“TV no longer commands our full attention”: Effects of second-screen viewing and task relevance on cognitive load and learning from news

Anna Van Cauwenberge a,*, Gabi Schaap b, Rob van Roy a

a Institute for Media Studies, University of Leuven, Parkstraat 45, Box 3603, B-3000 Leuven, Belgium
b Department of Communication, Radboud University Nijmegen, Thomas van Aquinostraat 2, 6500HE Nijmegen, The Netherlands

Abstract

Second-screen viewing—the use of smartphones, tablets, and laptops while watching television—has increased dramatically in the last few years. This study investigated the effects of second-screen viewing on cognitive load, factual recall and comprehension of news. Second, we examined the effects of relevant (i.e., looking up information related to the news story) and irrelevant (i.e., looking up information unrelated to the story) second-screen viewing on learning from news. Results from an experiment (N = 85) showed that second-screen viewing led to lower factual recall and comprehension of news content than single-screen viewing. These effects were mediated by cognitive load: second-screen viewing led to a higher cognitive load than single-screen viewing, with higher cognitive load, in turn, leading towards lower factual recall and comprehension of news content. Contrary to our expectations, we found no statistically significant differences between effects of relevant and irrelevant second-screen viewing.

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1. Introduction

Second-screen viewing—the use of smartphones, tablets, and laptops while watching television—has increased dramatically in the last few years. The latest Nielsen survey of connected device owners reported that in 2013 nearly half of U.S. smartphone owners (46%) and tablet owners (43%) said they use their devices daily as second screens while watching TV (Nielsen Company, 2013). Accordingly, the much-cited New Multi-screen World report from Google, which took a closer look at cross-platform consumer behavior, warned the TV industry that “TV no longer commands our full attention as it has become one of the most common devices that is used simultaneously with other screens” (Google, 2012).

The question that has kept television producers and advertisers busy is: what do multi-screen viewers use their second screen for? Do they follow up on something relating to the television program they are watching, or are they pursuing other activities? The Nielsen report shows it is both. Among tablet and smartphone owners, looking up general information (76% and 63%, respectively), web surfing (68% and 55%), and visiting social network sites (53% and 52%) are the most popular second-screen activities. However, almost one in two tablet owners also use their device to look up information about what they are watching, and one in five read conversations about the program on social network sites (Nielsen, 2013).

The latest State of the News Media report from the Pew Research Center (Sassen, Olmstead, & Mitchell, 2013) noted that second-screen viewing has become especially popular around news events such as the 2012 U.S. presidential debates, election night, and the State of the Union address. The report found that one in four who watched election night used both internet and television simultaneously to follow up on the results. In addition, a study from Verizon (2012) found that of the 65% adults saying they would watch the 2012 U.S. presidential debate on TV with a second device in hand, 46% planned to use this device for monitoring broadcast media reactions, 41% for fact checking candidate’s claims, 39% for following the live reactions of political reporter(s), and 32% for monitoring social media reactions.

These emerging news viewing trends offer tremendous opportunities for news producers who want to strengthen bonds with their audiences by providing supplementary digital content, or by offering online tools allowing viewers to share and engage with news content more actively. Still, despite the increasing use of second-screens to follow the same news event, indications are that viewers are far more likely to split their attention between distinct activities on each device (Verizon, 2012). As news is not only a commodity, but also has a pivotal role as a source of public affairs information and a tool for fostering citizenship, this raises questions about the
best way forward in news makers’ utilization of second-screen technology. How to design second-screens in terms of content and formal features to ensure informational effectiveness?

The present study sets out to examine the consequences of second-screen viewing on news learning. First, we investigate the effects of second-screen viewing—in this study defined as watching a newscast while simultaneously looking up information online—on cognitive load, factual recall and comprehension of news. Second, we take a closer look at the effects of related (i.e., looking up information related to the news story) and unrelated (i.e., looking up information unrelated to the story) second-screen viewing on learning from news. Results from this study may be of relevance to information producers such as news makers, instructional designers, or public service message producers looking into enhancing the effectiveness of second-screen usage.

Several studies across a wide range of contexts have examined effects of media multitasking on complex memory and learning outcomes such as reading comprehension tasks (Bowman, Levine, Waite, & Gendron, 2010; Fox, Rosen, & Crawford, 2009; Lee, Lin, & Robertson, 2012, 2011; Srivastava, 2013), recall of podcast (Srivastava, 2013) and television news content (Bergen, Grimes, & Potter, 2005), and classroom learning tests (Fried, 2008; Hembrooke & Gay, 2003; Rosen, Lim, Carrier, & Cheever, 2011; Sana, Weston, & Cepeda, 2013; Wood et al., 2012). Most of these studies found that media multitasking reduces memory performance. For example, the use of social media (Wood et al., 2012) and laptops (Fried, 2008; Hembrooke & Gay, 2003; Sana et al., 2013) during class, reading an online news story while simultaneously listening to a podcast (Srivastava, 2013), or reading a text while at the same time being engaged in instant messaging (Bowman et al., 2010; Fox et al., 2009) or video viewing (Lee et al., 2012; Lin et al., 2011), have all been found to negatively influence learning outcomes of the primary task at hand.

Few studies, however, examined effects of concurrent television viewing along with other tasks on memory for television content. In most cases, research has focused on the detrimental effects of television exposure for other tasks. For example, some studies reported interfering effects of background television on reading comprehension (Armstrong & Chung, 2000) and homework performance (Pool, Koolstra, & Voort, 2003; Pool, Van der Voort, Beentjes, & Koolstra, 2000). Others showed a negative influence of concurrent video exposure on reading comprehension (Jeong & Hwang, 2012; Lee et al., 2012; Lin et al., 2011), with news video affecting reading comprehension more severely than comedy video (Lin et al., 2011). One study did examine effects of simultaneous message presentations in a television news program on viewers’ attentional capacity and story fact recognition (Bergen et al., 2005). The researchers found that a multimedia format (i.e., the presentation of a news anchor, together with lexical news crawls, graphics, sports scores, weather icons, etc.) lead to lower recognition test scores than a simple format (i.e., the presentation of only a news anchor). These findings were attributed to the visual complexity of the multiple and conflicting message presentations which exceeded viewers’ attentional capacities, resulting in an inefficient allocation of attentional resources (Bergen et al., 2005).

