and Horowitz 2001; Holbrook 2002; Kwak 1999; Lee 2009; Shim 2008). In the same way, the educated group will perceive themselves to be more familiar with nanotechnology than the less educated. This is in line with the reasoning of Tichenor et al. (1970), who argued that individuals who receive more education will have an existing knowledge base which speeds up the integration of new knowledge. Formal education allows people to be exposed to information pertaining to science and thus prior knowledge facilitates quicker learning and enables people to understand the significance of the topic (Viswanath and Finnegan 1995).

The lack of formal education on the other hand will impede individuals from lower SES group from becoming familiar with nanotechnology as they may lack the cognitive ability to comprehend the subject matter. In addition, people tend to interact with others in their same social groups, and this will influence the choice of conversation topics (Cacciatore et al. 2014). The chances of nanotechnology and related sciences being discussed among the better educated are higher than the less educated. Thus, we posit:

H1: Education is positively associated with perceived familiarity with nanotechnology.

Media Attention, Education, and Gaps in Perceived Familiarity

Apart from education, one of the other factors that can influence perceived familiarity is the mass media. The media plays a key role as it is the main source of science knowledge for most people (Nelkin 1995). Knowledge gap studies have established that newspaper, television, and internet use were associated with greater knowledge gains (Lee and Scheufele 2006; Mares et al. 1999). Individuals who indicate familiarity with nanotechnology often cite these three sources as the avenues where they first encountered nanotechnology-related information (Hart Research Associates 2007). Thus we posit:

H2: Attention to science newspaper is positively associated with perceived familiarity with nanotechnology.

H3: Attention to science news on television is positively associated with perceived familiarity with nanotechnology.

H4: Attention to science news online is positively associated with perceived familiarity with nanotechnology.

While media attention on the whole may have a direct association with perceived familiarity, the effects on perceived familiarity may differ between the three types of media due to the moderating influence of education. For instance, newspaper use has been shown to have an amplifying effect on gaps in knowledge between the higher and lower SES groups (Kwak 1999). In Singapore, print news stories on nanotechnology had risen steadily from 2002 to 2005, and the amount of coverage remained steady since[1]. As newspaper use is biased toward the educated individuals in the population, more of such in this demographic group will use it (Neuman et al. 1992). The volume of information carried in newspapers can also contribute to familiarity gaps (Jenssen 2012). Since individuals in the higher SES group tend to pay closer attention to science stories in newspapers for educational purposes (Anderson et al. 2010; Nisbet et al. 2002), the likelihood of them encountering nanotechnology stories is higher.

[Insert Figure 1 about here.]

Moreover, print news stories on nanotechnology are often presented with more in-depth information. This means that only those with higher cognitive processing skills will be able to integrate and internalize such information (e.g. Brossard and Nisbet 2007; Yang and Grabe 2011). This is a cognitive ability that is cultivated by higher education. Even if those in the lower SES group come across nanotechnology stories in print newspapers, the difficulties in understanding the complexity of the issue will impede the assimilation of the science constructs into their memory. As such, this leads to a disparity in perceived familiarity between the higher and less educated. We posit:

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[1] To gauge the amount of print news coverage of nanotechnology in Singapore, we conducted a search on Factiva (see Figure 1). Similar to Cacciatore et al. (2014), we used the following search terms: (nanotechnology OR nanotech NOT ipod NOT tata NOT mp3). The search was limited to *Today, The Straits Times,* and *The Business Times* between 2002 and 2012 as they are the major newspapers in Singapore.

H5: Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science newspaper, such that the gap will be larger among those who pay more attention to science newspaper than those who pay less attention.

In contrast to attention to newspaper, attention to television has often been associated with the closure of knowledge gaps (Eveland and Scheufele 2000). Based on longitudinal survey data, Cacciatore et al. (2014) found that television was a knowledge leveler in the context of nanotechnology. People from lower SES group learn more from watching television (Kleinnijenhuis 1991) as the nature of the medium naturally commands attention due to the high entertainment value (Holbrook 2002; Jenssen 2012). As such, television facilitates accidental learning and has been regarded as a public educator (Prior 2007).

Individuals who claimed to be familiar with nanotechnology indicated that the television was a source of information (Jenssen 2012). By introducing new topics such as nanotechnology, it is a key factor in helping the general public to become familiar with nanotechnology, bridging the familiarity level between the higher and lower SES groups. Thus we posit:

H6: Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science news on television, such that the gap will be smaller among those who pay more attention to science news on television than those who pay less attention.

