Open Captioning as a Means of Communicating Health Information: The Role of Cognitive Load in Processing Entertainment-Education Content

Hyang-Sook Kim and Kyongseok Kim

Department of Mass Communication, Towson University, Towson, Maryland, USA

ABSTRACT

Despite considerable research on entertainment-education, the influence of cognition on viewer appreciation and learning remains unclear. A pretest-posttest laboratory experiment was conducted to examine the effects of explicit health information embedded in a medical drama via video captioning on the processing of the narrative and health information and acquisition of health knowledge. The captions increased cognitive load for health information processing, facilitating recall, and retention of health knowledge. Neither cognitive load for narrative processing nor narrative absorption differed between the captioned and uncaptioned videos. The findings suggest discrete but complementary areas of cognition for entertainment content designed for health education.

Previous findings about health education using entertainment media suggest that exposure to diverse forms of media content, including television dramas, can elicit desirable attitudinal and behavioral outcomes (e.g., Murphy et al., 2011). The appreciation of entertainment content in the context of health education can lead audiences (a) to accept with little resistance the behavior and choices of favorite characters in a storyline (Green & Brock, 2002) and (b) to reflect on health topics addressed during and after exposure to enjoyable content, thereby generating persuasive effects (Marcus et al., 2010; Murphy et al., 2011; Singhal & Rogers, 2002). These are target outcomes of *entertainment-education* (E-E), a communication strategy that blends educational messages with entertainment media programs to enhance knowledge and change attitude and behavior in an intended direction (Singhal & Rogers, 2004, p. 5).

To produce persuasive effects, E-E must feature the interplay between a narrative with storylines and characters (i.e., source of the message) and audience appreciation of the narrative (i.e., reception of the message). Whether the health message conveyed by a narrative with likable protagonists (i.e., encoding) elicits subjective experience in the audience depends, in part, on preexisting knowledge about and/or experience with the health issue addressed in the narrative (i.e., decoding) (Green & Brock, 2000). Subjective experience determines how much the audience might become immersed in the narrative (Green & Brock, 2002).

While numerous scholars have explored the effects of narratives on persuasion (Braddock & Dillard, 2016), few have investigated the underlying cognitive

mechanisms through which people spend mental resources on processing entertainment content and potentially retaining embedded health information. For example, Green and Brock (2000) found that participants who immersed themselves in a narrative were less successful in identifying false information about the story than those who did not. These findings suggested that narrative processing did require cognitive resources, but little is known about how cognitive processing might influence health-information learning during the consumption of entertainment content beyond attitudinal and behavioral change. Accordingly, the potential of E-E to enhance health-related knowledge requires further exploration using entertainment content already crafted and available to audiences. In particular, the integration of explicit health information in entertainment content as a tool for health education could advance current E-E practice.

The purpose of the current study was twofold: (a) to test the effects of explicit health information provided by video captioning on health knowledge retention (i.e., long-term recall) and (b) to shed light on the cognitive processes through which viewers acquire health knowledge while consuming narrative content and health information simultaneously. To this end, the present study collected longitudinal data in a closely controlled laboratory experiment to obtain more conclusive evidence for the hypothesized effects of video captioning on health knowledge retention.

Literature Review

Learning from Entertainment Content: Perspective of Cognitive Load Theory

Because of the implicit way in which narratives can deliver educational messages to the audience, narrative persuasion has been known to be an effective means to change attitude and behavior (Slater & Rouner, 2002). Hinyard and Kreuter (2007) defined a *narrative* as "any cohesive and coherent story with an identifiable beginning, middle, and end that provides information about the scene, characters, and conflict; raises unanswered questions or unresolved conflict; and provides resolution" (p. 778). In the context of E-E, a health message conveyed by a narrative can positively influence audiences as they immerse themselves in a storyline (i.e., narrative transportation) (Green & Brock, 2002) and place themselves in the protagonists' shoes (i.e., identification with characters) (Igartua & Vega Casanova, 2016), both activating narrative absorption (de Graaf & van Leeuwen, 2017). Narrative absorption often leads people to become less resistant to the educational message conveyed through a narrative (Slater & Rouner, 2002). Previous findings in E-E research also suggest that exposure to entertainment content featuring health information might improve knowledge about various health topics (Hoffman et al., 2017). However, findings about the role of cognition in acquiring E-E content remain inconclusive.