Although Bergen et al.’s study (2005) indicated that watching television news while simultaneously attending to other visuals on the same screen hampers cognitive processing and memory performance, it is hitherto unknown to what extent a cognitively more demanding activity such as the concurrent use of second screens affects learning from television news. The present study addresses this gap in the literature by examining news recall and comprehension for student participants who watched a newscast while simultaneously looking up information online (i.e., the media multitask condition) and student participants who watched a newscast without receiving a second task (i.e., single task condition). As far as we know, our study is the first to examine effects of second-screen viewing.

A second contribution of the current study is that it considers the relationship between tasks. More specifically, we seek to understand the role of task relevance in facilitating efficient cognitive resource allocation during multitasking. According to Wang, Irwin, Cooper, and Srivastava (2013, p. 6), task relevance refers to “whether the tasks involved in media multitasking serve closely related goals (or overall, a single goal).” Previous research most commonly defines media multitasking as the concurrent engagement in multiple tasks with different goals (e.g. Jeong & Fishbein, 2007; Ophir, Nass, & Wagner, 2009; Wang & Tchernev, 2012), reporting on the deleterious effects of media multitasking on cognitive functions (e.g., Ophir et al., 2009) and task performance (Wang et al., 2012). These findings led to the conclusion that the human brain is ill-equipped to handle multiple tasks simultaneously. However, recent studies found that under certain circumstances, depending on combinations of different individual and task related factors (for an overview see Wang et al., 2013), media multitasking performance may be more successful (David, Xu, Srivastava, & Kim, 2013; Srivastava, 2013; Wang et al., 2012, 2013). Especially in complex multitask situations, individuals tend to allocate their finite cognitive resources more strategically between tasks, seeking an optimal balance between the supply and demand of their resources to achieve the best outcomes (David et al., 2013; Wang et al., 2012, 2013). One way of doing so, it has been suggested, is by combining tasks that share a common goal (Wang et al., 2013).

Following this argument, it might be assumed that second-screen viewing is cognitively disruptive when the second screen is used to pursue activities that are irrelevant to the news program one is watching (e.g., checking email), whereas relevant use of the second screen (e.g., looking up additional information on the news story) might be less disruptive or even beneficial, because both tasks share a common goal, that is, information acquisition on a particular news issue. To our knowledge, no study to date has investigated the role of task relevance in the context of media multitasking. There is some evidence in the multimedia learning literature that the simultaneous presentation of corresponding visual (animation) and auditory (narration) material reduces cognitive load and enhances meaningful learning compared to a successive presentation of the same materials (Mayer & Moreno, 2003; Moreno & Mayer, 1999). However, these studies examined the role of temporal contiguity in multimedia learning and did not concern questions of task relevance. Therefore, in this study we focus on the role of task relevance by investigating news recall and comprehension for student participants who watched a newscast while simultaneously looking up relevant information online (i.e., information about the news story) and student participants who watched a newscast while simultaneously looking up irrelevant information online.

2. Predicting effects of second-screen viewing on recall and comprehension of news: multiple resource theory and threaded cognition

This study uses two theories of concurrent multitask performance to predict effects of second-screen viewing on recall and comprehension of news: multiple resource theory (Wickens, 1984, 2002) and threaded cognition (Salvucci & Taatgen, 2008).

2.1. Multiple resource theory

Resource theories of information processing offer a widely accepted explanation for the fact that performing two tasks
simultaneously impedes task performance. The basic assumption in these models is that humans have a limited amount of cognitive capacity to process information (Basel, 1994; Kahneman, 1973; Lang, 2000). When people engage in multiple tasks at the same time, these limited mental resources must be distributed between concurrent tasks according to the task demands. When processing demands from two or more tasks exceed a person's processing capacities—a situation called cognitive overload (Lang, 2000; Mayer & Moreno, 2003)—multitask performance is expected to decline. That is, parallel processing is possible until resources are depleted.

As one variation of resource theories, multiple resource theory described by Wickens (1984, 2002) posits that humans have several separate pools of mental resources that can be tapped simultaneously without interference, with each pool serving a qualitatively distinct information processing structure (e.g., visual vs. auditory processing). Performance decrement is expected only when concurrent tasks become more demanding on resource pools and when these tasks require the same resource pools. For instance, one resource pool is used for processing visual information whereas another pool is dedicated to verbal information, each possessing limited resources. When simultaneous messages can be processed using a separate pool for each message (e.g., a verbal and a visual message), the messages do not compete for the same resources. If however two tasks do compete for the same resource pools (e.g., two verbal messages) resource decrement is very likely to occur (Wang et al., 2012). For example, a multimedia learning study conducted by Moreno and Mayer (1999) found that learning was more successful when an animated presentation (i.e., nonverbal visual input) was presented with concurrent narration (i.e., verbal auditory input) than with concurrent on-screen text presentation (i.e., verbal visual input). These findings were explained by the fact that the competing verbal and nonverbal visual demands exceeded the capacity of the visual information processing channel, resulting in a loss of information, whereas the mixed modality presentation (i.e., visual and auditory input) split the information between the visual and the auditory channel (Mayer & Moreno, 2003; Moreno & Mayer, 1999). The authors argued that the latter condition enabled learners to hold more information in both auditory and visual working memory and that the combination of both resulted in deeper understanding of the materials presented (Moreno & Mayer, 1999).

In line with multiple resource theory, we expect that watching television news while simultaneously being engaged in an online information search will increase cognitive load, and subsequently reduce recall and comprehension for television news content, because (a) learning from news places high demands on limited mental resources (Mayer & Moreno, 2003), and (b) both tasks require the same mental resource pools, that is, watching television news and searching for information on the Internet both require visual as well as verbal processing (Wang et al., 2012). To examine this, two hypotheses were formulated.

In a first step, we tested the effect of second-screen viewing on factual recall and comprehension of news content. As reviewed earlier, ample research indicates the hampering effects of media multitasking on recall and comprehension. Therefore we predict that:

**Hypothesis 1.** Watching a television newscast while simultaneously looking up information online will lead to higher cognitive load than watching a television newscast without pursuing a second task.