Current research on whether the internet is a knowledge leveler or amplifier is inconclusive. Despite this, we argue that in the context of Singapore, internet use will amplify gaps in perceived familiarity. Compared to traditional mediums such as newspaper and television, the barriers to getting knowledge from the internet is larger for the less educated as the internet can be a source of digital divide (Lee 2009). There are two levels of digital divide (Attewell 2001). The first refers to the constraints in physical access to information, with the lower SES group having limited access to the internet as compared to the higher SES group. The second divide refers to skillset disparity, where the educated will find it easier to navigate the web for information as compared to the less educated (Shim 2008). In addition, the motivation for internet usage can also amplify gaps. Bonfadelli (2002) found that people with higher education use the internet for information seeking while the less educated use it for entertainment. As the educated seek science information online, they may become more familiar with nanotechnology as compared to the less educated who only use the Web for entertainment. The resulting consequence is the amplification of the familiarity gap (Lu and Hindman 2011). Thus we posit:

H7: Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science news online, such that the gap will be larger among those who pay more attention to science news online than those who pay less attention.

Reflective Integration: Interpersonal Communication and Elaborative Processing

Apart from media use and formal education, reflective integration is another factor that may be associated with familiarity disparity. Reflective integration consists of two dimensions—interpersonal communication about science and elaborative processing (Ho et al. 2010). Knowledge can be acquired by talking to friends, family members, or co-workers (Yang and Stone 2003). Earlier works such as the two-step flow model of communication have identified the importance of interpersonal communication (Katz 1957), and interpersonal interaction was highlighted as a contributor to knowledge among the higher SES groups in the original knowledge gap hypothesis (Tichenor et al. 1970).

Research has shown that the more individuals engaged in interpersonal discussion, the more knowledge they gained (e.g. Eveland and Hively 2009; Eveland and Thomson 2006; Powell et al. 2007; Robinson and Levy 1996). Interpersonal networks were cited as one of the avenues which people get to know about nanotechnology (Hart Research Associates 2007). This suggests that as people engage in interpersonal discussion about sciences, the higher their level of perceived familiarity. We also hypothesized that interpersonal discussion is a potential amplifier of familiarity gap between the higher and lower SES groups (Eveland and Scheufele 2000). Being a relatively low profile science, discussion about nanotechnology will be more likely among people in the higher SES group, resulting in a higher level of perceived familiarity (Cobb 2005; Satterfield et al. 2009).

Apart from external factors such as attention to media and interpersonal communication, cognitive processing such as news elaboration can influence perceived familiarity. Elaborative processing is the process where two bits of information are connected with each other (Hamilton 1997). Past studies have shown that engaging in elaborative processing is associated with factual knowledge beyond textbook-style knowledge in both political and scientific contexts (Eveland 2001). The topic of nanotechnology is not one that people think about everyday (Ladwig et al. 2012), but if people spend time piecing together information from the media and other sources, it may result in people becoming more familiar with the topic. We posit that engaging in interpersonal communication and elaborative processing will reduce gaps in perceived familiarity among the higher and lower SES groups:

H8: Interpersonal communication about science is positively associated with perceived familiarity with nanotechnology.

H9: Elaborative processing is positively associated with perceived familiarity with nanotechnology.

H10: Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on the level of interpersonal communication about science, such that the gap will be larger among those who engaged in more discussion about nanotechnology.

H11: Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on the level of elaborative processing, such that the gap will be smaller among those who engaged in high elaborative processing.

Methods

Data was collected at a large public university in Singapore using random digit dialing system at a Computer Assisted Telephone Interview laboratory. We randomly selected 719 Singaporeans and permanent residents aged 18 years old and above to participate in the study, which lasted for two weeks. Interviewers were trained to conduct the survey in the three most common languages—English, Mandarin, and Malay. To ensure a representative sample, the interviewers requested to speak with males 18 years and above; if no males were present, they requested to speak with the oldest female at home (Kennedy 1993). The response rate obtained was 27.1% (based on AAPOR formula 3), with a margin of error of +/- 4% at the 95% confidence level.

Measures

Demographics. Demographic variables included *age* (*M* = 39.9, *SD* = 15.5), *gender* (51.5% female), *monthly household income* (ranging from 1 = "Less than SGD 1, 000" to 11= "More than SGD 10,000;" *Median* = 5.00 or "SGD 4,000 to 5,000," *SD* = 3.06) and *ethnic groups* (73.0% Chinese, 10.3% Malay, 10.3% Indian, 0.7% Eurasian, and 4.5% Others). For *ethnic groups*, four dummy variables were created: "Malay," "Indian," "Eurasian" and "Others," with Chinese as the baseline group.

Independent variables

Education. Education ranged from 1 = "no formal education" to 9 = "postgraduate" (*Median* = 7.00 or "Diploma," *SD* = 1.98).

Attention to newspaper/television news/online news. Participants were asked how much attention they paid to the following news stories on newspaper, television, and the internet on a five-point scale (1 = "None at all," 5 = "A lot"): (a) "Stories related to science and technology," (b) "Stories about scientific studies in new areas of research, such as nanotechnology," and (c) "Stories about social or ethical implications of emerging technologies." The three items were averaged to form three composite indices for *attention to science newspaper* (*M* = 2.88, *SD* = .78, Cronbach's α = .76), *attention to science news on television* (*M* = 2.92, *SD* = .86, Cronbach's α = .81), and *attention to science news online* (*M* = 2.68, *SD* = .85, Cronbach's α = .85).