The mechanisms behind narrative processing can be explained, in part, by Cognitive Load Theory (CLT) (Paas, 1992; Paas & Sweller, 2014). The theory postulates that working memory is crucial to optimizing learning, given that long-term memory is inherent to the individual and that when encoding new information, a person consumes a certain "amount of capacity that is allocated to instructional demands," a concept

known as *cognitive load* (Paas, 1992, p. 429). Typically, three types of cognitive load are involved in learning: intrinsic, extraneous, and germane. *Intrinsic load* occurs when a learner attempts to process the focal point of the learning material and associate the new information with relevant information from long-term memory. On the other hand, *extraneous load* occurs when a learner is distracted from the learning process by irrelevant information. Both intrinsic load and extraneous load require a significant amount of working memory, but they differ greatly in their consequences for learning. Finally, *germane load* is the difference between intrinsic load and extraneous load; as germane load increases, the learning process becomes more effective (Paas & Sweller, 2014).

Accordingly, CLT suggests that a successful instructional design will not distract learners but help them attend to the focal point of the learning material (Cierniak et al., 2009). In the context of the current study, health knowledge should improve when viewers (a) allocate cognitive load solely to the entertainment content into which the health message is properly integrated (i.e., increase in intrinsic load) and (b) avoid unnecessary attention to distractions (e.g., complex storylines and other unnecessary informational input) (i.e., decrease in extraneous load). As a result, germane load increases and health information is more likely to be stored in long-term memory.

Role of Cognitive Load in Narrative Absorption and Learning

Stressing the role of cognitive load in narrative absorption, Green and Brock (2002) claimed that when appreciating media content (e.g., television dramas and movies), viewers must exert a reasonable amount of mental effort to make sense of storylines and characters. In the context of E-E, therefore, cognitive load has been defined as the amount of mental resources required to generate thoughts about the storyline, characters, and health information embedded in the storyline (de Graaf & van Leeuwen, 2017; Green & Brock, 2002; Slater & Rouner, 2002). This process leads viewers to plunge into the narrative, engage in sufficient cognitive elaboration and, potentially, produce fewer counterarguments to the health information embedded in the narrative (Igartua & Vega Casanova, 2016; Slater & Rouner, 2002). As a result, viewers are more likely to retain the health information presented in the narrative (e.g., Green & Brock, 2002). For example, van Laer et al. (2014) found that subjects higher in narrative absorption tend to generate fewer critical thoughts (i.e., ones generated by a message that differs from preexisting beliefs) and that such absorption might result from a cognitive motivation rather than an affective motivation. However, they do not explain how cognitive load might be linked to learning beyond narrative absorption.

A few scholars have examined the role of cognitive load in the consumption of entertainment content, but the relationships among cognitive load, cognitive elaboration of narrative and persuasive outcomes remain unclear. For example, Bartsch and Hartmann (2017) found that narratives requiring lower cognitive load led to more pleasant experiences with story content, whereas narratives requiring higher cognitive load led to more thought-provoking experiences. However, Das et al. (2017) found no difference in narrative transportation between participants in the cognitive load condition (i.e., asked to do a simple mathematical task while watching the movie) and those in the non-load condition (i.e., asked to watch the movie without doing any

additional task). These mixed findings might indicate a non-parsimonious approach to operationalizing cognitive load in this line of research. For example, Das et al. (2017) did not yield evidence for which type of cognitive load (i.e., narrative processing or task) was associated with content appreciation. Nevertheless, their findings suggest that despite the possible emergence of the extraneous load from a content-irrelevant task, narrative transportation still occurred, suggesting that intrinsic load for narrative processing might overwhelm extraneous load.

Captions as Explicit Health Information: Do They Facilitate or Hinder Learning?

Closed captioning provides viewers with word-for-word transcription of television and movie scripts (Udo & Fels, 2010). Numerous scholars have tested the effects of closed captioning on learning for various populations, including children, adults, second-language learners, and people with hearing impairment (Gernsbacher, 2015), and found that closed captioning improved information comprehension, knowledge acquisition, and language proficiency (Birulés-Muntané & Soto-Faraco, 2016; Kruger & Steyn, 2014). However, closed captioning is also likely to hinder narrative transportation and learning motivation, given that it constantly displays voiced words and various sound descriptions on top of the entertainment content (Ozdemir et al., 2016).