**Hypothesis 2.** Watching a television newscast while simultaneously looking up information online will lead to lower factual recall and comprehension of news content than watching a television newscast without pursuing a second task.

Next, we examine whether the effect of second-screen viewing on news recall and comprehension was mediated by perceived cognitive load. Both theory and research suggest that effects of multitasking are determined by the amount of cognitive load induced by the tasks (Fox et al., 2009; Lang, 2000; Lang, Potter, & Bolls, 1999; Lee et al., 2012; Mayer & Moreno, 2003). However, this causal sequence has not been tested in media multitasking research before. Therefore, we predict as follows:

**Hypothesis 3.** The effect of second-screen viewing on factual recall and comprehension of news is mediated by cognitive load, with second-screen viewing leading to higher cognitive load, which in turn leads to a decrease in factual recall and comprehension of news.

2.2. Threaded cognition and the role of task relevance

The threaded cognition theory (Salvucci & Taatgen, 2008; Salvucci & Taatgen, 2010) is a variation of multiple resource theory that offers an advanced insight into the role of the interrelatedness between tasks. As seen, multitasking performance depends on the interaction between multiple processing goals and the ability to use available resources (Srivastava & David, 2013). Threaded cognition theory posits that “cognition maintains a set of active goals that produce threads of goal-related processing across available resources” (Salvucci & Taatgen, 2008, p. 107). In threaded cognition concurrent tasks are represented by separate cognitive threads, each in service of a particular task-related goal. Similar to multiple resource theory, threads can be processed in parallel in so far as they do not require the same resources at the same time. In other words, it is possible to process various simultaneous tasks effectively, as long as they share common goals, but not the same resources (cf. Wang et al., 2013). In a multitasking situation, multiple threads are in use at the same time. However, multiple threads may represent sub-goals that can be combined as needed to reach a higher goal in the most efficient way. Tasks that share processing goals can be processed more effectively than tasks that do not have overlapping goals. In other words, threaded cognition incorporates the flexible ways in which people juggle two tasks at the same time through its representation of separate tasks as streams of thought that can be swapped and combined as necessary to facilitate cognitive processing and task performance. For example, it has been suggested that two concurrent learning tasks that share a common goal enhance meaningful learning through the facilitating of linkages between related streams of information (Mayer & Moreno, 1999).

Wang et al. (2013) have called this task relevance: the degree to which “the tasks involved in media multitasking serve closely related goals (or overall, a single goal)” (p. 6). Extending this logic to the present study, relevant second-screen viewing (in this study operationalized as looking up additional information on a news story online) might be less detrimental to cognitive processing and learning from news than irrelevant second-screen viewing (i.e., looking up non-related information online), because both news-related tasks are centered around a common goal, that is, meaningful learning of news content. More specifically, it could be argued that irrelevant second-screen viewing may work as a distraction from the processing of television news content, thereby demanding more processing resources and enhancing cognitive load, whereas relevant second-screen viewing may decrease cognitive load by providing additional information that facilitates television news processing. To investigate the role of task relevance in effects of second-screen viewing on learning from news, the following hypotheses were formulated:

**Hypothesis 4.** Relevant second-screen viewing will lead to lower cognitive load than irrelevant second-screen viewing.
Hypothesis 5. Relevant second-screen viewing will lead to higher factual recall and higher comprehension of news compared to irrelevant second-screen viewing.

3. Method

3.1. Participants and design

Participants for this study (N = 85) were recruited from courses at the University of Leuven in the winter of 2013. 42% of the participants were undergraduate students and 58% were graduate students (mean age = 21 years, SD = 1.58%; 78.8% female).

An experiment was performed using a 3 (media multitask mode) x 2 (story order) factorial between-subjects design. The basic study design required participants to watch a three-story newscast of approximately 14 min length in which two target stories were embedded, one at the beginning and one at the end of the newscast. Participants were randomly assigned to the six experimental groups, with approximately 14 participants in each group.

The three levels of the media multitask factor were relevant media multitasking, irrelevant media multitasking, and a control condition without media multitasking. In all three conditions, participants watched the newscast on a desktop computer with headset (i.e. the first media task). For the second media task, participants in the two multitask conditions were provided two printed questionnaires each consisting of a different set of five questions (i.e., the multitask questions). In the relevant media multitask condition, the first and second set of questions were related to the first and second target story respectively. In the irrelevant media multitask condition the questions were not related to the target stories. Using the split screen mode, the left side of the computer screen displayed the newscast, while on the right side Google’s homepage was shown. Participants in the two multitask conditions were asked to look up online and write down the answers to the first set of questions while watching the first target story, and do the same for the second set of questions while watching the second target story (i.e. the second media task). The split screen mode allowed participants to keep an eye on the newscast while simultaneously use the Web for the second media task.

To control for effects of story order, story order was used as a design variable in this study. Two versions of the three-story newscast were created in which the order of the two target stories was reversed.

3.2. Stimulus materials

Two types of stimuli were produced for this experiment: a television newscast and multitask questions, that is, the questions participants in the two media multitask conditions had to answer while watching the target news stories.

A three-story television newscast of approximately 14-min length was produced, using three news fragments from the Dutch public television news program Nieuwsuur (‘News Hour’). Nieuwsuur is a daily evening broadcast that provides background on the main news stories of the day. News items from this program mostly consist of a lead in provided by the studio anchor, followed by a video report, and a closing studio interview with a studio guest or correspondent on location. Because Flemish students mostly consist of a lead in provided by the studio anchor, followed by a video report, and a closing studio interview with a studio guest or correspondent on location. Because Flemish students

The relevant questions were constructed in such a way that the content of the questions was related to the content of the target news stories without showing a major overlap. For example, if a specific term or abbreviation was mentioned in the story without further clarification, a question was: “what does this term/abbreviation stands for?” In addition, the answers to the multitask questions had to differ from the answers participants had to produce for the comprehension and recall tasks in the post-test questionnaire. The irrelevant multitask questions were unrelated to the target stories. Because each set of relevant questions concerned one specific subject (i.e. the Scottish referendum or the murder investigation), the two sets of irrelevant questions were also each centred around one topic. The first set of irrelevant questions was about geography and the second set of irrelevant questions was about movies. All multitask questions were tested in a pilot study so as to ensure the answers to the questions were one-dimensional, easy retrievable online, and of similar difficulty.