Interpersonal communication. Interpersonal communication was measured on a five-point scale (1 = "None at all," 5 = "A lot") by asking participants how often they talked with family, friends, and co-workers about the following topics: (a) "Stories related to science and technology," (b) "Stories about scientific studies in new areas of research, such as nanotechnology," and (c) "Stories about social or ethical implications of emerging technologies." The three items were averaged to form a composite index for *interpersonal communication* (M = 2.50, SD = .85, Cronbach's α = .79).

Elaborative processing. Elaborative processing was measured on a ten-point scale (1 = "Do not agree at all," 10 = "Agree very much") in which participants were asked how agreeable they were with the following statements: (a) "I try to make sense of what I encounter in the media by comparing it to my own experiences," (b) "After getting information from the media, I use it to help organize my thoughts, " and (c) "Often when I've learned about something in the news, I'll recall it later and think about it." The three items were averaged to form a composite item called *elaboration* (M = 5.47, SD = 1.86, Cronbach's α = .75).

Dependent variable

Perceived familiarity. Perceived familiarity was a single-item measure in which participants were asked how well informed they were about nanotechnology on a 10-point scale (1= "Not informed at all," 10 = "Very well informed") (M = 3.37, SD = 2.09).

Analytical Approach

We used hierarchical ordinary least squares (OLS) regression analysis to examine the relationship between the independent and dependent variables. To prevent the situation of multicollinearity between interaction terms and the components, the interaction terms were computed by multiplying the standardized values of the respective main effect variables (Cohen et al., 2003). The blocks were entered into the regression model based on their assumed causal order:

1) Demographics (age, gender, income, ethnic groups)

2) Education
3) Attention to media (Attention to science news on newspaper, television, and the internet)
4) Reflective integration (Interpersonal communication and elaboration)
5) Interactions (5 two-way interactions and 6 three-way interactions)

Results

Table 1 shows the zero-order correlations and final standardized beta coefficients obtained from the hierarchical regression analysis. The zero-order correlations show how each of the variables relate to perceived familiarity without accounting for the effects of other factors, while the final standardized beta coefficient shows how each of the variables relate to perceived familiarity with the effects of other variables controlled for.

The value of the final standardized beta coefficient indicates the strength of the relationship between an independent variable and the outcome variable (i.e., perceived familiarity). For example, 1 unit increase in interpersonal communication is associated with a .22 unit increase in perceived familiarity. The final standardized beta coefficients, together with the *p* values, can give us an indication of whether the hypotheses are supported or not. If the *p* value of the standardized beta coefficient is less than .05 (denoted by asterisks in Table 1), it shows that there is a significant association between the independent and dependent variable.

[Insert Table 1 about here.]

First, none of the demographic variables were associated with perceived familiarity. The demographics block accounted for 3.80% of the variances in perceived familiarity.

RQ1 and RQ2 (Block 5) asked how interpersonal communication and elaborative processing moderate the effects of education and attention to science news on perceived familiarity. Block 5 showed that significant three-way interaction were significant for elaboration, education, and attention to science newspaper (β = .10, p < .01). For people with low elaborative processing, there was no significant interaction between education and newspaper (Figure 2a). But for individuals with high elaborative processing, attention to newspaper widened the perceived familiarity gap between the higher and less educated groups, while the gap was negligible for those who did not pay attention to newspaper (Figure 2b).

Elaboration, education, and attention to science news on television also had a significant additive effect on perceived familiarity (β = .09, p < .05). Among individuals who engaged in less elaborative processing, television use did not interact with education (Figure 3a). For individuals with higher elaborative processing, paying more attention to television closed the perceived familiarity gap between the more and less educated groups, while the gap remained for those who paid less attention to television (Figure 3b).

[Insert Figures 2 and 3 about here.]

H1 postulated that education (Block 2) was positively associated with perceived familiarity. However the regression results showed that the standardized coefficient beta was nonsignificant (β = .00, p > .05), thus H1 was not supported. The inclusion of education accounted for .70% of the variances in perceived familiarity.

H2 to H4 (Block 3) postulated that attention to science news on newspaper, television and the internet were positively associated with perceived familiarity. The results showed that attention to science news on newspaper (β = .06, p > .05), television (β = .07, p > .05), and the internet (β = .07, p > .05) were not significantly associated with perceived familiarity. As such, H2 to H4 were not supported. The three measures for media attention to science news accounted for 10.30% of the variances in perceived familiarity.

H5 to H7 (Block 5) theorized that attention to science newspaper ($\beta = .00$, $p > .05$), science news on television ($\beta = -.06$, $p > .05$), and online science news ($\beta = -.02$, $p > .05$) would moderate the effects of education on perceived familiarity. However, the regression analysis indicated that there were no significant two-way interactions. As such, H5 to H7 were not supported.

