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Motivations to seek science videos on YouTube: Free-choice learning in a connected society

Do individuals use video sharing sites in their free time to learn about science, and if so, why? This study takes a preliminary look at individual differences that motivate online science video seeking. Among 150 Singapore university undergraduates and 123 Singapore Internet users surveyed, most reported using YouTube during the previous week, and one-third reported using it to watch science videos. Hierarchical regression analysis explained 55% of the variance in their intention to seek science videos during the subsequent week. Significant predictors of interest were seeking-related subjective norm, enjoyment of science, and informational orientation to YouTube. Although these results do not distinguish YouTube from other venues of informal science learning, they help characterize YouTube as such a venue and have novel implications for developing online video content to promote science learning in everyday life.

Keywords: YouTube, science videos, public engagement, free-choice learning, planned behavior, uses and gratifications

Word count: 8,898

Introduction

Recent scholarship on science in public emphasizes participation in science-related discourse (Feinstein, 2011; Leshner, 2003; Nisbet & Scheufele, 2009; Stilgoe, Lock, & Wilsdon, 2014).

This public engagement perspective is critical of the view that science communication can improve public acceptance of science simply by imparting scientific knowledge to an undifferentiated mass audience. Rather, effective science communication should attend to contextual factors that reveal who has interest in what science topics and for what reasons: audiences are not passive recipients, but active participants in science communication.

Increasingly, scholars are turning attention to science discourse in social media, where a top-down model of mass science education fails to explain goal-oriented audience engagement (Dudo, 2015; Nisbet & Scheufele, 2009; Uren & Dadzie, 2015).

The current study focuses on YouTube, where several popular channels produce videos on science topics. Some of these channels are associated with established media companies (e.g., National Geographic), while others were started by engineers (e.g., Smarter Every Day), science journalists (e.g., Periodic Videos), science educators (e.g., SciShow), and others interested in sharing science with a global audience. The kinds of videos they produce are often entertaining and educational, and appropriate for both children and adults. For example, a popular video on the channel, Veritasium, demonstrates the Magnus effect with a back-spinning basketball dropped from height, explains the effect using animations, gives historical context, and describes some of its practical applications (Muller, 2015). Within one year of its uploading, the video had garnered more than 30 million views, which suggests its popularity among YouTube audiences.

Although characteristics of channels and video content may help explain their varying popularity, the current study takes an audience-centered perspective to explain the draw of

science videos on YouTube. Past research suggests that individuals engage with online science video content in order to satisfy learning goals (Barry et al., 2016; Moll & Nielsen, 2016). The current study describes consumption of science videos as a kind of free-choice science learning and defines potential audiences by their orientations to such content. This is the first study to attempt understanding how lay publics use YouTube to learn about science.

Data collection takes place in Singapore, where Internet penetration and social media use are among the highest in the world. Web surveys of university undergraduates and Singapore Internet users measure their use of YouTube and intentions to seek science videos on YouTube. The prediction of seeking intention accounts for the influence of attitude toward seeking, seeking-related subjective norm, enjoyment of science, and informational and entertainment orientations of YouTube use. As much as this study is about science learning, it is also a study of media audiences; thus, conceptualization draws on models of media psychology, including the uses and gratifications perspective (Rubin, 1983, 1994) and communication mediation model (Cho et al., 2009; Shah et al., 2007). The results of this preliminary work can guide future research efforts and also support efforts of science communicators to develop enjoyable, informative, and engaging content for YouTube and other video sharing platforms.

The following literature review has two major sections. The first section, Part I, describes the concept of informal science learning and argues that YouTube is a unique venue for public engagement with science. The second section, Part II, considers factors that may motivate public engagement with science on YouTube.

Part I: Informal science learning on YouTube

Public engagement with science on YouTube may be regarded as a kind of informal science learning. Informal science learning refers to engagement with science outside a formal learning environment. Science museums, science centers, zoos, and aquariums are examples of informal science learning venues, where many visitors attend out of curiosity and without specific learning objectives (Falk et al., 2016; Schwan, Grajal, & Lewalter, 2014). In these spaces, learning outcomes align with the unique interests and needs of each visitor, and the experience of science is highly contextual. Scholars have called this sort of self-directed learning *free-choice learning* because learners approach information freely, often guided by intrinsic motivations (Chittenden, Farmelo, & Lewenstein, 2004; Falk & Dierking, 2002). Free-choice learning is a lifelong activity, and it is unsurprising that many adults identify it as their primary source of information on science topics that interest them (Falk & Needham, 2013; Falk, Storksdieck, & Dierking, 2007).

Recent work has differentiated among sources of information that support free-choice science learning. One study found that adults' self-reported knowledge of science and technology was most strongly related to the use of books and magazines, watching science-related documentaries and videos, and using the Internet (Falk & Needham, 2013). As well, individuals who use a variety of traditional media and Internet sources to learn about science have better understanding of specific science issues (Author, blinded) and also of science more generally (Su, Akin, Brossard, Scheufele, & Xenos, 2015).

While traditional and new media continue a long trend toward convergence, audiences are increasingly using Internet-enabled smart devices to access all kinds of media content (Cooke, 2005; Ellingsen, 2014). These trends suggest that the relative importance of Internet

sources for various uses, including free-choice science learning, is likely to grow. Indeed, countless websites devoted to science topics garner diverse audiences, each with a particular set of interests, and YouTube has become a plentiful source of science videos. For example, as of September 2016, ten of the more popular science-related YouTube channels collectively have close to 50 million subscribers and 6 billion video views (see Table 1).

As a point of comparison, YouTube is gaining popularity as teaching tool in formal learning environments. A 2013 survey of more than 6,000 university educators in Italy showed that, among several social media platforms they used for teaching, video sharing sites were used most frequently (Manca & Ranieri, 2016). Nearly 40% of those educators said they had used YouTube or Vimeo for teaching, half of whom reported at least monthly use. Another study found that educators in the U.S. and Japan had positive intentions to use YouTube for teaching, and were motivated by the belief that such use would help them perform their jobs (Jung & Lee, 2015). Finally, Sugimoto and Thelwall (2013) compiled a list of more than 1,000 recorded TED Talks available online. They found that nearly all of the recordings appeared in the reading lists of online syllabi. These studies suggest that educators see pedagogical value in video sharing websites, whose value may extend into informal learning environments. Indeed, among different social media platforms individuals use on their own time for learning, video sharing sites seem to be the most useful (Kind & Evans, 2015).