Open captioning, on the other hand, refers to "captions on the screen which appear as part of the original broadcast [or streaming] and, thus, require no special equipment to receive or decode them" (Garza, 1996, p. 9). In the United States, educational programs have occasionally featured open captioning, but the entertainment industry rarely uses it (Garza, 1996). Similar to closed captioning, open captioning could distract viewers from narrative transportation. However, appearing on the screen only when the target health issue is relevant to the story (i.e., the current study), open captioning might also help viewers acquire health information embedded in the narrative and retain the information over the long term. Seamless integration of open captions, perceived as part of the narrative rather than as a content-irrelevant feature, might increase the intrinsic load for processing both entertainment content and health information and minimize possible extraneous load.

As instructional design scholars suggested (e.g., Cierniak et al., 2009), if viewers find two cognitive activities (e.g., watching an entertainment program and reading open captions) incongruent, poor narrative transportation and learning outcomes are likely due to low germane load. However, if viewers find the two cognitive activities complementary, high germane load is more likely. In other words, the learning outcomes of using open captions in entertainment content might depend on how well the open captions help viewers focus on the content (e.g., Hawlitschek & Joeckel, 2017). Thus, the following hypotheses were proposed:

H1 [Processing of Entertainment Content]

Well-integrated open captions will hinder neither cognitive load for narrative processing nor narrative absorption. Between viewers of the medical drama episode with open captions and without open captions, no differences will emerge in (a) intrinsic load for narrative processing, (b) germane load for narrative

processing, (c) narrative absorption, and (d) narrative content recall.

H2 [Processing of Health Information Embedded in Entertainment Content]
Well-integrated open captions will help viewers maintain intrinsic and germane load for health information processing, yielding the desired learning outcomes. Viewers of the medical drama episode with open captions will present (a) higher intrinsic load and (b) higher germane load for health information processing and report (c) greater health knowledge acquisition and (d) greater health knowledge retention than viewers of the medical drama episode without open captions.

To confirm that the effects of open captions on health knowledge acquisition and retention were not merely due to additional textual information, two conditions were also tested: delivery of health information via (a) open captions in a medical drama episode and (b) plain text in a slideshow format (i.e., control). When open captions are optimized for entertainment content, health information embedded in the narrative should yield better learning outcomes, a prediction consistent with the notion of E-E and narrative absorption:

H3 [Learning Outcome Comparisons with Control Group]
Viewers of the medical drama episode with open captions will report (a) greater health knowledge acquisition and (b) greater health knowledge retention than viewers of the medical drama episode without open captions or viewers who receive the health information via plain text in a slideshow (i.e., control).

Method

Participants

A total of 82 students from a large public university in the eastern United States were selected into the sample; they were recruited through an e-mail invitation that was sent out to 2,546 students. The average age of the participants was 20.7 (SD = 4.18, N = 82) at the time of data collection, and White was the most dominant racial group (41.5%), followed by Black (30.5%), Asian (17.1%), and Hispanic or Latino (6.1%). Most of the participants were female (70%).

Experimental Design and Procedure

A three-group (medical drama episode with open captions vs. medical drama episode with no open captions vs. plain text slideshow), pre-and posttest design was implemented in a closely controlled laboratory setting. The interval between the pretest and posttest was one week. Participants assigned to the control condition viewed the health information via plain text in a slideshow that contains identical content, font, and exposure time to the text delivered via open captions in the medical drama episode.

Upon arrival, each participant received an identification number used to match the data collected during the pretest and posttest. In the pretest (Session 1), participants provided informed consent electronically and reported involvement with syphilis

prevention and two other health issues (to minimize target health topic priming). Participants viewed the stimulus medical drama episode (i.e., with or without open captions) or slideshow of the health information (i.e., control) and then responded to measurement items for key variables: narrative content recall, narrative absorption, cognitive load, health knowledge acquisition, and control variables. To avoid the recency effect, participants in the control condition responded to the items for cognitive load and control variables before responding to the items for health knowledge acquisition. In the posttest (Session 2), participants responded to the same set of items assessing their health issue knowledge (i.e., retention) and health literacy. After completing both sessions, participants received a 25 USD gift card as compensation.

Stimulus Videos

A 17-minute clip of an actual episode of the medical drama series *Grey's Anatomy* ("Who's Zoomin' Who?" *ABC Production*, Episode 9 in Season 1, aired May 22, 2005) was the stimulus for the two medical drama conditions. The focal point of the narrative in this clip was a health issue relevant to the participants (i.e., college students): syphilis as a sexually transmitted disease (Centers for Disease Control and Prevention, 2017). The male protagonist found himself infected with syphilis and traced a route of infection. To increase realism, the edited episode also contained scenes about the romantic relationships among the other characters.