3.3. Procedure

The experiment took place in an on-campus computer lab during one week in February 2013. Upon arrival, participants were assigned to a computer with headset. Next, each participant was asked to sign an informed consent. Each form contained a unique code which randomly assigned participants to one of the six experimental groups. Participants assigned to one of the four multitask conditions also received two printed questionnaires with multitask questions. In the relevant multitask conditions, one questionnaire listed the five questions about the Scottish referendum and the other the five questions about the murder investigation. In the irrelevant multitask conditions one questionnaire listed the five questions about geography and the other the five questions about movies.

The experiment consisted of a pre-test questionnaire followed by the experimental stimuli and a post-test questionnaire. The pre-test questionnaire consisted of questions measuring sociodemographics, media multitasking experience, internet efficacy, need for cognition, and prior knowledge of the target news stories. After filling out the pre-test questionnaire participants in the control condition were informed that they were about to watch three news items from the Dutch television news program Nieuwsuur. They were instructed to pay close attention to these news stories. Participants in the multitask conditions were instructed to look up online and write down the answers to the first set of questions while watching the first target story, and do the same for the second set of questions while watching the second target story. The order of the two printed questionnaires was adjusted to the order of the news stories. It was explicitly requested that participants divide their attention between watching the news stories and answering the questions. Participants were instructed to stop looking up answers when the accompanying news story had ended, and put aside the printed questionnaire. To ensure participants followed the outlined procedure, short reminders appeared in the
newscast before and after each news story. Next, detailed instruc-
tions were provided to setup the split screen mode, which enabled
participants to look up the answers online while simultaneously
watch the newscast. A researcher was available to help out in case
there were problems with setting up the split screen mode. After
reading the instructions and setting up the split screen mode, par-
ticipants were directed to the page showing the newscast.

The final part of the experiment consisted of a post-test
questionnaire which measured factual recall, cognitive load, and
comprehension. After completing the questionnaire, participants
got a debriefing about the nature of the experiment.

3.4. Measures

A pre-test questionnaire measured a number of demographic
control variables and other variables that were used in this study as
covariates for statistical control.

3.4.1. Demographics

Gender (78.8% female) was coded as a dummy variable with
male set as the reference category. Age (M = 20.96, SD = 1.58,
range = 17–27) was measured by asking participants their date of
birth and then calculating their age. Education was measured by
asking participants their highest level of education pursued
(including the one they were pursuing at the time of the experi-
ment). Based on the string variables, a dummy variable was
constructed with two categories: undergraduate students (42.4%,
coded as the reference category) and graduate students.

3.4.2. Need for cognition

To control for individual differences in cognitive motivations
that might influence our learning outcomes, we used the need
for cognition scale developed by Cacioppo and Petty (1982). Need
for cognition (M = 3.40, SD = 0.48, range = 2.39–4.56) was mea-
sured with 18 5-point Likert-type items (α = .82), indicating the
degree to which participants enjoy thinking on a scale from one
(“I totally disagree”) to five (“I totally agree”).

3.4.3. Internet self-efficacy

Individuals with more internet skills may perform better on the
second media task than those with less internet skills, leaving the
ones with more internet skills more cognitive capacity for the first
media task than those with less internet skills. To control for
individuals’ internet skills, we used Eastin and LaRose’s (2000)
internet self-efficacy scale that measures individual’s perceived
internet skills (2000). Internet self-efficacy (M = 3.85, SD = 1.12,
range = 1.75–6.75) was measured with 8 7-point Likert-type items
(α = .88) indicating the degree to which participants were familiar
with a number of Internet related skills, ranging from one (“I totally
disagree”) to seven (“I totally agree”).

3.4.4. Frequency of media multitasking

Frequency of media multitasking influences individuals’ media
multitasking performance (Brasel & Gips, 2011; Ophir et al.,
2009). Following Collins (2008) and Srivastava (2013), frequency of
media multitasking was measured by asking participants to
indicate on a 7-point Likert scale how often they perform media
tasks simultaneously. The values on the scale ranged from one
(“never”) to seven (“always”). Because the focus of this study is
on the combination of watching television news while simulta-
neously using a second medium, seven items measured how often participants
watch a television news program while at the same
time using one of the following media: laptop, cell phone or smart
phone, tablet, printed newspaper, magazine, radio or MP3 player,
book. To construct a single measure that indicates how often people
media multitask while watching a television news program, the
seven items were averaged (M = 2.75, SD = 0.84, range = 1.00–
4.86).

3.4.5. Prior knowledge

Embedded in the pre-test questionnaire were eight short answer
format questions of which four tapped participants’ prior
knowledge of the two target news stories used in this experiment.
Incorrect answers or answers that were left blank were coded as
correct, correct answers were coded as one, and answers that were
partly correct received a half point. Prior knowledge (M = 0.47,
SD = 0.51, range = 0–1.50) was an additive index of the items about
the Scottish referendum story (M = 0.47, SD = 0.51, range = 0–1.50)
and about the murder investigation story (M = 0.00, SD = 0.00).
Three outcome variables that were of interest to this study were
measured in a post-test questionnaire.

3.4.6. Cognitive load

Following Eveland and Dunwoody (2001), cognitive load was
measured using four 5-point Likert-type items that assessed partici-
pants’ perceived difficulty following and understanding the
main storylines of the target stories. On a scale from one (“I totally
disagree”) to five (“I totally agree”) participants had to indicate the
degree to which they agreed with the five statements. The phrasing
of the items was slightly adjusted to fit the media multitasking
design of this study. Cognitive load was assessed for the two target
stories separately. A factor analysis yielded a one-component solu-
tion for both stories, explaining 66.10% (Scottish referendum story)
and 68.12% (murder investigation story) of the variance. To con-
struct an overall measure of participants’ perceived cognitive load
during the two target stories, the cognitive load items for the story
about the Scottish referendum (M = 2.71, SD = 0.90, x = .82) and the
story about the murder investigation (M = 2.89, SD = 0.89, x = .84)
were averaged (M = 2.80, SD = 0.75, x = .84, range = 1.13–4.50).