Scholars have yet to focus their attention on the audiences, or even potential audiences, of science videos on YouTube, but previous research on informal science learning in other contexts may help characterize these audiences. For example, Author (blinded) found that attendees of an informal science lecture series were motivated to attend out of interest, curiosity, and social utility. Similarly, Vedder-Weiss and Fortus (2013) found that extracurricular science learning

among middle school students was positively related to their science mastery goals, a relationship that increased with the age of the students. Their results suggest that students who enjoy learning are more likely to engage with science outside the classroom. Similarly, Falk et al. (2016) found that individuals who “really like science,” a segment representing nearly half of a large international sample, used the Internet weekly to learn about science.

YouTube in Singapore

The national context of the current study, Singapore, has been at the forefront of data network and smart device diffusion. In 2005, the Infocomm Development Authority of Singapore published a 10-year masterplan to grow the infocommunication sector. Among several targets, the masterplan sought to increase home broadband access from 54% to 90%. At the conclusion of the 10-year period, 85% of homes had broadband access (Infocomm Development Authority of Singapore, 2015). Although the Internet user penetration rate was only 73% in 2013, Singapore led the world in mobile broadband access, with a penetration rate of 134% (Broadband Commission, 2014). Thus, while there are many individuals not using the Internet, most have access, and those who are online are well connected.

Among those who are online, most use social media. In 2014, the social media penetration rate was 71% (Broadband Commission, 2014), which nearly equals the Internet penetration rate. Official statistics of YouTube use in Singapore are not published, but market research suggests that in 2015 roughly 50% of Singapore residents had YouTube accounts (Hashmeta, 2016). The potential value of YouTube as a venue for informal science learning depends partly on individuals using YouTube to watch science videos, which two research questions address:

RQ1: How much do Singapore Internet users report using YouTube?

RQ2: How much do Singapore Internet users report watching science videos on YouTube?

Use of science videos on YouTube likely differs among individuals, and an additional empirical question might ask about what factors influence science information seeking on YouTube. The answer to this question can build on theories of media use and the findings of communication research.

Part II: Model of (science) information seeking

Seeking as reasoned action

Modern paradigms of mass communication and science communication implicate rational decision making by audiences, and media use and information seeking are a kind of reasoned or planned behavior. The theory of reasoned action describes cognitions that influence behavioral intention and actual behavior (Fishbein & Ajzen, 1975), and provides a straightforward account of information seeking intention (Ross, Kohler, Grimley, & Anderson-Lewis, 2007). According to the theory, intention to perform a behavior is a good predictor of actual behavior, assuming individuals have volitional control over the behavior. Behavioral intention arises from two factors: attitude toward the behavior and subjective norm.

Attitude toward seeking

Attitudes are valenced summary evaluations about an object that reflect underlying beliefs about it (Ajzen, 2001). They are valenced insofar as they convey positive or negative attributes of an attitude object. For example, individuals tend to regard seeking cancer information as a valuable, productive, and beneficial behavior (Hovick, Kahlor, & Liang, 2014). Research shows consistently that the more positive the attitude toward the behavior, the stronger the behavioral intention (Armitage & Conner, 2001). In the current context, believing that seeking science

videos on YouTube is useful, enjoyable, or otherwise worthwhile should motivate individuals to engage in that behavior.

H1: The more positive the attitude toward seeking, the greater the intention to seek science videos on YouTube.

Seeking-related subjective norm

Another factor that influences behavioral intention is the belief that a behavior is normal. Individuals prefer to engage in behaviors that are consistent with a perceived, or subjective, social norm in their immediate social environment (Bond & Smith, 1996). Consequently, individuals are motivated to direct their intended behaviors toward norm-compliance. Prior research shows that individuals have greater information seeking intention when they perceive a seeking-related social norm (Hovick et al., 2014; Kahlor, 2010; Ross et al., 2007). In the current context, individuals may be motivated to seek science videos on YouTube because they see that others do it or believe that others would approve of it.

H2: The greater the seeking-related subjective norm, the greater the intention to seek science videos on YouTube.

Audience Orientations

The literature review above provides a baseline predictive model is well established in many behavioral contexts and aligns with characterizations of media use as a planned behavior. Consistent with this description of media use, the uses and gratifications perspective (Rubin, 1983, 1994) provides an audience-focused account of why individuals use media to gratify specific social and psychological needs. The kinds of needs that audiences may seek to gratify vary by the types of media content under consideration, characteristics of audiences, communication settings, and other factors. For example, individuals use social media to gratify

several needs—e.g., entertainment, getting news, and learning—and regard personalization as an important channel characteristic that supports their use (Korhan & Ersoy, 2016).

Building partly on the uses and gratifications framework, the O-S-R-O-R model is a communication mediation model that explains seeking, processing, and responding to media messages, a sequence that begins with audience predispositions, or orientations, to engage with media messages. (Cho et al., 2009; Shah et al., 2007). Audience orientation, the first “O” in the model, refers to “the set of structural, cultural, cognitive, and motivational characteristics the audience brings to the reception situation that affect the impact of messages” (McLeod, Kosicki, & McLeod, 1994, pp. 146-147). That is, audience orientation affects to what extent audiences engage with a media stimulus, the “S” in the model. Engaged audiences may reason about the message, invoking the first “R,” and develop an outcome orientation, the second “O,” which may include new knowledge, attitudes, or perceptions about the object of the message. Finally, individuals may alter their opinion or behavior, for example, by engaging with an issue in public. This response is the second “R” in the model.

The current study focuses on the O-S portion of the model, which accords with the use and gratifications perspective, and identifies orientations that may predispose audiences to seek science videos on YouTube. Such focus is one starting point to explain free-choice science learning on YouTube, which in this study emphasizes two kinds of audience orientations. First, *enjoyment of science* can explain effects of contextual relevance and intrinsic motivation. Second, *user orientation* to YouTube may influence the kinds of videos audiences seek. The subsections below explore these concepts.

Enjoyment of science

Prior work suggests that individuals are motivated to engage with science when they find it interesting or enjoyable (Falk et al., 2016; Falk et al., 2007). Krapp and Prenzel (2011) described interest in science as an orientation to science content characterized by goal-related cognitions and positive affective states. They distinguished the closely related concept, *enjoyment of science*, as being a more purely affective orientation. This latter concept captures both the intrinsic motivations that drive engagement and the positive feelings, e.g., happiness, that come from it. Both interest and enjoyment may influence public engagement with science, but enjoyment seems especially related to free-choice science learning (Lin, Lawrenz, Lin, & Hong, 2013). That special influence further suggests that free-choice science learning is related to intrinsic motivation, and also that individuals who enjoy science are oriented to engage with science-related stimuli.

Gogolin and Swartz (1992) conceptualized enjoyment of science as a dimension of attitude toward science. They identified additional dimensions of attitude toward science, including anxiety toward science (e.g., being fearful of taking a science class), value of science in society (e.g., believing that science can solve problems in everyday life), and self-concept in science (e.g., feeling competent about science). For parsimony, this study emphasizes enjoyment of science, which relates both the contextual relevance and intrinsic motivation for individuals to seek science videos on YouTube. Prior work shows that individuals who enjoy science report more engagement with science in the media (e.g., Falk et al., 2016), an effect that may extend to predict intentions to seek science videos on YouTube.