The two medical drama conditions were identical, except that one of the videos displayed explicit health information via open captions. Used in limited fashion, only during relevant scenes, the captions pertained to (a) a medical definition of syphilis, (b) common symptoms of the disease, (c) disease transmit methods, (d) possible complications of the disease, (e) prevention methods, and (f) treatment options (Genç & Ledger, 2000; Mayo Clinic, 2019). Each caption appeared for 10–20 seconds at the bottom of the screen, depending on word count, to give viewers a reasonable amount of time to process the information (Newman & Koskinen, 1992).

Measured Variables[1]

Narrative content recall was measured using five multiple-choice questions that asked how well participants retained the story content and characters presented in the stimulus medical drama episode; each correct answer to the five questions was coded as "1" and summed to represent overall recall (Oviedo et al., 2015). *Narrative absorption* was measured using fifteen 7-point items adopted from the original scale of narrative transportation (Green & Brock, 2000; Murphy et al., 2011) and narrative engagement scale (Busselle & Bilandzic, 2009) (α =.87, M = 4.92, SD = .98, N = 55). Overall cognitive load for narrative processing was measured using two 7-point items to assess the amount of mental effort (i.e., *intrinsic load*) (Martin, 2014; Paas, 1992) and concentration (i.e., *germane load*) invested (Cierniak et al., 2009; Salomon, 1984).

[1]Please contact the corresponding author for the full list of measurement items used in the study.

Cognitive load for processing the health information embedded in the stimulus medical drama episode was also assessed. *Intrinsic load* was measured, using three 7-point items about perceived complexity of the health information (α = .81, M = 2.60, SD = 1.37, N = 55). *Germane load* was measured, using four 7-point items about perceived helpfulness of the stimulus in facilitating understanding of the health issue addressed in the episode (i.e., syphilis) (α = .94, M = 4.45, SD = 1.70, N = 55) (Leppink et al., 2013). To assess *health knowledge acquisition* (Session 1) and *retention* (Session 2), five multiple-choice questions about the health issue were used; each correct answer was coded as "1" and summed (Marcus et al., 2010).

Four control variables were also measured to rule out possible moderating effects on narrative and health information processing. Health literacy is a significant moderator in learning health information (e.g., Chisolm et al., 2014) and, thus, needs to be controlled. Nine items of the health literacy scale developed by Bann et al. (2012) were used to assess the ability to process health information (M = 7.24, SD = 1.27, N = 75). In addition, preferred modality of verbal information (α = .82, M = 5.10, SD = 1.07, N = 82) was measured because the implementation of open captions was key to the experimental design (Ramsey & Deeter-Schmelz, 2008). Personal involvement with the target health topic was also measured (Zaichkowsky, 1985) (α = .85, M = 4.79, SD = .96, N = 82) to rule out the potential moderating effect of involvement on cognitive processing (Petty & Cacioppo, 1986) and narrative engagement (Luong et al., 2020). Lastly, familiarity with the topic was measured (single item, M = 4.50, SD = 1.62, N = 82) because it can affect both narrative processing (Green, 2004) and cognitive load for learning (Cook, 2006).

Results

To test H1, H2a, and H2b, 59 complete sets of responses were used. Responses from participants who were not native English speakers (n = 4), had previously watched the medical drama episode used in the experiment (n = 14), and/or failed to attend Session 2 (n = 6) were excluded (Open-caption condition: OC = 17; No open-caption condition: NC = 20; Control condition: CC = 22). To compare health knowledge acquisition and retention (H2c, H2d, and H3), only 55 sets of responses provided data; participants who attempted to seek information about syphilis after Session 1 were excluded (n = 4) (OC = 17; NC = 17; CC = 21).[2]

A series of analyses of variance of the four covariates revealed no differences in involvement (F[2, 54] = 2.82, p = .07) and familiarity (F[2, 54] = .49, p = .62) with syphilis or verbal preference (F[2, 54] = 1.08, p = .35) across the three conditions. However, general health literacy was significantly different between the no-caption (M = 6.64, SD = 1.46) and open-caption (M = 7.94, SD = .97) conditions, while the control condition (M = 7.24, SD = 1.00) was not different from either of the narrative conditions, F(2, 52) = 5.41, p < .01. Therefore, health literacy was included as a

[2] Power analysis calculated by G*Power (Erdfelder et al., 1996) indicated that the total estimated sample size was 54, with the effect size of .44 obtained from the interaction effect between condition and time on the two repeated-measures outcomes of the current study.

covariate in the main analyses for hypothesis testing.