H8 and H9 (Block 4) postulated that interpersonal communication about science ($\beta = .22$, $p < .001$) and elaborative processing ($\beta = .09$, $p < .05$) were positively associated with perceived familiarity and results supported the two hypotheses. The inclusion of interpersonal communication and elaborative processing explained 4.70% of the variances in perceived familiarity.

H10 and H11 (Block 5) theorized that interpersonal communication about science and elaborative processing would moderate the effects of education on perceived familiarity. Results showed that there was no significant interaction between education and interpersonal communication on perceived familiarity ($\beta = .01$, $p > .05$). Hence, H10 was not supported. However, education and elaborative processing had a significant additive effect on perceived familiarity ($\beta = -.07$, $p < .05$), thus supporting H11 (see Figure 4).

[Insert Figure 4 about here.]

Conclusion of results

Table 2 lists all the hypotheses and indicates if they are supported or not supported. In summary, the regression analysis showed that there were significant three-way interactions between education, attention to science news on television and elaborative processing as well as education, attention to newspaper and elaborative processing; thereby answering RQ2. Support was found for H8, H9 and H11.

[Insert Table 2 about here.]

Discussion

We found partial support for the proposed perceived familiarity gap hypothesis in the context of nanotechnology in Singapore. Significant three-way interactions were found among education, attention to science news, and reflective integration on perceived familiarity. Specifically, attention to science news on television closed the perceived familiarity gap between the higher and lower SES groups for those who engaged in higher elaborative processing, while newspaper use accentuated the gap for those who engaged in higher elaborative processing. Two-way interaction between education and elaborative processing were found, where engaging in high elaborative processing closed the perceived familiarity gap. We also found that interpersonal communication about science and elaborative processing were positively associated with individuals' familiarity with nanotechnology.

The results from the significant three-way and two-way interactions between education, attention to science news on television and elaborative processing highlighted the importance of television in closing the perceived familiarity gap between the more and less educated groups (Figure 3b). This finding is important in the current new media context, where some scholars have downplayed the educational role of television (e.g. Bennett 1994). This study suggests otherwise and shows that television plays a unique role in generating familiarity with nanotechnology and bridging any familiarity gap between the higher and lower SES groups.

This finding is in line with research that claims that television has a knowledge leveling effect (Jenssen 2012). In Singapore, television remains the main choice of entertainment for a large majority (Singapore Business Review 2010). As the less educated tend to pay more attention to television due to its entertainment value (Neuman et al. 1992), the possibility of encountering nanotechnology news in their television usage is higher. Thus, those who are exposed to more coverage of nanotechnology will most likely perceive themselves as being familiar with the topic more than those who paid little attention to television content. Moreover, television is one of the avenues in which people get to know about nanotechnology (Hart Research Associates 2007).

Spending higher cognitive load on elaborative processing and paying more attention to science news on television can bridge perceived familiarity gap between the more and less educated. The nature of engaging in elaborative processing is to use existing stored knowledge structures for the expansion and inclusion of new ideas (Kalyuga 2009). Television use will provide the content for nanotechnology; and if the less educated group spends time processing the content of nanotechnology, familiarity will increase.

The role of cognitively processing information cannot be undermined. Our results also show that without television usage, engaging in elaborative processing closes the perceived familiarity gap between the higher and lower SES groups (see Figure 4). Consistent with previous research (e.g. Eveland 2001), the more individuals engage in elaboration, the higher more they learn.

In contrast to television, science newspaper attention amplified perceived familiarity gaps for Singaporeans, especially for those who engage in high elaborative processing (Figure 2b). This is consistent with previous knowledge gap studies, which attributed the widening gap between higher and less educated segments of society partially to newspaper use (Liu and Eveland 2005; Lu and Hindman 2011). Highly educated Singaporeans may become more familiar with nanotechnology with higher newspaper attention and higher elaborative processing. The reception of information may be faster for the better educated due to the ability to process and integrate information because of the development of higher cognitive processing in higher education.

In terms of direct relationships, interpersonal communication and elaboration were associated with perceived familiarity. The more people discussed and thought about nanotechnology, the more familiar they were with nanotechnology.

There are some practical implications that can be drawn from this study. We gather from our study that gaps in perceived familiarity do exist between the higher and lower strata of society in Singapore when it comes to nanotechnology. Science communicators should think of ways to engage people to think about scientific issues by leveraging on both the media and reflective integration.

When targeting the lower SES group in public communication efforts, television is an important avenue to increase their familiarity with nanotechnology. It is important to let the general public be familiar with nanotechnology as unfamiliarity with science often leads to a rejection of positive technological advances. In our results, elaborative processing is strongly associated with perceived familiarity. Science communicators ought to use television content as a primer for elaborative processing. Since nanotechnology is used in many household products such as washing machines, socks and household appliances, one way to get the less educated group to start thinking about nanotechnology is to emphasize the use of nanotechnology in such products through the media. By getting the public to think about whether they should or should not use nanotechnology products, it will facilitate familiarity.