H3: The greater the enjoyment of science, the greater the intention to seek science videos on YouTube.

Use orientation

As the uses and gratifications perspective suggests, media users approach particular media content when they expect it to satisfy a specific need. Consequently, such users are oriented to that content with respect to that need. The current study focuses on instrumental needs (e.g., surveillance and learning) and experiential needs (e.g., entertainment and leisure), which researchers have differentiated to explain uses of informational and online media (Zhang & Zhang, 2013). For example, individuals who go online to gather knowledge and information have a utilitarian or practical orientation to the Internet (Weiser, 2001).

Video-sharing sites, like YouTube, blend information technologies with entertainment media (see Li, 2015). These characteristics of video-sharing sites suggest a distinction between instrumental and experiential orientations of media use. In one study, instrumental orientation was related to online news seeking, while entertainment orientation was related to watching online videos (Zhou, Fong, & Tan, 2014). In another study, Go, You, Jung, and Shim (2016) found that use of social media was positively related to information seeking and unrelated to entertainment motivation. Finally, Bondad-Brown, Rice, and Pearce (2012) found that online user-shared video use was positively related to informational uses and negatively related to uses for entertainment and passing time. This prior work suggests a consistent positive effect of instrumental orientation, but the effect entertainment orientation is equivocal. The current study explores these relationships in the context of science video seeking on YouTube.

H4: The greater the informational uses of YouTube, the greater the intention to seek science videos on YouTube.

RQ4: What is the relationship between entertainment uses of YouTube and intention to seek science videos on YouTube?

Method

Sample

This study recruited 273 participants in two waves to complete an online survey in English. The first wave, during one week in November 2015, took a convenience sample of 150 undergraduate communication students at a large research university in Singapore. Participants received partial course credit. The student sample was 79% female with a median age of 21 years and a self-reported median household income of \$6,001 to \$7,000 (Singapore dollars) per month.

The second wave, during two weeks in December 2015, took a probability-based sample of households in western Singapore. The sampling frame was all public-scheme housing units in the Jurong West region.¹ Multistage cluster sampling involved three steps: (1) random selection of five neighborhoods, (2) random selection of four residential buildings in each neighborhood, and (3) random start floor in each building. Every other unit on a floor received an invitation to participate. The invitation letter contained a simple URL that invitees could follow using a computer or smart device. Of 840 invitations distributed, 123 individuals completed the questionnaire. The neighborhood sample was 51% female with a median age of 31 years and a self-reported median household income of \$5,001 to \$6,000 (Singapore dollars) per month.

Measurement

Use of YouTube

Participants first read a brief description of YouTube and then answered the question, “During the last week, how many days did you use YouTube to watch videos?” Response options ranged

¹ In Singapore, the Housing Development Board develops high-rise housing projects, which it sells or rents to citizens. According to the Housing Development Board (2014), in fiscal year 2013/2014, 82% of Singaporeans lived in public-scheme units, and the Jurong West region contained more housing units than any other region, accounting for roughly 7.5% of all units in Singapore. Furthermore, assignment to housing units in Singapore involves a computerized random balloting system to ensure fairness of residential assignment (Housing Development Board, 2015), while strict quotas maintain a balance of ethnic groups within housing blocks and neighborhoods (Housing Development Board, 2016).

from 0 to 7. Respondents who answered one day (or more than one day) saw a second question, “About how much time did you spend that day (or each day) watching YouTube?” Response options were in 15-minute increments for the first hour, then half-hour increments up to 8 hours. The maximum response option was “more than 8 hours.”

Next, participants read a brief description of science videos on YouTube, “Some YouTube channels contain science videos that are intended to be educational and entertaining,” and answered, yes or no, “During the last week, did you watch any of these kinds of videos on YouTube?” For respondents who answered in the affirmative, a second question asked, “During the last week, approximately how many of these videos did you watch on YouTube?” Response options were “1 or 2,” “3 to 5,” “6 to 10,” and “more than 10.” The results section presents the descriptive statistics for these items.

Seeking intention

Measurement of intention, attitude, norm, and perceived control follow Ajzen’s (2006) recommendations for constructing a theory of planned behavior questionnaire. Four items measured seeking intention on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Examples of these items are “During the next week I intend to watch science videos on YouTube” and “During the next week I do not plan to find any science videos on YouTube” (reverse-coded; $M = 2.96$, $SD = 0.84$, Cronbach’s $\alpha = .91$).

Attitude toward seeking

Ten semantic differentials measured attitude toward seeking on instrumental and experiential dimensions (Ajzen & Driver, 1992), which prior research has linked with information seeking (Author, blinded). These dimensions correspond respectively with perceived functional value and perceived entertainment value of information seeking. Each measurement item contained a

pair of opposing adjectives with a common root, “Watching a science video on YouTube during the next week would be.” Response options ranged from 1 (*negative adjective*) to 5 (*positive adjective*). Examples of the five items measuring instrumental attitude are “foolish/wise” and “uninformative/informative,” and examples of the five items measuring experiential attitude are “unpleasant/pleasant” and “uninteresting/interesting.” The composite index was the average of the 10 items ($M = 3.74$, $SD = 0.67$, Cronbach’s $\alpha = .92$).

Seeking-related subjective norm

Six items measured subjective norm on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The items shared the common root, “During the next week:” and reflected two dimensions of subjective norm, descriptive and injunctive, which reflect beliefs about how much others engage in the behavior and how much others approve or disapprove of the behavior, respectively (Cialdini, Kallgren, & Reno, 1991; Lapinski & Rimal, 2005). Examples of items measuring descriptive norm are “The people I spend most of my time with will watch science videos on YouTube” and “It is unlikely that my friends will watch any science videos on YouTube” (reverse-coded). Examples of items measuring injunctive norm are “If I watched science videos on YouTube my friends would approve” and “Most people who are important to me would approve of me watching science videos on YouTube.” The composite index was the average of the six items ($M = 3.16$, $SD = 0.58$, Cronbach’s $\alpha = .78$).

Enjoyment of science

A subset of three items modified from Gogolin and Swartz’s (1992) Attitude Toward Science Inventory measured enjoyment of science on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*): “Science is something I enjoy very much,” “I enjoy talking to

other people about science,” and “Science is one of my favorite topics” ($M = 3.16$, $SD = 0.83$, Cronbach’s $\alpha = .86$).