Differences in Processing Narrative and Health Information

A multivariate analysis of covariance (MANCOVA) with open caption usage as a between-subject factor showed no differences in intrinsic load, germane load, or narrative absorption, suggesting that the inclusion of open captions might not hinder narrative appreciation. However, a significant difference in narrative content recall emerged between OC (M = 4.42, SD = .62) and NC (M = 3.65, SD = .75) ($F_{[1,\ 31]}$ = 8.76, p < .01, η^2 = .22) (Wilks' λ = .72, p < .05, η^2 = .28). Therefore, the results supported H1a, H1b, and H1c, but not H1d (see Table 1 for mean differences in the dependent variables between the two groups).[3] Another MANCOVA with open caption usage as between-subject factor revealed significant main effects on the dependent variables at univariate levels. Participants in OC (vs. NC) reported spending greater intrinsic load (M_{OC} = 3.08, SD = 1.67 vs. M_{NC} = 2.20, SD = 1.01; $F_{[1,\ 33]}$ = 5.93, p < .05, η^2 = .16) when processing the embedded health information. However, no difference in germane load emerged between the two conditions (M_{OC} = 4.76, SD = 1.70 vs. M_{NC} = 3.78, SD = 1.81, n = 20; $F_{[1,\ 33]}$ = 3.78, p = .06, η^2 = .11). The results suggest that the open captions facilitated health information processing, supporting H2a only.

Table 1. Descriptive statistics of dependent variables.

		Open Captions (n = 17)	No Open Captions (n = 20)	Control (Text only) (n = 21)	F (p-value)	η^2
Intrinsic Load	NP	4.59 (1.50)	4.00 (1.70)	.	1.34 (.26)	.04
	HIP	3.08 (1.67)	2.20 (1.01)	.	5.93 (.02) *	.16
Germane Load	NP	5.71 (1.65)	5.29 (1.90)	.	1.24 (.27)	.04
	HIP	4.76 (1.70)	3.90 (1.88)	.	3.78 (.06)	.11
Narrative Absorption		4.84 (1.15)	4.76 (1.15)	.	.12 (.73)	.00
Narrative Content Recall		4.41 (.62)	3.59 (.71)	.	11.89 (.002)**	.27
Health Knowledge (Pretest)		[a]4.29 (.69)	[b]2.53 (1.23)[+]	[b]2.52 (.75)	16.26 (.000) ***	.39
Health Knowledge (Posttest)		[a]4.00 (.87)	[b]2.35 (.93) [+]	[a]3.86 (1.24)	11.10 (.000) ***	.30

NP: Narrative processing; HIP: Health information processing. Means are reported in the condition columns with standard deviations in parentheses. *p <.05; **p <.01; ***p <.001. Cell means that do not share a letter in their superscripts differ at p <.001. [+]The sample size in Session 2 decreased to 17 after exclusion of participants who sought additional information about syphilis after Session 1 (n = 3). No significant effect emerged for health literacy (covariate).

Differences in Learning Outcomes

A repeated-measures analysis was performed to test H2c, H2d, and H3 with video condition (medical drama episode with open captions vs. medical drama episode with no open captions vs. control) as a between-subject factor and time (Session 1 vs. Session 2) as a within-subject factor. The analysis revealed a significant video condition × time interaction effect (Wilks' λ = .56, p < .001, η^2 = .44; see Figure

[3] We acknowledge that a more precise statistical test for the first set of hypotheses (i.e., null) would be Bayesian hypothesis testing (Ortega & Navarrete, 2017). However, we used identical statistical testing for all hypotheses for the sake of analytic consistency.