This study, like many others, has its fair share of limitations. First, the cross sectional nature of the data does not allow for causality to be inferred. Instead of attention to media predicting familiarity, the relationship may be in the reversed direction. Second, perceived familiarity is a one-item measure and future studies can use multiple items to measure perceived familiarity in order to ensure statistical rigor. Third, this study did not take into account how motivation variables and issue relevance influenced perceived familiarity, or how these variables could widen or close existing familiarity gaps. Future studies can incorporate these suggestions and test the perceived familiarity gap with longitudinal data to understand how gap in familiarity closes or widens with time.

Conclusion

This study has made a case for the proposed perceived familiarity gap hypothesis in the context of nanotechnology. We found partial support for the framework—education, media attention, and reflective integration had significant additive effects on perceive familiarity with nanotechnology. While the primary focus of this study is to examine the antecedents of perceived familiarity, future research should examine the relationship between perceived familiarity and public support for nanotechnology, and find out if the nature of the relationship differs when compared to other knowledge dimensions.

Table 1. Hierarchical OLS Regression Analysis for Perceived Familiarity With Nanotechnology

Block 1: Demographics	Zero-order correlations	Final standardized beta
Age	-.07	-.03
Gender	-.09*	-.01
Income	.06	.01
Ethnic Groups		
Malay	-.03	-.05
Indian	-.11**	-.07
Eurasian	-.04	-.05
Others	-.08*	-.07
Incremental R^2 (%)	--	3.80***
Block 2: Education		
Education	.14***	.00
Incremental R^2 (%)	--	.70*
Block 3: Media attention (Science news)		
Newspaper	.29***	.06
Television	.32***	.07
Internet	.30***	.07
Incremental R^2 (%)	--	10.30***
Block 4: Reflective integration		
Interpersonal communication	.38***	.22***
Elaboration	.22***	.09*
Incremental R^2 (%)	--	4.70***
Block 5: Interaction effects	--	
Education*Newspaper	--	.00
Education*Television	--	-.06
Education*Internet	--	-.02
Education*Interpersonal Communication	--	.01
Education*Elaboration	--	-.07*
Education*Newspaper*Interpersonal Communication	--	-.01
Education*Television*Interpersonal Communication	--	.05
Education*Internet*Interpersonal Communication	--	.01
Education*Newspaper*Elaboration	--	.10**
Education*Television*Elaboration	--	.09*
Education*Internet*Elaboration	--	.06
Incremental R^2 (%)	--	2.00
Total R^2 (%)	--	21.50

Note. N = 719; Singaporean Chinese was used as a reference category among the dummy variables of race; *$p < .05$, **$p < .01$, ***$p < .001$.

Table 2. Summary of results

No.	Research questions/Hypotheses	Conclusion
RQ1	Does interpersonal communication about science moderate the effects of media attention and education on perceived familiarity with nanotechnology?	No interactions found
RQ2	Does elaborative processing moderate the effects of media attention and education on perceived familiarity with nanotechnology?	Education*attention to newspaper*elaboration ($\beta = .10$, $p < .01$)
		Education* attention to television*elaboration ($\beta = .09$, $p < .05$)
H1	Education is positively associated with perceived familiarity with nanotechnology.	H1 unsupported ($\beta = .00$, $p > .05$)
H2	Attention to science newspaper is positively associated with perceived familiarity with nanotechnology.	H2 unsupported ($\beta = .06$, $p > .05$)
H3	Attention to science news on television is positively associated with perceived familiarity with nanotechnology.	H3 unsupported ($\beta = .07$, $p > .05$)
H4	Attention to science news online is positively associated with perceived familiarity with nanotechnology.	H4 unsupported ($\beta = .07$, $p > .05$)
H5	Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science newspaper, such that the gap will be larger among those who pay more attention to science newspaper than those who pay less attention.	H5 unsupported ($\beta = .00$, $p > .05$)
H6	Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science news on television, such that the gap will be smaller among those who pay more attention to science news on television than those who pay less attention.	H6 unsupported ($\beta = -.06$, $p > .05$)
H7	Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on individuals' attention to science news online, such that the gap will be larger among those who pay more attention to science news online than those who pay less attention.	H7 unsupported ($\beta = -.02$, $p > .05$)
H8	Interpersonal communication about science is positively associated with perceived familiarity with nanotechnology.	H8 supported ($\beta = .22$, $p < .001$)

H9	Elaborative processing is positively associated with perceived familiarity with nanotechnology.	H9 supported (β = .09, $p < .05$)
H10	Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on the level of interpersonal communication about science, such that the gap will be larger among those who engaged in more discussion about nanotechnology.	H10 unsupported (β = .01, $p > .05$)
H11	Gaps in perceived familiarity with nanotechnology between the more and less educated groups will depend on the level of elaborative processing, such that the gap will be smaller among those who engaged in high elaborative processing.	H11 supported (β = -.07, $p < .05$);