3.4.7. Factual recall

A cued-recall test consisting of eight short answer questions—
four questions about each target news story—tapped participants’
factual recall. Incorrect answers or answers that were left blank
were coded as zero, correct answers were coded as one, and
answers that were partly correct received a half point. Factual
recall was an additive index (M = 1.53, SD = 1.83, range = 0–6.50,
α = .77) of the four short answer items about the Scottish referen-
dum story (M = 1.07, SD = 1.28, range = 0–4) and the four about
the murder investigation story (M = 0.69, SD = 0.46, range = 0–2.50).

3.4.8. Comprehension

Two open-ended questions—one about each target news story—
assessed participants’ comprehension, that is, the extent to which
people captured the meaning of the news story. The question about
the Scottish referendum story read: “Why is the referendum on
Scottish independence organized just now, and what are the main
advantages and disadvantages of independence?” The question
about the murder investigation read: “How has the research in
the murder case of Vaatstra developed from start to finish?” In line
with Yang and Grabe (2011) and Robinson and Levy (1986), partici-
pants’ responses were coded using a coding scheme which out-
lined the main points to each story. The coding scheme was
based on two researchers’ independent identification of the main
points in each target story. The story about the Scottish referen-
dum contained seven main points, the story about the murder
investigation six main points. Comprehension was measured as
the total number of accurate main points participants could formu-
late for both target stories. An accurate main point was coded as
one; a main point that was only partly mentioned received a half
point. To construct an overall measure of news comprehension, the
scores participants received for both target stories were added
Given there was no interaction effect of story order and media multitasking condition on cognitive load, \( F(2,79) = 0.18, p > .05 \), factual recall \( F(2,79) = 3.07, p > .05 \), and comprehension, \( F(2,79) = 0.14, p > .05 \), the six experimental groups were merged to three groups, representing the three media multitasking conditions: a relevant media multitask group \((n = 29)\), an irrelevant media multitask group \((n = 28)\), and a non-media multitask group \((n = 28)\). Next, we examined whether our three experimental groups differed in age, gender, education, need for cognition, internet self-efficacy, frequency of media multitasking, and prior knowledge. No statistically significant between-group differences were found, indicating that randomization was successful.

### 4.1. Manipulation check

The answers to the multitask questions which participants had to look up while simultaneously watching the news cast were analyzed to check whether our experimental manipulation was successful. Incorrect answers or answers that were left blank were coded as zero, correct answers were coded as one, and answers that were partly correct received a half point. This resulted in a score for each target story ranging from zero (no questions answered correctly) to five (all questions answered correctly) \( (M_{Scotland \text{ story}} = 2.82, SD = 2.11; M_{Murder \text{ story}} = 2.77, SD = 2.06) \). We reasoned that the higher participants scored on the multitask questions, the more their attention was diverted to the second media task. If our experimental manipulation was successful, the scores of participants in the media multitask conditions had to be significantly higher than zero, which was the score participants received in the control condition. A Kruskal–Wallis one-way analysis of variance indicated significant between-group differences on the mean scores of the multitask questions for both target stories, \( H(2,30)_{Scotland \text{ story}} = 63.75; \ p < .001; H(2)_{Murder \text{ story}} = 58.71; \ p < .001 \). Multiple pairwise comparisons confirmed that for both target stories the mean scores in the relevant \( (M_{Scotland \text{ story}} = 3.83, SD = 0.97; M_{Murder \text{ story}} = 4.12, SD = 0.79) \) and irrelevant multitask condition \( (M_{Scotland \text{ story}} = 4.59, SD = 0.58; M_{Murder \text{ story}} = 4.13, SD = 0.88) \) were significantly higher than in the control condition, all \( p s < .001 \).

### 4.2. Direct effects of second-screen viewing on cognitive load, factual recall and news comprehension

To test direct effects of second-screen viewing on cognitive load, factual recall and news comprehension three General Linear Model analyses were conducted (see Table 1). Each analysis included the media multitasking manipulation as a between-subjects factor and age, gender, education, internet self-efficacy, media multitasking frequency, prior knowledge, and need for cognition as covariates.

#### 4.2.1. Effects on cognitive load

It was hypothesized that watching a television news cast while simultaneously looking up information online would lead to a higher cognitive load than watching a television news cast without pursuing a second task (H1). Second, a distinction was made between relevant and irrelevant second-screen viewing, with relevant second-screen viewing leading to a lower cognitive load than irrelevant second-screen viewing (H4). We examined the effect of the experimental manipulation. Table 1 presents the results of this analysis. There was a statistically significant effect of the experimental manipulation on cognitive load, \( F(2,75) = 20.68, \ p < .001, \ \eta^2_p = .355 \). The means are presented in Table 2. Multiple pairwise comparisons using the Sidak adjustment showed that relevant \( \left(M_{adj} = 2.89, SD = 0.12 \right) \) and irrelevant second-screen viewing \( \left(M_{adj} = 3.28, SD = 0.12 \right) \) led to a significant higher cognitive load than non-second-screen viewing \( \left(M_{adj} = 2.22, SD = 0.12, both \ p < .001 \right) \), confirming our first hypothesis. Although, irrelevant second-screen viewing led to a marginally significantly higher cognitive load than relevant media multitasking \( (p = .07) \), the findings did not provide statistically significant proof that relevant second-screen viewers