1) and significant main effects of video condition on health knowledge acquisition (Session 1) ($F_{[2, 54]} = 16.3$, $p < .001$, $\eta^2 = .39$) and retention (Session 2) ($F_{[2, 54]} = 11.1$, $p < .001$, $\eta^2 = .30$). Post-hoc pairwise comparisons revealed that in Session 1, participants in OC reported significantly greater recall of the embedded health information than participants in NC or CC ($M_{OC} = 4.29$, $SD = .69$ vs. $M_{NC} = 2.53$, $SD = 1.23$ vs. $M_{CC} = 2.52$, $SD = .75$). A week later (Session 2), participants in OC still presented significantly higher recall scores (i.e., knowledge retention) than participants in NC. Regarding recall scores from Session 1 and Session 2, however, participants in CC retained the health information better than participants in NC ($M_{OC} = 4.00$, $SD = .86$, $n = 17$; $M_{NC} = 2.35$, $SD = .93$, $n = 17$; $M_{CC} = 3.86$, $SD = 1.24$, $n = 21$). Thus, the results supported H2c, H2d, and H3a but failed to support H3b.

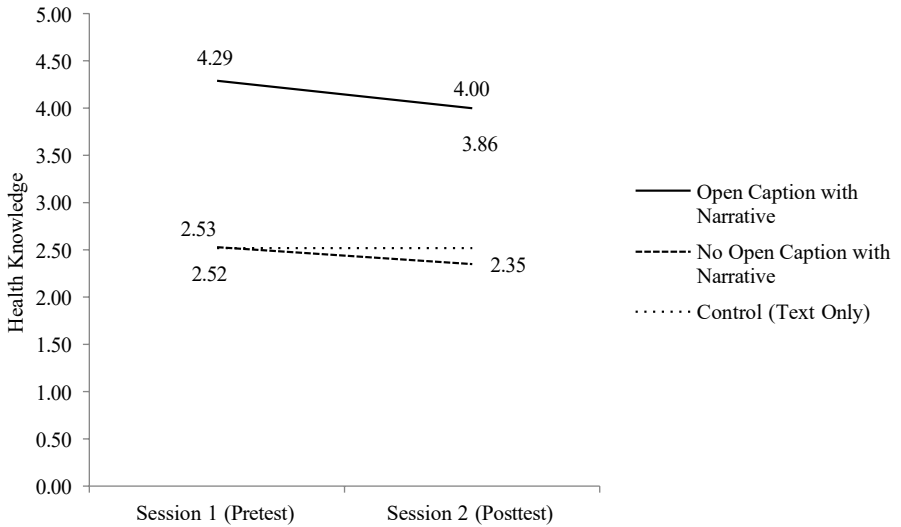

Figure 1. Interaction effect between video condition and time on health knowledge. $F_{(2,\ 51)} = 19.89$, $p < .001$, $\eta^2 = .44$.

Additional Analysis[4]

An additional analysis was used to probe possible associations between cognitive load and outcome variables such as narrative content recall, narrative absorption, health knowledge acquisition, and health knowledge retention. Partial correlations including one covariate (i.e., health literacy) revealed that both intrinsic load and germane load for narrative processing positively correlated with narrative absorption. In addition, the intrinsic load for health information processing positively correlated with narrative content recall only, while narrative content recall positively correlated with knowledge acquisition and knowledge retention (see Table 2).

Table 2. Partial correlations.

Variables	ILNP	GLNP	ILHIP	GLHIP	NCR
ILNP	1.00	.64 (.000)**	.41 (.03)*	.31 (.08)	.29(.10)
GLNP		1.00	.40 (.02)*	.50 (.003)**	.31 (.08)
ILHIP			1.00	.55 (.001)**	.54 (.001)**
GLHIP				1.00	.29 (.10)
NCR					1.00
NA					
KA					
KR					

ILNP: Intrinsic load for narrative processing; GLNP: Germane load for narrative processing; ILHIP: Intrinsic load for health information processing; GLHIP: Germane load for health information processing; NCR: Narrative content recall; NA: Narrative absorption; KA: Knowledge acquisition; KR: Knowledge retention. Health literacy was entered as a controlling variable. $N = 34$. *$p < .05$; **$p < .01$; ***$p < .001$. Exact p-values are in parentheses.

Based on these partial correlation results, a series of mediation analyses were performed using PROCESS with a bootstrapping method of 10,000 (sample size) and bias-corrected 95% confidence intervals (Hayes, 2013) to confirm the possible mediating effects of intrinsic and germane load for narrative and health information processing and narrative content recall on the knowledge outcomes. The tests revealed that the intrinsic load for health information processing mediated the relationship between the experiment condition (no captions = 0 vs. open captions = 1) and narrative content recall (b = .29, SE = .16, LLCI: .05, ULCI: .72), while the other cognitive load measures and narrative content recall did not mediate the experiment condition and the outcome variables. Taken together, the results imply that open captions helped participants better recall the narrative content via the intrinsic load for health information processing.