Use orientation

Six items measured how often respondents use YouTube for informational and entertainment purposes. The items shared the common root, “When you use YouTube, how often do you use it for....” Response options ranged from 1 (*never*) to 5 (*all of the time*). Table 2 contains item wording. Three items measured informational use ($M = 3.28$, $SD = 0.68$, Cronbach’s $\alpha = .78$) and three items measured entertainment use ($M = 3.95$, $SD = 0.77$, Cronbach’s $\alpha = .85$). Maximum likelihood factor analysis with oblique rotation showed two weakly correlated factors ($r = .19$) with good simple structure. The two factors explained 74% of the variance in the items (see Table 2). Table 3 contains the variance, covariance, and correlation matrix of the measured variables.

Results

Use of YouTube

The small samples do not allow generalization to either students or the general public in Singapore, but the data may partially answer the first two research questions, which asked how frequently people in Singapore use YouTube and watch science videos on YouTube.

Respondents reported using YouTube an average of five days in the previous week ($M = 4.97$, $SD = 2.07$, $Mdn = 5$). Only eight respondents said they did not use YouTube at all during the previous week, and more than one-third ($n = 102$) reported using it every day. Among those who reported using YouTube at least one day ($n = 265$), the maximum amount of time spent using YouTube each day was seven hours ($Mdn = 1$ hour). The lower 25th percentile used YouTube for a half-hour, while the upper 25th percentile used it for two hours. Self-reported use

among the student sample ($M = 5.55$, $SD = 1.64$, $Mdn = 6$) was greater than among the neighborhood sample ($M = 4.26$, $SD = 2.33$, $Mdn = 4$), $t(271) = 5.37$, $p < .001$

Those who reported using YouTube at least one day during the previous week also reported how many science videos they had watched. Nearly two-thirds ($n = 169$) said that they did not watch any science videos, which was the median and modal response for both subsamples. About one-fifth ($n = 52$) said they watched 1 or 2 videos and about one-tenth ($n = 29$) said they watched 3 to 5 videos. Far fewer respondents said they watched 6 to 10 videos ($n = 10$) or more than 10 videos ($n = 5$). Self-reported science video seeking was greater among the neighborhood sample ($M = 0.80$, $SD = 1.13$) than among the student sample ($M = 0.43$, $SD = 0.73$), $t(271) = -3.29$, $p = .0011$. This variable (hereafter, “past seeking”) was a control variable in the regression model.

Prediction of Seeking Intention

Although the two samples were distinct with respect to demographics, YouTube use, and science video seeking, the predicted relationships were invariant between samples. Specifically, the interaction between sample and each hypothesized predictor variable was not significant. The only interaction effect that approached significance was between sample and experiential orientation ($\beta = -.15$, $p = .059$). Among the remaining interaction terms, $\bar{p} = .49$. Thus, subsequent analyses use the pooled sample ($N = 273$).

Hierarchical linear OLS regression in SPSS version 24 predicted seeking intention. Independent variables were sample (0 = student, 1 = public), sex (0 = male, 1 = female), past seeking,² attitude toward seeking, seeking-related subjective norm, perceived seeking control,

²Ajzen (1991) argued that, after controlling for past behavior, any residual relationship between past behavior and behavioral intention suggests that the model has omitted an important explanatory factor (p. 203). Furthermore, including past information seeking as a predictor controls for the more habitual aspects of information seeking (Ho, Detenber, Rosenthal, & Lee, 2012; Rosenthal, 2011).

enjoyment of science, entertainment orientation, and informational orientation. The analysis used 1,000 bias-corrected and accelerated bootstrap samples to estimate standard errors and 95% confidence intervals of the unstandardized slopes (see Table 4). The regression slopes reported below refer to the final model after all variables have been entered. For additional reference, Table 5 shows the standardized slopes of the model split by sample.

Control variables

In the first block of the regression model, seeking intention was and positively related to past seeking ($\beta = .13, p = .010$) and negatively related to sex ($\beta = -.09, p = .030$). It was unrelated to sample ($\beta = .09, p = .063$). This first block explained 27.6% of the variance in seeking intention.

Reasoned action

The second block tested hypotheses based on the theory of reasoned action, which stated that seeking intention is related to attitude toward seeking (H1) and seeking-related subjective norm (H2). Failing to support H1, seeking intention was unrelated to attitude ($\beta = .14, p = .065$). Supporting H2, seeking intention was positively related to norm ($\beta = .29, p < .001$). This block of independent variables explained 21.8% of the variance in seeking intention.

Audience orientation

The third block tested extensions of the theory of reasoned action, which predicted that seeking intention is positively related to enjoyment of science (H3) and informational use of YouTube (H4). In support of H3 and H4 seeking intention was positively related to enjoyment of science ($\beta = .26, p < .001$) and informational use ($\beta = .12, p = .015$). One research question (RQ4) asked about the effects of entertainment use of YouTube, which results showed was non-significant ($\beta = .005, p = .929$). This block of independent variables explained 5.4% of the variance in seeking intention. Total explained variance was 54.8%.

Discussion

This study examined some of the reasons individuals seek science videos on YouTube. Analysis of survey data found that respondents—university students and members of the public—reported using YouTube regularly, but do not watch many science videos. The literature review developed a straightforward model of science video seeking intention based on the theory of reasoned action (Fishbein & Ajzen, 1975), uses and gratifications perspective (Rubin, 1983, 1994), and O-S-R-O-R model (Cho et al., 2009; Shah et al., 2007). The results of a regression analysis have theoretical and practical implications for free-choice science learning on YouTube.

Seeking as reasoned action

The results showed a predicted effect of seeking-related subjective norm, but failed to show an effect of attitude toward seeking. However, the latter null finding emerged only in the third regression model. In the second regression model, attitude and norm had comparably significant effects on seeking intention. The attenuated effect of attitude in the third model was related to the addition of variables in the third block with which it had moderate-to-strong correlations: enjoyment of science ($r = .57, p < .001$) and informational uses of YouTube ($r = .40, p < .001$). The attenuation suggests that the effect of attitude toward seeking is nuanced and reflects not only beliefs about the act of seeking (e.g., that it is worthwhile), but also beliefs about the epistemological domain of content being sought (e.g., that science is interesting) and the channel through which seeking occurs (e.g., that YouTube is useful). It may also be that these three kinds of beliefs share a common antecedent and have a spurious relationship. For example, need for cognition, or individuals' inclination to engage in effortful thinking, is distal predictor seeking intention (Bailey, 1997; Das, Echambadi, McCardle, & Luckett, 2003; Hughes, Rowe, Batey, & Lee, 2012), and correlates with attitude toward science (Feist, 2012). Whatever the relationship,

current results suggest that the influence of attitude toward seeking is completely mediated, at least in the context of science videos on YouTube. What are more general features of topical enjoyment and channel beliefs that would have this effect in other contexts? Future research can address this question.