Figure 1. Coverage of news stories on nanotechnology (print)

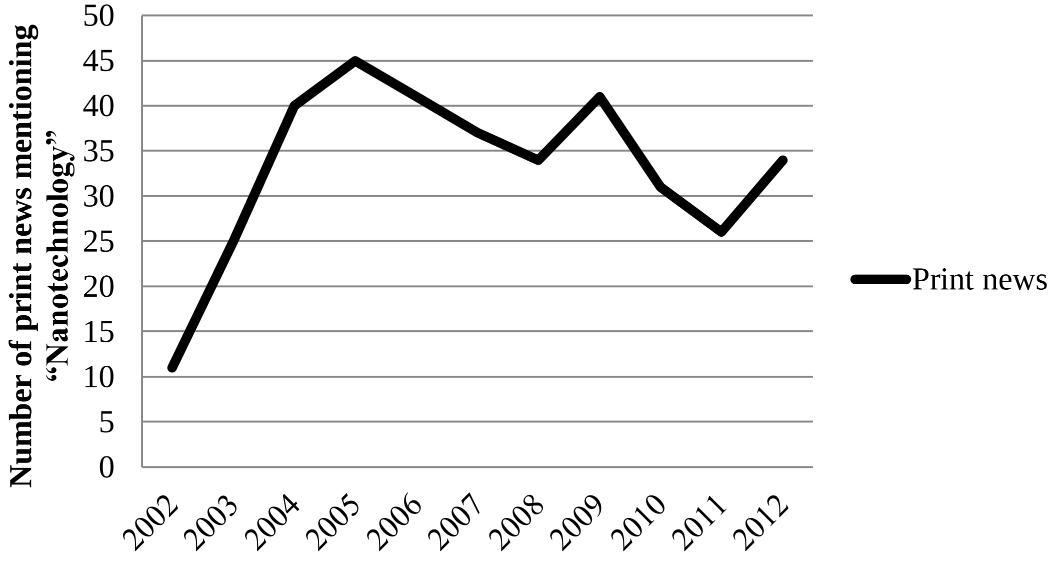
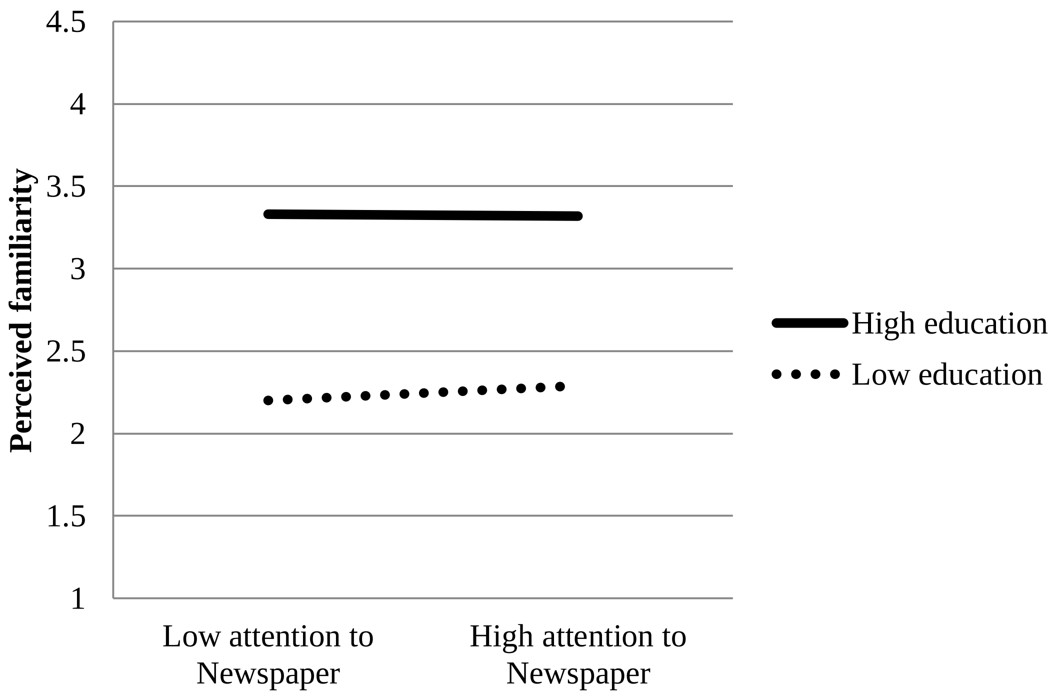
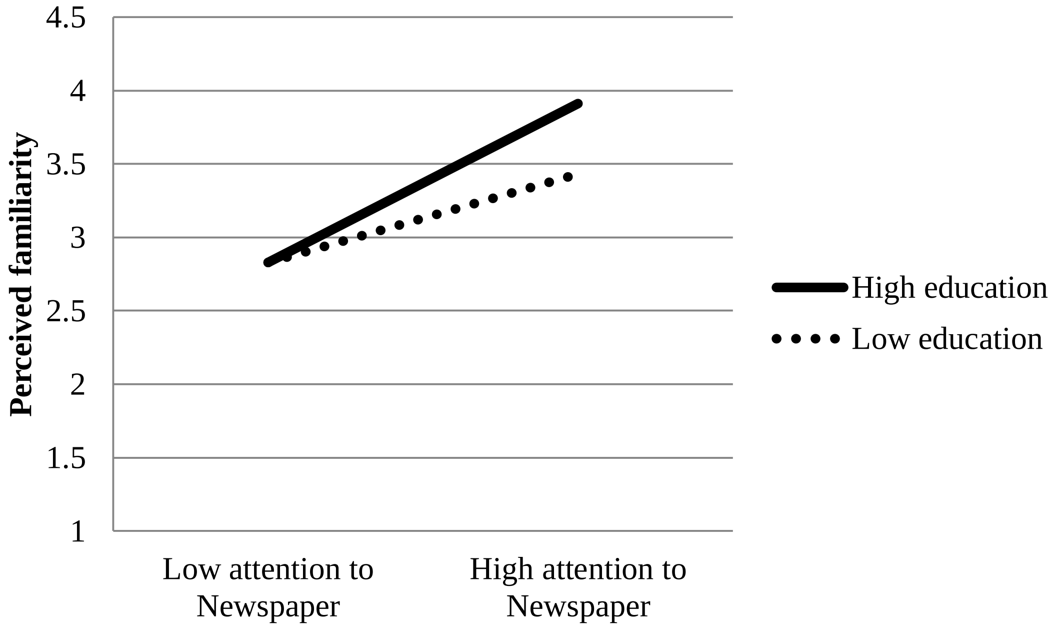