---

**Table 1**

<table>
<thead>
<tr>
<th>Cognitive load</th>
<th>df</th>
<th>F</th>
<th>B</th>
<th>p</th>
<th>Partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>9</td>
<td>5.72</td>
<td>-</td>
<td>.000</td>
<td>.407</td>
</tr>
<tr>
<td>Intercept</td>
<td>1</td>
<td>16.07</td>
<td>5.74</td>
<td>.000</td>
<td>.176</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.18</td>
<td>0.09</td>
<td>.673</td>
<td>.002</td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>0.85</td>
<td>-0.05</td>
<td>0.360</td>
<td>.011</td>
</tr>
<tr>
<td>Education</td>
<td>1</td>
<td>0.47</td>
<td>-0.12</td>
<td>0.493</td>
<td>.006</td>
</tr>
<tr>
<td>Internet self-efficacy</td>
<td>1</td>
<td>0.99</td>
<td>-0.07</td>
<td>0.323</td>
<td>.013</td>
</tr>
<tr>
<td>Media multitasking frequency</td>
<td>1</td>
<td>0.95</td>
<td>-0.09</td>
<td>0.332</td>
<td>.013</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>1</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.959</td>
<td>.000</td>
</tr>
<tr>
<td>Need for cognition</td>
<td>1</td>
<td>3.20</td>
<td>-0.27</td>
<td>0.078</td>
<td>.041</td>
</tr>
<tr>
<td>Media multitasking manipulation</td>
<td>2</td>
<td>2.06</td>
<td>-0.20</td>
<td>.000</td>
<td>.355</td>
</tr>
<tr>
<td>Error</td>
<td>75</td>
<td></td>
<td></td>
<td>.000</td>
<td>.355</td>
</tr>
</tbody>
</table>

Note: Cognitive load \( R^2 = .407 (Adjusted R^2 = .336) \). Factual recall \( R^2 = .614 (Adjusted R^2 = .567) \). Comprehension \( R^2 = .514 (Adjusted R^2 = .456) \).

*Including the relevant and irrelevant media multitask conditions, but not the control condition.

---

**Table 2**

<table>
<thead>
<tr>
<th>Media multitask condition</th>
<th>Irrelevant</th>
<th>Relevant</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M SD</td>
<td>M SD</td>
<td>M SD</td>
</tr>
<tr>
<td>Cognitive Load</td>
<td>3.28(^a)</td>
<td>0.12</td>
<td>2.89(^b)</td>
</tr>
<tr>
<td>Factual recall</td>
<td>0.46(^a)</td>
<td>0.23</td>
<td>0.51(^b)</td>
</tr>
<tr>
<td>Comprehension</td>
<td>1.72(^a)</td>
<td>0.30</td>
<td>2.01(^b)</td>
</tr>
</tbody>
</table>

Note: Cognitive load, factual recall, and comprehension means are adjusted for gender, age, education, internet self-efficacy, media multitasking frequency, prior knowledge, and need for cognition. Means within a row with different superscripts differ significantly at \( p < .001 \).
perceive less cognitive load than irrelevant second-screen viewers. Therefore, Hypothesis 4 was rejected.

4.2.2. Effects on factual recall and comprehension

Hypothesis 2 predicted that watching a television newscast while simultaneously looking up information online would lead to lower factual recall and comprehension of news content than watching a television newscast without pursuing a second task. In addition, it was expected that relevant second-screen viewing would lead to higher factual recall and comprehension of news than irrelevant second-screen viewing (H5). We found a statistically significant effect of the manipulation on factual recall, $F(2,75) = 56.73$, $p < .001$, $\eta_p^2 = .602$, and comprehension, $F(2,75) = 30.43$, $p < .001$, $\eta_p^2 = .448$. Multiple pairwise comparisons using the Sidak adjustment revealed that relevant ($M_{adj} = 0.61$, $SD = 0.23$) and irrelevant second-screen viewing ($M_{adj} = 0.46$, $SD = 0.23$) led to significantly less factual recall than non-second-screen viewing ($M_{adj} = 3.55$, $SD = 0.23$, both $p < .001$). With regard to comprehension, pairwise comparisons showed that relevant ($M_{adj} = 2.01$, $SD = 0.30$) and irrelevant second-screen viewing ($M_{adj} = 1.72$, $SD = 0.30$) led to significantly less comprehension than non-second-screen viewing ($M_{adj} = 4.75$, $SD = 0.30$, both $p < .001$). These findings confirm Hypothesis 2. However, relevant second-screen viewing did not lead to higher factual recall ($p > .05$) and comprehension ($p > .05$) than irrelevant second-screen viewing, rejecting Hypothesis 5.

4.3. Mediating effects of cognitive load

In a second step, we examined whether effects of second-screen viewing on factual recall and comprehension were mediated by cognitive load. Two simple mediation models using ordinary least squares path analyses were conducted with the SPSS version of Hayes (2013) PROCESS macro. To include our three-categorical independent variable in the mediation analyses, two dummy variables (relevant second-screen viewing dummy and irrelevant second-screen viewing dummy) were constructed using indicator coding. With each run one dummy variable was included in the analysis as the independent variable and the other as a covariate. In addition, all mediation analyses controlled for age, gender, education, internet self-efficacy, media multitasking frequency, prior knowledge, and need for cognition.

The first mediation analysis analyzed the effect of irrelevant and relevant second-screen viewing on factual recall through cognitive load. Fig. 1 shows that irrelevant second-screen viewers ($a_1 = 1.062$, $p < .001$) and relevant second-screen viewers ($a_2 = 0.672$, $p < .001$) perceived a significantly higher cognitive load during media multitasking than participants who did not multitask, and participants who perceived a higher cognitive load were significantly less likely to recall facts from the target news stories ($b = -0.568$, $p < .05$). As Table 3 reports, the bias-corrected bootstrap confidence interval for the indirect effect of irrelevant second-screen viewing on factual recall through cognitive load ($a_1b = -0.603$) did not include zero ($-1.1919$ to $-0.1729$), indicating that the indirect effect was statistically different from zero. This means that cognitive load significantly mediated the effect of irrelevant second-screen viewing on factual recall. This finding was confirmed by the Sobel test ($Z = -2.093$, $p < .05$). For the indirect effect of relevant media multitasking on factual recall through cognitive load ($a_2b = -0.382$), the BC bootstrap confidence interval ($-0.8413$ to $-0.1221$) showed that cognitive load significantly mediated the effect of relevant second-screen viewing on factual recall. However, the Sobel test was only marginally significant ($Z = -1.9185$, $p = .055$). With regard to the direct effects of irrelevant and relevant second-screen viewing on factual recall, we found evidence that irrelevant ($c_1 = -2.489$) and relevant second-screen viewing ($c_2 = -2.557$) influenced factual recall independent of its effects on cognitive load (both $p < .001$). The direct effect of irrelevant second-screen viewing was statistically different from zero, $t(74) = 4.914$, $p < .001$, with a 95% confidence interval from $-3.4977$ to $-1.4795$. The direct effect of relevant second-screen viewing was statistically different from zero, $t(74) = 6.1954$, $p < .001$, with a 95% confidence interval from $-3.3791$ to $-1.7345$.