On the other hand, while norm was related to enjoyment of science ($r = .39, p < .001$), its effect on seeking intention was virtually unchanged between the second and third regression models. The moderate correlation with enjoyment of science may be the result of individuals associating (or at least perceiving they associate) with like-minded others, which may alter their perception that others share their view of science. This assertion is somewhat consistent with the norm activation model, which suggests that personal norms reflect subjective norms (Doran & Larsen, 2016; Lauper, Moser, Fischer, & Matthies, 2016). Then again, enjoyment of science is less a personal norm than it is an attitude, which is perhaps why its effect on seeking intention was independent of subjective norm. Self-concept in science (Gogolin & Swartz, 1992), while still conceptualized as a dimension of attitude toward science, might better capture a science-related personal norm. It would be interesting to see if self-concept in science mediates the influence of subjective norm on seeking intention.

Audience orientations

This study extended the prediction of seeking intention by looking at audience orientations that may incline YouTube users to seek science videos. Relevant theorization drew on the uses and gratifications perspective and the communication mediation model. The first orientation, enjoyment of science, was positively related to seeking intention. This finding suggests that individuals who seek science videos on YouTube have positive feelings toward science and are intrinsically motivated to engage with it. Enjoyment of science characterizes a key audience

orientation that motivates individuals to seek science-related stimuli. As a similar orientation underlies free-choice science learning (Chittenden et al., 2004; Falk & Dierking, 2002), this finding corroborates the assertion that science video seeking on YouTube is a kind of free-choice science learning. Whereas science educators in formal learning environments may use YouTube as an instructional tool (e.g., Jung & Lee, 2015), additional value of science videos on YouTube arises when individuals use it to learn about science on their own time.

The second orientation distinguished between two kinds of YouTube use, one related to informational uses and the other related to entertainment uses. Results showed that individuals whose YouTube use is more oriented to information than to entertainment have greater intention to seek science videos on YouTube. This result suggests a need to ensure that science content on YouTube contains high-quality information, as users may be seeking to satisfy learning objectives when they watch science videos (Moll & Nielsen, 2016). Also, Earnhardt (2013) found that individuals who use the Internet for information seeking have a higher need for cognition and are more likely to process media messages with effort. Thus, science videos on YouTube that contain high-quality information may help meet the needs of information-oriented users and also support effortful information processing. On the other hand, use of YouTube for entertainment was unrelated to seeking intention. One explanation of this null finding is that individuals tend not to associate science with entertainment. Lending support to this explanation, there was a negative relationship between enjoyment of science and entertainment use of YouTube ($r = -.22, p < .001$).

As well, respondents' infrequent viewing of science videos on YouTube may be related to them reporting more entertainment ($M = 3.95$) than informational ($M = 3.28$) uses of YouTube, $t(272) = 11.93, p < .001$. Further work might clarify this finding by exploring the

relationship between entertainment orientation and other dimensions of attitude toward science, such as anxiety toward science (Gogolin & Swartz, 1992). If individuals who use YouTube for entertainment have negative feelings about science, then promoting science video seeking among those individuals may prove challenging. Overcoming anxiety toward science can be achieved in a formal learning environment (Follette & McCarthy, 2012), but it is unclear how to achieve such an outcome via free-choice learning. If the challenge is simply that individuals dissociate “science” and “fun,” then there is an opportunity to promote science through developing content that has mass entertainment appeal, while still containing high-quality information.

Limitations and future directions

As a preliminary effort to study audience predispositions to seek science videos on YouTube, this study did not consider processes that occur during or subsequent to stimulus exposure, as the O-S-R-O-R model describes (Cho et al., 2009; Shah et al., 2007). If seeking science videos on YouTube is a kind of free-choice learning, then it is important to study learning outcomes, which involve the R-O-R portion of the model. Future research might consider how audience orientations and characteristics of science videos influence information processing. Such inquiry could look to models of information processing (e.g., Griffin, Dunwoody, & Neuwirth, 1999) that explain not only why individuals seek information, but to what extent they process it with effort. Research on message processing could also consider perceptions of credibility that affect how audiences evaluate science videos on YouTube, given the lack of information gatekeepers (Shapiro & Park, 2015). Such cognitions could affect content selection and information retention.

Further, content analysis of science videos on YouTube could identify characteristics of videos and content channels that mediate the relationship between audience orientation and

information processing. Some research has begun to conduct such analysis in limited science-related contexts (e.g., Jaspal, Turner, & Nerlich, 2014). There is also a need to conduct semantic analysis of comments, and evaluate the nature of interactions among content creators and multiple audience members, which research has begun to explore (e.g., Shapiro & Park, 2015). That kind of research can add a social dimension to free-choice science learning on YouTube.

An additional limitation, this study predicted behavioral intention and not actual behavior. Although behavioral intention is a good predictor of actual behavior in many behavioral contexts, the correspondence is far from perfect (Sheeran, 2002). It is possible that individuals overstate their intention, as viewing science videos on YouTube may be socially desirable. Prior research shows that behavioral intention has upward bias when the behavior is socially desirable (Chao & Lam, 2011). It is also possible that, by asking respondents about their intention, they modify their subsequent seeking behavior (Rodrigues, French, & Sniehotta, 2016), which would limit the ecological validity of the current study. Also, it will be necessary to account for actual seeking if future research is to address learning outcomes.

Finally, this study was limited by two small samples, one of which was based on non-probability sampling. It is encouraging that the regression model was invariant between the two samples, but that conclusion may be a Type II error, where limited statistical power obscured real differences in slopes between the two samples.

Conclusion

In conclusion, this study took preliminary steps to document and explain the use of YouTube for viewing science videos. Results suggest that, although YouTube use is widespread in Singapore, its use for viewing science videos is less prevalent. A regression model based on the theory of reasoned action, uses and gratifications perspective, and communication mediation model

predicted 55% of the variance in science video seeking intention. Entertainment-oriented YouTube users were not particularly motivated to seek science videos, while those who use it for information and also those who enjoy science had greater seeking intention. These findings suggest that seeking science videos on YouTube is a reasoned action and a kind of free-choice science learning.

Table 1. Summary of popular science-related channels on YouTube

	Creation Date	Number of Videos	Subscribers (millions)	Video Views (millions)
AsapSCIENCE	05/2012	197	6.0	677.3
CrashCourse	05/2016	658	5.3	506.6
In a Nutshell	07/2013	56	3.4	187.3
MinutePhysics	06/2011	185	3.6	300.0
National Geographic	05/2006	7,586	5.5	1,744.7
Numberphile	09/2011	397	1.9	234.0
SciShow	10/2011	1,133	3.9	575.9
SmarterEveryDay	04/2006	246	4.4	336.5
Veritasium	07/2010	213	3.9	311.2
Vsauce	07/2007	328	11.3	1,102.1
Total		10,999	49.2	5,975.7

Note. Figures updated 28 December 2016.