Figure 2a. Perceived familiarity by Education, Attention to Science Newspaper and Elaboration (Low level of Elaboration)



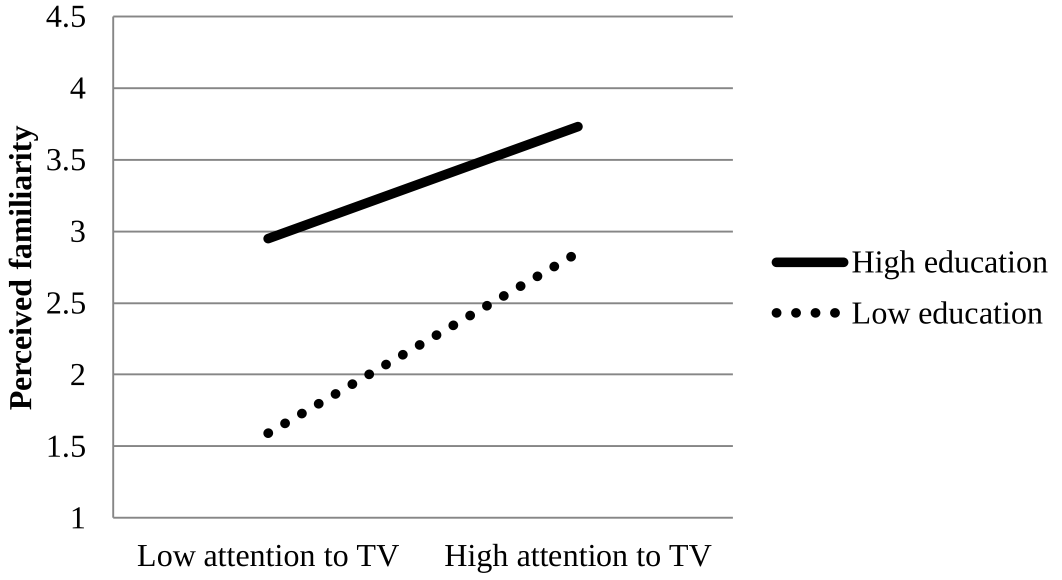
Note. Y-axis presents the estimated values of perceived familiarity, which controlled for all the demographic and independent variables. Scale ranges were only partially displayed on the Y-axis.