[4] This analysis included the two video conditions (open captions vs. no open captions) because no data for narrative content recall and absorption were obtained from the control condition.

Discussion

The findings of the current study show that open captions, as a means of presenting health information explicitly, augmented the cognitive load necessary to process the embedded health information, thereby helping viewers acquire and retain the information. Notably, the addition of open captions to the video did not disturb narrative consumption; no difference emerged in narrative absorption between viewers of the medical drama episode with open captions and viewers of the medical drama episode without open captions (Kim & Kim, 2019). Moreover, when integrated well into the narrative, open captions resulted in better recall of the health information, especially compared to plain text delivery apart from the video. Additional analysis revealed that intrinsic load for health information processing mediated the effect of the open captions on narrative content recall.

How Different Types of Cognitive Load Work for E-E Content Processing

In the context of E-E and health education, the findings of the current study suggest (a) that cognitive load for narrative processing and health information processing might play different roles and (b) that to yield desirable learning outcomes, cognitive load for the latter might be more crucial than cognitive load for the former. Indeed, the inclusion of open captions increased cognitive load for health information processing. Interestingly, the intrinsic load for health information processing increased narrative content recall for the narrative with open captions. These findings suggest that processing open captions might demand cognitive load for processing narrative content as well as health information. However, if integrated well into the narrative, open captions might not interrupt narrative appreciation but, instead, help viewers attend not only to the health information delivered by open captions but, also to the key information related to the storylines and characters.

According to the limited capacity model of motivated mediated message processing, stimulating senses by "eliciting orienting responses" is critical to encoding and storing incoming information during media consumption (Lang, 2006, p. 567). In this sense, open captions might elicit orienting responses that help viewers retain the narrative content even better than the uncaptioned version. These orienting responses should be salient when open captions are seamlessly integrated into narrative content, increasing the relevance of two different types of cognitive load (i.e., storyline and health information). The theory of threaded cognition also suggests that people use different "threads" to process information and that each serves a different goal (Salvucci & Taatgen, 2008). Different threads compete for cognitive resources; thus, cognitive demand increases when people process different tasks with distinct goals through different threads. However,

people might process multiple tasks with a common goal (i.e., tasks that are relevant to each other) through the same thread. These related tasks do not have to compete for cognitive resources and are less cognitively demanding than unrelated ones, resulting in a higher recall of media content (Salvucci & Taatgen, 2008).

In addition to playing different roles, cognitive load for narrative processing and health information processing might have different intensities. Scholars have pointed out that the amount of cognitive labor for imagery transportation depends on media type. For example, little cognitive investment is required to process the narrative and characters in a television drama or movie, which are already visualized, whereas readers of a novel might need to engage in greater cognitive investment to picture the scenes and characters presented in the narrative (Green & Brock, 2002). Accordingly, although the participants spent a good amount of cognitive load while viewing the medical drama episode, regardless of open captions, they might have been able to spare cognitive load for health information processing because of the familiar, visualized form of the narrative. This process might have allowed two cognitive-load areas (i.e., narrative processing and health information processing) not to conflict with, but to complement each other. Therefore, the difference in the learning outcomes (i.e., knowledge acquisition and retention) might have been the mental capacity available for incoming health information.

Open Captions as a Guiding Tool for Health Knowledge in Entertainment Media

Successful implementation of open captions in E-E is more likely when they are well integrated in the narrative, allowing narrative processing and health information processing to complement each other. The findings of the current study suggest that to advance E-E, health professionals should make educational components more salient while preserving the psychological benefits viewers seek from entertainment content. In previous E-E studies, scholars have primarily examined the persuasiveness of narratives by measuring attitudes and behavioral intention (Braddock & Dillard, 2016), while also addressing knowledge acquisition and retention (Tukachinsky & Stokunaga, 2013). More importantly, considering that entertainment content can enhance target knowledge by elevating learner motivation (Hawlitschek & Joeckel, 2017), attitudes and behavioral intention might not be the best measures of learning, because learner predisposition toward a particular topic could skew such subjective responses (Fishbein, 2008).