Table 2. Factor analysis of use orientation items

<i>Factor Label</i>	Factor	
Item wording	1	2
<i>Informational Use</i>		
Learning something new	.020	.627
Having an educational experience	-.097	.858
Watching informative videos	.076	.738
<i>Entertainment Use</i>		
Relaxing at home	.733	.009
Having some entertainment	.872	.006
Watching enjoyable videos	.851	-.012
R^2	43%	31%

Note. The items shared the common root, “When you use YouTube, how often do you use it for...” Factor loadings show the pattern matrix. Explained variance reflects the initial eigenvalues.

Table 3. Variance, covariance, and correlation matrix of measured variables

Variable	0	1	2	3	4	5	6	7	8
0. Seeking intention	0.71	0.36	0.12	-0.13	0.31	0.27	0.41	-0.07	0.21
1. Sample	.29	0.25	-0.07	0.09	0.06	0.05	0.13	-0.19	-0.01
2. Sex	-.34	-.30	0.22	-0.12	-0.07	-0.04	-0.12	0.06	-0.06
3. Past seeking	.46	.19	-.29	0.90	0.23	0.17	0.28	0.13	0.24
4. Attitude toward seeking	.56	.37	.17	-.23	0.44	0.19	0.32	-0.07	0.18
5. Subjective norm	.54	.31	.16	-.15	.48	0.34	0.19	0.10	0.05
6. Enjoyment of science	.59	.36	.31	-.32	.57	.39	0.69	-0.14	0.17
7. Informational use	.36	.37	-.03	-.19	.40	.13	.31	0.59	0.08
8. Entertainment use	-.10	.02	-.48	.17	-.14	.02	-.22	.16	0.46

Note. The diagonal (bold) contains variances. Covariances are above the diagonal and correlations are below the diagonal. Magnitudes of correlations larger than .12 are statistically significant ($p < .05$).

Table 4. Prediction of intention to seek science videos on YouTube

Predictor	Model I				Model II				Model III			
	<i>B</i> (<i>SE</i>)	95% CI	β	<i>p</i>	<i>B</i> (<i>SE</i>)	95% CI	β	<i>p</i>	<i>B</i> (<i>SE</i>)	95% CI	β	<i>p</i>
Intercept	2.87 (0.09)	2.69, 3.02		<.001	0.17 (0.26)	-0.33, 0.71		.50	-0.39 (0.35)	-1.10, 0.28		.28
Block I: Control												
Sample	0.27 (0.09)	0.09, 0.43	.16	.005	0.19 (0.08)	0.02, 0.33	.11	.019	0.15 (0.08)	0.01, 0.30	.09	.063
Sex	-0.33 (0.09)	-0.50, -0.15	-.18	<.001	-0.24 (0.08)	-0.39, -0.08	-.14	<.001	-0.17 (0.08)	-0.31, -0.01	-.09	.030
Past seeking	0.33 (0.05)	0.24, 0.44	.37	<.001	0.17 (0.05)	0.08, 0.27	.19	.003	0.12 (0.05)	0.03, 0.21	.13	.010
Block II: Reasoned Action												
Attitude toward seeking					0.37 (0.09)	0.19, 0.55	.29	<.001	0.17 (0.09)	-0.01, 0.36	.14	.065
Subjective norm					0.44 (0.10)	0.23, 0.66	.31	<.001	0.43 (0.10)	0.22, 0.63	.29	<.001
Block III: User Orientation												
Enjoyment of science									0.26 (0.05)	0.16, 0.37	.26	<.001
Informational orientation									0.15 (0.06)	0.03, 0.28	.12	.015
Entertainment orientation									0.00 (0.06)	-0.11, 0.12	.005	.929
ΔR^2			.28	<.001			.21	<.001			.05	<.001
R^2			.28				.49				.55	

Note. The unstandardized slope (*B*) and standardized slope (β) are based on the observed covariance matrix of the full sample. The standard error of the unstandardized estimate (*SE*), two-tail 95% confidence interval (CI) of the unstandardized estimate, and two-tail *p*-value are based on 1,000 bias-corrected and accelerated bootstrap replications.

Table 5. Comparison of standardized slopes between samples

Predictor / Sample	Model I		Model II		Model III	
	0	1	0	1	0	1
Past seeking	.52***	.29**	.31***	.12	.23***	.10
Sex	-.14*	-.24**	-.07	-.24**	-.06	-.16*
Attitude toward seeking			.30***	.24**	.14	.09
Subjective norm			.27***	.37***	.24***	.39***
Enjoyment of science					.27***	.21*
Informational orientation					.12	.10
Entertainment orientation					.08	-.08
ΔR^2	.32***	.18***	.18***	.25***	.06***	.04*
R^2	.32	.18	.50	.43	.57	.47

Note. 0 = Student. 1 = Public. * $p < .05$. ** $p < .01$. *** $p < .001$.

References

- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211. doi: 10.1016/0749-5978(91)90020-T
- Ajzen, I. (2001). Nature and operation of attitudes. *Annual Review of Psychology*, 52, 27-58. doi: 10.1146/annurev.psych.52.1.27
- Ajzen, I. (2006). Constructing a TPB questionnaire: conceptual and methodological considerations. <http://people.umass.edu/aizen/pdf/tpb.measurement.pdf>
- Ajzen, I., & Driver, B. L. (1992). Application of the theory of planned behavior to leisure choice. *Journal of Leisure Research*, 24(3), 207-224.
- Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology*, 40, 471-499. doi: 10.1348/014466601164939
- Bailey, J. R. (1997). Need for cognition and response mode in the active construction of an information domain. *Journal of Economic Psychology*, 18(1), 69-85. doi: 10.1016/s0167-4870(96)00047-5
- Barry, D. S., Marzouk, F., Chulak-Oglu, K., Bennett, D., Tierney, P., & O'Keeffe, G. W. (2016). Anatomy education for the YouTube generation. *Anatomical Sciences Education*, 9(1), 90-96. doi: 10.1002/ase.1550
- Bond, R., & Smith, P. B. (1996). Culture and conformity: A meta-analysis of studies using Asch's (1952b, 1956) Line judgment task. *Psychological Bulletin*, 119(1), 111-137. doi: 10.1037/0033-2909.119.1.111
- Bondad-Brown, B. A., Rice, R. E., & Pearce, K. E. (2012). Influences on TV viewing and online user-shared video use: Demographics, generations, contextual age, media use,