The second mediation analysis examined the effect of irrelevant and relevant second-screen viewing on comprehension through cognitive load. As can be seen in Fig. 2, the $b$ path showed that participants who perceived a higher cognitive load were significantly less likely to comprehend the target news stories ($b = -0.748$, $p < .05$). As Table 3 reports, the BC bootstrap confidence interval ($-1.6913$ to $-0.2542$) indicated that the indirect effect of irrelevant second-screen viewing on comprehension through cognitive load ($a_1b = -0.795$) was statistically different from zero. The Sobel test confirmed that the effect of irrelevant second-screen viewing on comprehension was significantly mediated by cognitive load ($Z = -2.2338$, $p < .05$). For the indirect effect of relevant second-screen viewing on comprehension through cognitive load ($a_2b = -0.503$), the BC bootstrap confidence interval ($-1.1186$ to $-0.1607$) and the Sobel test ($Z = -2.030$, $p < .05$) showed that cognitive load significantly mediated the effect of relevant

---

**Table 3**

<table>
<thead>
<tr>
<th>Point Estimate</th>
<th>SE</th>
<th>Z</th>
<th>BC 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV $\rightarrow$ CL $\rightarrow$ FR $\rightarrow$ 0.603</td>
<td>0.248</td>
<td>-2.093</td>
<td>-1.192, -0.173</td>
</tr>
<tr>
<td>ISV $\rightarrow$ CL $\rightarrow$ FR $\rightarrow$ 0.382</td>
<td>0.169</td>
<td>-1.919</td>
<td>-0.841, -0.122</td>
</tr>
<tr>
<td>ISV $\rightarrow$ CL $\rightarrow$ C $\rightarrow$ 0.795</td>
<td>0.351</td>
<td>-2.234</td>
<td>-1.691, -0.254</td>
</tr>
<tr>
<td>ISV $\rightarrow$ CL $\rightarrow$ C $\rightarrow$ 0.503</td>
<td>0.230</td>
<td>-2.030</td>
<td>-1.119, -0.161</td>
</tr>
</tbody>
</table>

Note: BC, bias corrected; 5000 bootstrap samples. ISV = irrelevant second-screen viewing; RSV = relevant second-screen viewing; CL = cognitive load; FR = factual recall. **Controlling for age, gender, education, internet self-efficacy, media multitasking frequency, prior knowledge, and need for cognition.**

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**Fig. 1.** Mediation model of second-screen viewing, cognitive load, and factual recall.

<table>
<thead>
<tr>
<th>a'</th>
<th>b</th>
<th>c'</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.062</td>
<td>$-0.568$</td>
<td>$-2.489$*** (0.256)</td>
</tr>
<tr>
<td>0.672</td>
<td>$0.489$</td>
<td>$-2.557$*** (0.413)</td>
</tr>
</tbody>
</table>

---

**Fig. 2.** Mediation model of second-screen viewing, cognitive load, and factual recall.

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second-screen viewing on comprehension. Regarding the direct effects of irrelevant and relevant second-screen viewing on comprehension, the mediation analysis found that irrelevant ($c'_1 = -2.237$) and relevant second-screen viewing ($c'_2 = -2.240$) influenced comprehension independent of its effects on cognitive load (both $p < .001$). The direct effect of irrelevant second-screen viewing was statistically different from zero, $t(74) = -3.588$, $p = < .001$, with a 95% confidence interval from $-3.4792$ to $-0.9947$. The direct effect of relevant second-screen viewing was statistically different from zero, $t(74) = -4.742$, $p = < .001$, with a 95% confidence interval from $-3.1818$ to $-1.2990$.

In sum, evidence from both mediation analyses provided support that the effect of second-screen viewing on factual recall and comprehension of news was mediated by cognitive load, with second-screen viewing leading towards a higher cognitive load, which in turn led towards a decrease in factual recall and comprehension of news (H3). However, our findings also revealed that other influences may play a role as well in explaining effects of second-screen viewing on news learning.

### 5. Discussion

This study contributes to the research field of media multitasking in three ways: First, it is the first study to examine effects of second-screen viewing on information processing and learning from the news. Second, it provides empirical evidence that the negative effects of media multitasking on recall and comprehension of news are induced by cognitive load. Third, it shows that in complex multitasking situations such as second-screen viewing, little difference exists between effects of relevant and irrelevant media multitasking. As expected, our study indicated that second-screen viewing led to lower factual recall and comprehension of news content than non-multitasking viewing. These effects were mediated by cognitive load: individuals engaging in second-screen viewing perceived a higher cognitive load than single-screen viewers, and individuals with higher levels of cognitive load recalled and comprehended less of the news content than those with lower levels of cognitive load. Although a marginally significant effect indicated a tendency for relevant second-screen viewers to perceive slightly less cognitive load during multitasking than irrelevant second-screen viewers, we found no major differences between relevant and irrelevant multitasking for learning from the news. This finding is important, because it shows that irrespective of whether multitaskers pursue related or unrelated activities on their devices, second-screen viewing may hamper what is remembered and learned from the news.