Figure 2b. Perceived familiarity by Education, Attention to Science Newspaper and Elaboration (High level of Elaboration)



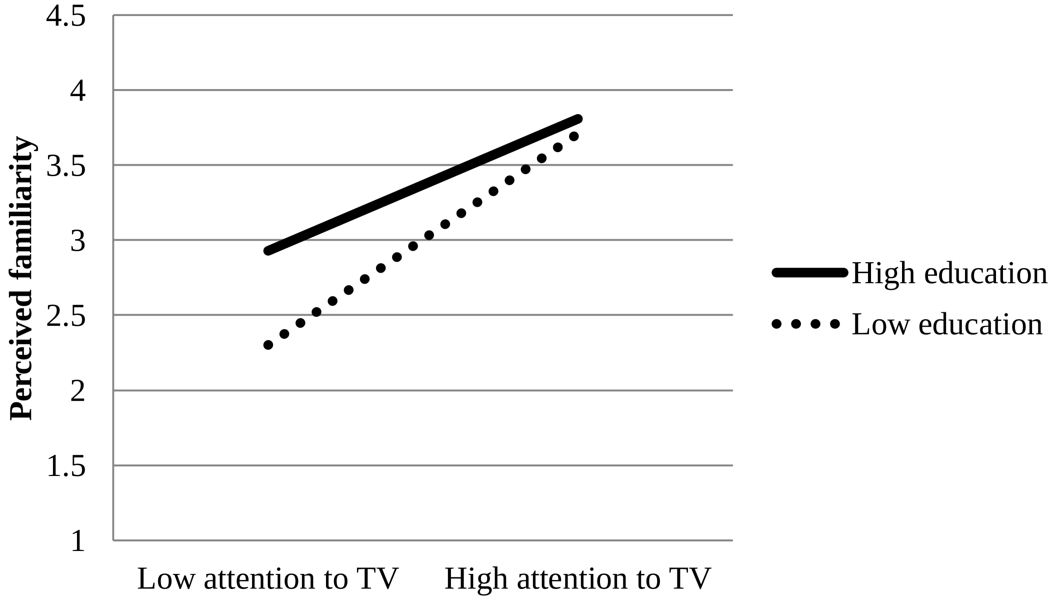
Note. Y-axis presents the estimated values of perceived familiarity, which controlled for all the demographic and independent variables. Scale ranges were only partially displayed on the Y-axis.

Figure 3a. Perceived familiarity by Education, Attention to Science News On TV and Elaboration (Low level of Elaboration)



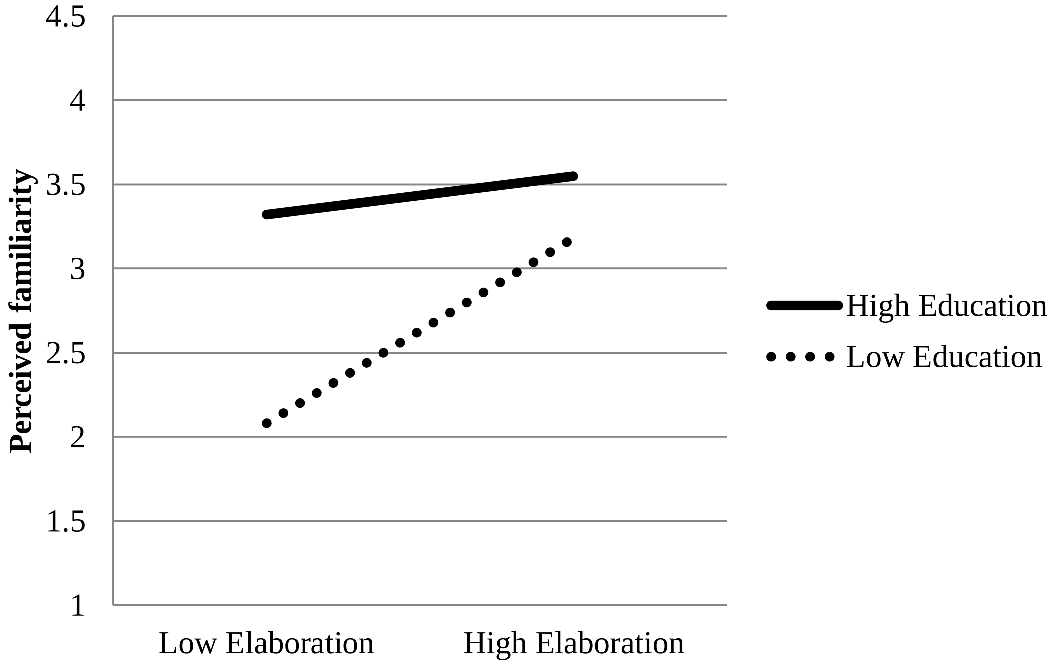
Note. Y-axis presents the estimated values of perceived familiarity, which controlled for all the demographic and independent variables. Scale ranges were only partially displayed on the Y-axis.

Figure 3b. Perceived familiarity by Education, Attention to Science News On TV and Elaboration (High level of Elaboration)



Note. Y-axis presents the estimated values of perceived familiarity, which controlled for all the demographic and independent variables. Scale ranges were only partially displayed on the Y-axis.

Figure 4. Perceived familiarity by Education and Elaboration



Note. Y-axis presents the estimated values of perceived familiarity, which controlled for all the demographic and independent variables. Scale ranges were only partially displayed on the Y-axis.

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