- motivations, and audience activity. *Journal of Broadcasting & Electronic Media*, 56(4), 471-493. doi: 10.1080/08838151.2012.732139
- Broadband Commission. (2014). The state of broadband 2014: Broadband for all. Geneva: The Broadband Commission.
- Chao, Y. L., & Lam, S. P. (2011). Measuring responsible environmental behavior: Self-reported and other-reported measures and their differences in testing a behavioral model. *Environment and Behavior*, 43(1), 53-71. doi: 10.1177/0013916509350849
- Chittenden, D., Farmelo, G., & Lewenstein, B. V. (2004). *Creating connections: Museums and the public understanding of current research*. Walnut Creek, CA: AltaMira Press.
- Cho, J., Shah, D. V., McLeod, J. M., McLeod, D. M., Scholl, R. M., & Gotlieb, M. R. (2009). Campaigns, reflection, and deliberation: Advancing an O-S-R-O-R model of communication effects. *Communication Theory*, 19(1), 66-+. doi: 10.1111/j.1468-2885.2008.01333.x
- Cialdini, R. B., Kallgren, C. A., & Reno, R. R. (1991). A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human-behavior. *Advances in Experimental Social Psychology*, 24, 201-234. doi: 10.1016/s0065-2601(08)60330-5
- Cooke, L. (2005). A visual convergence of print, television, and the Internet: Charting 40 years of design change in news presentation. *New Media & Society*, 7(1), 22-46. doi: 10.1177/1461444805049141
- Das, S., Echambadi, R., McCardle, M., & Lockett, M. (2003). The effect of interpersonal trust, need for cognition, and social loneliness on shopping, information seeking and surfing on the Web. *Marketing Letters*, 14(3), 185-202. doi: 10.1023/a:1027448801656

- Doran, R., & Larsen, S. (2016). The relative importance of social and personal norms in explaining intentions to choose eco-friendly travel options. *International Journal of Tourism Research*, 18(2), 159-166. doi: 10.1002/jtr.2042
- Dudo, A. (2015). Scientists, the media, and the public communication of science. *Sociology Compass*, 9(9), 761-775. doi: 10.1111/soc4.12298
- Earnheardt, M. B. (2013). Motivating the U.S. voter: The functions of elaboration and political motives when using TV and the Internet. *Atlantic Journal of Communication*, 21(1), 65-94. doi: 10.1080/15456870.2012.728116
- Ellingsen, S. (2014). Seismic shifts: Platforms, content creators and spreadable media. *Media International Australia*(150), 106-113.
- Falk, J. H., & Dierking, L. D. (2002). *Lessons without limit: How free-choice learning is transforming education*. Walnut Creek, CA: AltaMira Press.
- Falk, J. H., Dierking, L. D., Swanger, L. P., Staus, N., Back, M., Barriault, C., . . . Verheyden, P. (2016). Correlating science center use with adult science literacy: An international, cross-institutional study. *Science Education*, 100(5), 849-876. doi: 10.1002/sce.21225
- Falk, J. H., & Needham, M. D. (2013). Factors contributing to adult knowledge of science and technology. *Journal of Research in Science Teaching*, 50(4), 431-452. doi: 10.1002/tea.21080
- Falk, J. H., Storksdieck, M., & Dierking, L. D. (2007). Investigating public science interest and understanding: Evidence for the importance of free-choice learning. *Public Understanding of Science*, 16(4), 455-469. doi: 10.1177/0963662506064240
- Feinstein, N. (2011). Salvaging science literacy. *Science Education*, 95(1), 168-185. doi: 10.1002/sce.20414

- Feist, G. J. (2012). Predicting interest in and attitudes toward science from personality and need for cognition. *Personality and Individual Differences*, 52(7), 771-775. doi: 10.1016/j.paid.2012.01.005
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: an introduction to theory and research*. Reading, MA: Addison-Wesley.
- Follette, K., & McCarthy, D. (2012). *An informed approach to improving quantitative literacy and mitigating math anxiety in undergraduates through introductory science courses* (Vol. 457). San Francisco: Astronomical Soc Pacific.
- Go, E., You, K. H., Jung, E., & Shim, H. (2016). Why do we use different types of websites and assign them different levels of credibility? Structural relations among users' motives, types of websites, information credibility, and trust in the press. *Computers in Human Behavior*, 54, 231-239. doi: 10.1016/j.chb.2015.07.046
- Gogolin, L., & Swartz, F. (1992). A quantitative and qualitative inquiry into the attitudes toward science of nonscience college students. *Journal of Research in Science Teaching*, 29(5), 487-504. doi: 10.1002/tea.3660290505
- Griffin, R. J., Dunwoody, S., & Neuwirth, K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. *Environmental Research*, 80(2), S230-S245. doi: 10.1006/enrs.1998.3940
- Hashmeta. (2016). Social media Singapore 2015. Retrieved July 8, 2016, from <http://www.hashmeta.com/social-media-singapore-infographic/>
- Ho, S. S., Detenber, B. H., Rosenthal, S., & Lee, E. (2012). *Seeking information about climate change: Attention to news media, objective knowledge, and other antecedents in an*

- augmented PRISM*. Paper presented at the annual meeting of the Association for Education in Journalism and Mass Communication, Chicago.
- Housing Development Board. (2014). *Key Statistics*. Singapore: Retrieved from http://www20.hdb.gov.sg/fi10/fi10320p.nsf/ar2014/pdf/HDB_Key%20Statistics_13_14_d9_HiRes.pdf.
- Housing Development Board. (2015). *Online buzz: Can a BTO flat applicant retain his queue number if he cancels his application under a priority scheme?* Singapore: Retrieved from <http://hdbspeaks.sg/fi10/fi10336p.nsf/cw/FlatBallotingProcess?OpenDocument>.
- Housing Development Board. (2016). *Ethnic integration policy and SPR quota*. Singapore: Retrieved from <http://www.hdb.gov.sg/cs/infoweb/residential/buying-a-flat/resale/ethnic-integration-policy-and-spr-quota>.
- Hovick, S. R., Kahlor, L., & Liang, M. C. (2014). Personal cancer knowledge and information seeking through PRISM: The planned risk information seeking model. *Journal of Health Communication, 19*(4), 511-527. doi: 10.1080/10810730.2013.821556
- Hughes, D. J., Rowe, M., Batey, M., & Lee, A. (2012). A tale of two sites: Twitter vs. Facebook and the personality predictors of social media usage. *Computers in Human Behavior, 28*(2), 561-569. doi: 10.1016/j.chb.2011.11.001
- Infocomm Development Authority of Singapore. (2015). *Living the iN2015 vision*. Singapore: Infocomm Development Authority of Singapore Retrieved from <https://www.ida.gov.sg/~media/Files/Infocomm%20Landscape/iN2015/IDAInfographi.pdf>.