Some might argue that plain text might be as efficient as open captions, due to similar levels of knowledge retention (Session 2) found in the control and open-caption conditions. In fact, the health knowledge reported in the

control condition was greater in Session 2 than Session 1. This result might be attributed, in part, to the positive effect of familiar information format (i.e., text) on long-term memory in learning (Kintsch et al., 1999). According to the theory of long-term working memory (Ericsson & Kintsch, 1995), retrieval and storage of long-term memory are relatively easy when people perform a task familiar to them due to their expertise. In this sense, the retrieval of the lesson about syphilis during Session 2 might have been easier, because the input of the initial knowledge about the health topic was familiar to those in the control condition (i.e., reading the text on the computer screen), facilitating long-term working memory.

However, this finding does not imply that health education in the form of narratives would not be more effective than conventional text-based health education. Our findings clearly show that viewers consumed a significant amount of cognitive resources processing the health information delivered by open captions and also a reasonable amount of cognitive resources processing the narrative content. Thus, the use of open captions in entertainment content can optimize learning without disrupting the effects of narrative persuasion. Indeed, the open captions used to deliver explicit health information enhanced health knowledge acquisition more effectively than the same information given in plain text format, clearly demonstrating the benefits of E-E as a health education tool (i.e., learning by enjoying) (Alvarado & Maskiewicz, 2011; Hawlitschek & Joeckel, 2017; Jerrentrup et al., 2018).

Limitations and Future Research

The partial correlation analyses of the present study did not reveal positive associations between narrative absorption and the learning outcomes (i.e., knowledge acquisition and retention). Therefore, scholars and practitioners should interpret the results with caution, given that the goal of E-E is to achieve positive learning outcomes using the power of narrative (Singhal & Rogers, 2002). The notion of E-E is premised on the unobtrusive delivery of health messages by generating fewer counterarguments to the health messages embedded in the narrative (Green & Brock, 2002; Slater & Rouner, 2002; van Laer et al., 2014). While previous scholars have tended to measure knowledge about broad health issues presented in E-E (e.g., breast cancer screening and drug overdose) (Murphy et al., 2011; O'Connor et al., 1999), the purpose of the current study was to assess specific knowledge about a health issue (not merely syphilis as a broad health issue but its definition, common symptoms, infection routes, prevention, and treatment). Accordingly, while narrative absorption might still have played an important role in keeping participants attentive to narrative content, it might not have been directly associated with the specific learning outcomes that required intrinsic and germane load for detailed health information

processing.

Although a one-week interval, pretest-posttest design was implemented to overcome the limitation of cross-sectional, posttest-only design research, the present study featured a single video clip of a relatively short length (17 minutes) and single health topic in the experimental stimuli. This lack of external validity might indicate that no direct link exists between narrative appreciation and the learning outcomes observed in the present study. Previous findings suggest a positive relationship between narrative transportation and knowledge acquisition based on data collected from real viewers (e.g., Hether et al., 2008; Murphy et al., 2011). However, even with a small sample, the effects of the target-independent variable (i.e., open captions) on the learning outcomes of entertainment content were strong, and the different paths of cognitive load for health information and narrative processing were clear.

Another potential limitation is that the cognitive load measures used in this study were all self-reported. Although physiological measures (e.g., heart rate, eye movement, brain activity) are considered objective, they have their own limitations, including limited accessibility and difficulty in data interpretation (Kruger et al., 2018). However, scholars should consider increasing experimental rigor by using both subjective and objective measures to crystallize the cognitive mechanisms behind E-E consumption for educational purposes.

Nonetheless, the present study is the first attempt to explicate the cognitive mechanisms behind E-E consumption. Despite the small sample, the findings suggest that limited and unobtrusive use of open captions can facilitate the operation of working memory not only for processing health information embedded in a narrative, but also for processing the narrative itself, resulting in positive learning outcomes.

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Notes on contributors

Hyang-Sook Kim (Ph.D., Pennsylvania State University) is an associate professor in the Department of Mass Communication at Towson University. Her research interests include development of effective strategies for health promotion and the use of communication technology for public health education, drawing on theoretical foundations of cognitive and social psychology.

Kyongseok Kim (Ph.D., University of Georgia) is an associate professor in the Department of Mass Communication at Towson University. His research interests include audience motivation and information processing, strategic communication using new media, and health and environmental communication.

ORCID

Hyang-Sook Kim http://orcid.org/0000-0002-5650-5505
Kyongseok Kim http://orcid.org/0000-0003-1216-1154

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