Theoretically, the findings from this study showed that there are limits to human’s flexible multitasking skills. In line with threaded cognition theory, recent studies demonstrated that in some situations strategic allocation of limited mental resources may enhance successful media multitasking performance (David et al., 2013; Wang et al., 2012, 2013). Indeed, our study also provided indications that combining task-related activities was somewhat less demanding on limited mental resources than pursuing concurrent unrelated activities. However, in the end, impaired recall and comprehension of news was evident for both kinds of media multitasking. The multiple resource theory provides a straightforward explanation for this: processing two concurrent tasks, whether they be related or unrelated, is still cognitively more demanding than processing a single task. Especially in the case of complex concurrent tasks that compete for the same mental resources, impaired task performance is to be expected, as shown in this study. Even when news viewers use their second screens for related pursuits, they have to split their perceptual and cognitive resources between two concurrent streams of information processing (e.g., using working memory to store or transform two streams of information at the same time) with cognitive overload and loss of information as an inevitable consequence. The mediation analyses supported this; both relevant and irrelevant second-screen viewers experienced difficulties to follow the main storylines of the television newscast which directly led to impaired recall and comprehension of news content. Still, following threaded cognition theory, we predicted at the outset of this paper that concurrent tasks that share a common goal (relevant second-screen viewing) would be less detrimental to cognitive processing and news learning than concurrent tasks that do not have an overlapping goal (irrelevant second-screen viewing).

### 5.1 Results from the Mediation Analyses

To better understand the processing differences in both relevant and irrelevant multitasking, we conducted mediation analyses in order to determine whether multitasking had an effect on cognitive load and comprehension. The mediation analyses supported this: both relevant and irrelevant second-screen viewers experienced difficulties to follow the main storylines of the television newscast which directly led to impaired recall and comprehension of news content. Still, following threaded cognition theory, we predicted at the outset of this paper that concurrent tasks that share a common goal (relevant second-screen viewing) would be less detrimental to cognitive processing and news learning than concurrent tasks that do not have an overlapping goal (irrelevant second-screen viewing).

Given these predictions were unsupported by our results, what do the findings of the present study imply for threaded cognition as a theory of complex multitasking, in particular the role of task interrelatedness in explaining multitasking performance? At first sight, the findings of the current study may lead to question the validity of threaded cognition theory for explaining complex multitasking such as second-screen viewing. We are, however, hesitant to jump to this conclusion for two reasons: First, although threatened cognition allows for the parallel execution of multiple tasks or processing threads, the theory posits that all resources operate sequentially, serving only one task or thread at a time. Especially in the case of newly learned tasks, the declarative resource, which represents factual knowledge that can be recalled, can be a prominent source of interference (Salvucci & Taatgen, 2008). The reason for this is that “the declarative resource (...) is most active in early stages of learning because of dependence on memorized task instructions.” (Salvucci & Taatgen, 2008, p. 127) Applied to the present study, it is likely that participants’ dependence on task-specific knowledge to complete the online search assignment while simultaneously watching a news clip, may have caused processing bottlenecks and, as a result of that, impeded the kinds of flexible multitasking strategies we expected to arise during relevant second-screen viewing. Secondly, participants in the relevant second-screen viewing condition were provided with a compulsory, fixed set of news-related questions, which may not have been reflective of the personal multitasking strategies they would have pursued in a more natural second-screen viewing condition.
threaded perspective of multitasking “provides an account for how people integrate their skills as necessary to adapt to the demands of the current task environment.” Because the present study did not account for these idiosyncratic multitasking strategies, it is possible that participants’ news elaboration and learning did not fully benefit from the operationalization of relevant second-screen viewing applied in this study, hence, explaining why cognitive threading remained unsupported by our findings.

Nonetheless, it is conceivable that in some situations combining less stringent related tasks that do not share cognitive resources may have more constructive effects than the ones found in this study. Also, the mediation analyses pointed out that our measurement of perceived cognitive load only partially captured the cognitive processes through which second-screen viewing resulted in impaired recall and comprehension of news. We suggest a way forward would be to differentiate between different types of cognitive load that are involved in learning. For example, Sweller (2010) distinguished between intrinsic cognitive load (related to the complexity of the content), extraneous cognitive load (related to the difficulty of the learning design) and germane cognitive load (related to individual learning capacities). In addition, future research might want to complement post hoc self-reports of cognitive load with online measures of cognitive load (e.g. pupillometric measures), as different measurement techniques were found to tap separate aspects of cognitive load (Zheng & Cook, 2012).

From a practical point of view, this study has a number of implications for news producers and audiences. Although second-screen viewing appears to be a successful means for enhancing attention to and involvement with TV programs and media brands (Fitzgerald & Clarke, 2012), the current study indicates that there may also be unsolicited negative audience effects. This may not be a great problem in a context where the primary focus is on increasing market shares and audience entertainment. It becomes, however, problematic in the case of informational programs such as news programs, where a primary goal is to inform the user. Given the expected rise of second-screen viewing in the coming years, and the fact that second-screen applications will most likely continue to constitute a major strategic tool in the increasingly competitive fight for audiences, we advise producers of second-screen applications to focus on designing apps that improve information processing during media multitasking. For example, informational message designers and researchers may want to focus on how to integrate first and second-screen information—both in terms of content and format—so that depletion of cognitive resources is put to a minimal.

Our study has a number of limitations. First, as in any experimental study some degree of ecological validity was sacrificed in order to be able to make causal claims. The artificial design and setting of our study limits the extent to which our findings may be generalized to other second-screen viewing contexts. In everyday life, different contexts may engender distinct multitasking goals, motivations, and strategies. For instance, recent theory and research indicates that in everyday life people often pick combinations of concurrent tasks that are relatively easily to combine, such as, tasks that do not require the same cognitive resources or that differ in processing demands (Srivastava & David, 2013; Wang et al., 2013). This also ties in with the fact that the second task in our experiment was compulsory. Although this secured that participants in the multitask conditions divided their attention between the two concurrent media tasks, this does not reflect a natural second-screen viewing situation. Therefore, it would be relevant to extend the study of second-screen viewing to more natural settings, for example by means of observational research methods.

A final limitation concerns the operationalization of second-screen viewing in this study. For practical reasons, this study used a computer split-screen mode for the presentation of two concurrent media stimuli. We acknowledge that this setting is different from the natural second-screen viewing situation in which people watch a newscast on television while simultaneously using a second screen, such as a smartphone or tablet. However, because both screens were clearly distinguished from each other, we are confident that our operationalization accurately approached participants’ natural experience of second-screen viewing.

As a final remark, this study urges news producers, media researchers, and media technology developers, to further explore how news audiences use second-screens to engage with television news content. In light of our findings, we specifically encourage future studies to explore how second-screen viewing might contribute to better learning of public affairs information.

References