- Jaspal, R., Turner, A., & Nerlich, B. (2014). Fracking on YouTube: Exploring risks, benefits and human values. *Environmental Values*, 23(5), 501-527. doi: 10.3197/096327114x13947900181473
- Jung, I., & Lee, Y. (2015). YouTube acceptance by university educators and students: a cross-cultural perspective. *Innovations in Education and Teaching International*, 52(3), 243-253. doi: 10.1080/14703297.2013.805986
- Kahlor, L. (2010). PRISM: A planned risk information seeking model. *Health Communication*, 25(4), 345-356. doi: 10.1080/10410231003775172
- Kind, T., & Evans, Y. (2015). Social media for lifelong learning. *International Review of Psychiatry*, 27(2), 124-132. doi: 10.3109/09540261.2014.990421
- Korhan, O., & Ersoy, M. (2016). Usability and functionality factors of the social network site application users from the perspective of uses and gratification theory. *Quality & Quantity*, 50(4), 1799-1816. doi: 10.1007/s11135-015-0236-7
- Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, 33(1), 27-50. doi: 10.1080/09500693.2011.518645
- Lapinski, M. K., & Rimal, R. N. (2005). An explication of social norms. *Communication Theory*, 15(2), 127-147. doi: 10.1111/j.1468-2885.2005.tb00329.x
- Lauper, E., Moser, S., Fischer, M., & Matthies, E. (2016). Explaining car drivers' intention to prevent road-traffic noise: An application of the norm activation model. *Environment and Behavior*, 48(6), 826-853. doi: 10.1177/0013916515570476
- Leshner, A. I. (2003). Public engagement with science. *Science*, 299(5609), 977-977. doi: 10.1126/science.299.5609.977

- Li, S.-C. S. (2015). Lifestyles and the adoption of information versus entertainment technologies: An examination on the adoption of six new technologies in Taiwan. *New Media & Society*, 17(10), 1696-1714. doi: 10.1177/1461444814531874
- Lin, H. S., Lawrenz, F., Lin, S. F., & Hong, Z. R. (2013). Relationships among affective factors and preferred engagement in science-related activities. *Public Understanding of Science*, 22(8), 941-954. doi: 10.1177/0963662511429412
- Manca, S., & Ranieri, M. (2016). Facebook and the others. Potentials and obstacles of Social Media for teaching in higher education. *Computers & Education*, 95, 216-230. doi: 10.1016/j.compedu.2016.01.012
- McLeod, J. M., Kosicki, G. M., & McLeod, D. M. (1994). The expanding boundaries of political communication effects. In J. Bryant & D. Zillmann (Eds.), *Media effects: Advances in theory and research* (2nd ed., pp. 123-162). Hillsdale, NJ: Lawrence Erlbaum.
- Moll, R., & Nielsen, W. (2016). Development and validation of a social media and science learning survey. *International Journal of Science Education, Part B*, 1-17. doi: 10.1080/21548455.2016.1161255
- Muller, D. [Veritasium]. (July 15, 2015). *Surprising applications of the Magnus effect*. [Video file]. Retrieved from <https://www.youtube.com/watch?v=2OSrvzNW9FE>
- Nisbet, M. C., & Scheufele, D. A. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10), 1767-1778. doi: 10.3732/ajb.0900041
- Rodrigues, A. M., French, D. P., & Sniehotta, F. F. (2016). Commentary: The impact of asking intention or self-prediction questions on subsequent behavior: A meta-analysis. *Frontiers in Psychology*, 7, 3. doi: 10.3389/fpsyg.2016.00879

- Ross, L., Kohler, C. L., Grimley, D. M., & Anderson-Lewis, C. (2007). The theory of reasoned action and intention to seek cancer information. *American Journal of Health Behavior*, 31(2), 123-134. doi: 10.5555/ajhb.2007.31.2.123
- Rubin, A. M. (1983). Television uses and gratifications: The interactions of viewing patterns and motivations. *Journal of Broadcasting*, 27(1), 37-51.
- Rubin, A. M. (1994). Media uses and effects: A uses-and-gratifications perspective. In J. Bryant & D. Zillmann (Eds.), *Media effects: Advances in theory and research* (pp. 417-436). Hillsdale, NJ: Lawrence Erlbaum.
- Schwan, S., Grajal, A., & Lewalter, D. (2014). Understanding and engagement in places of science experience: Science museums, science centers, zoos, and aquariums. *Educational Psychologist*, 49(2), 70-85. doi: 10.1080/00461520.2014.917588
- Shah, D. V., Cho, J., Nah, S., Gotlieb, M. R., Hwang, H., Lee, N. J., . . . McLeod, D. M. (2007). Campaign ads, online messaging, and participation: Extending the communication mediation model. *Journal of Communication*, 57(4), 676-U113. doi: 10.1111/j.1460-2466.2007.00363.x
- Shapiro, M. A., & Park, H. W. (2015). More than entertainment: YouTube and public responses to the science of global warming and climate change. *Social Science Information Sur Les Sciences Sociales*, 54(1), 115-145. doi: 10.1177/0539018414554730
- Sheeran, P. (2002). Intention-behavior relations: A conceptual and empirical review. *European Review of Social Psychology*, 12(1), 1-36. doi: 10.1080/14792772143000003
- Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? *Public Understanding of Science*, 23(1), 4-15. doi: 10.1177/0963662513518154

- Su, L. Y. F., Akin, H., Brossard, D., Scheufele, D. A., & Xenos, M. A. (2015). Science news consumption patterns and their implications for public understanding of science. *Journalism & Mass Communication Quarterly*, 92(3), 597-616. doi: 10.1177/1077699015586415
- Sugimoto, C. R., & Thelwall, M. (2013). Scholars on soap boxes: Science communication and dissemination in TED videos. *Journal of the American Society for Information Science and Technology*, 64(4), 663-674. doi: 10.1002/asi.22764
- Uren, V., & Dadzie, A. S. (2015). Public science communication on Twitter: a visual analytic approach. *Aslib Journal of Information Management*, 67(3), 337-355. doi: 10.1108/ajim-10-2014-0137
- Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching*, 50(8), 952-988. doi: 10.1002/tea.21103
- Weiser, E. B. (2001). The functions of Internet use and their social and psychological consequences. *Cyberpsychology & Behavior*, 4(6), 723-743. doi: 10.1089/109493101753376678
- Zhang, L. Z., & Zhang, W. Y. (2013). Real-time Internet news browsing: Information vs. experience-related gratifications and behaviors. *Computers in Human Behavior*, 29(6), 2712-2721. doi: 10.1016/j.chb.2013.07.009
- Zhou, R. G., Fong, P. S. W., & Tan, P. K. (2014). Internet use and its impact on engagement in leisure activities in China. *Plos One*, 9(2), 1-11. doi: 10.1371/journal.pone.0089598