THE MEDIUM CAN INFLUENCE THE MESSAGE: PRINT-BASED VERSUS DIGITAL READING INFLUENCES HOW PEOPLE PROCESS DIFFERENT TYPES OF WRITTEN INFORMATION

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Abstract

While electronic reading devices are extremely popular, research is equivocal regarding their benefits for outcomes such as reader comprehension. Integrating literatures on reading medium comparisons and matching effects in persuasion, this research tested whether comprehension is maximized when the content of the material (e.g., whether it is traditional versus modern) matches the medium (e.g., reading from a traditional book versus digital e-reader). In Study 1, participants read a traditional- or modern-themed short story from either a book or an e-reader. Story comprehension was greater when participants read from the printed medium compared to the e-reader, an effect that was marginally moderated by story content, consistent with a matching effect. In Study 2, participants read a persuasive message that emphasized either a traditional versus modern solution to improving health in either a magazine format or on an iPad. Message comprehension was marginally greater among participants who read their message in a printed format. Participants' interest in weight loss showed evidence of a matching effect – participants were more interested in losing weight when a modern solution to obesity article was presented on an iPad compared to a printed format. The results are applied to the study of reading and attitude change.

KEYWORDS: print reading, digital reading, communication, matching effects, attitude change

The medium can influence the message: Print-based versus digital reading influences how people process different types of written information

Reading books or magazines from digital screen devices such as e-readers, laptops, mobile phones, and tablets is extremely common. These devices allow users to pick up the daily newspaper from their own pocket or access a library from their fingertips, downloading a novel of choice in seconds. Given the immense popularity of digital reading, it is important to investigate how it compares to reading a printed book, especially as digital reading continues to develop as a market. To that end, the present research tests whether reading written material from a print or digital medium influences reader comprehension and interest, and whether the written material's theme affects the impact of reading medium on comprehension.

To date, different strands of research have explored whether reading from a printed book or electronic device affects readers' perceptions of written text. In one set of studies, Wästlund, Reinikka, Norlander, and Archer (2005) asked Swedish participants to read text in either a printed format or PDF format (on a computer), which was followed by an assessment of comprehension. These researchers found that comprehension was enhanced among participants who read printed text compared to participants who read in a digital format. Further, participants found the digital format to be particularly stressful compared to the paper format. The authors speculated that this latter effect might have been attributable to increased cognitive demands of the digital format.

Gable and Thompson (2011) compared information retention of an article read on printed text, an Apple iPad, or a Kindle. These researchers found that the e-readers did not reduce the time needed to read the information, though reading from them did improve short-term memory retention. There was, however, no significant difference

between all three formats on long-term retention. Gable and Thompson also noted that individuals were faster reading from printed text compared to electronic text, and suggested that this could be due to lack of familiarity with the e-readers. Supporting this view, they found that participants who had previously used e-readers were quicker reading from them.

Mangen, Walgermo, and Brønnick (2013) measured differences in story comprehension as a function of reading medium in a sample of Norwegian high school students. In this study, participants read narrative and expository texts either in a print or digital medium (the latter done via a computer screen). The results revealed that reading comprehension was greater among students who read the printed text, an effect that was independent of individual differences in vocabulary acuity and reading ability. From a pedagogical perspective, these researchers argued that increased digitization of school children's books could lead to negative learning consequences.

Ackerman and Goldsmith (2011) considered the effects on comprehension as a result of print versus digital reading under fixed versus non-fixed (i.e., self-regulated) reading time. These researchers also assessed participants' metacognitive perceptions of their comprehension of the text. It was found that under a fixed reading time, comprehension did not differ as a function of reading format, whereas under no fixed reading time participants showed greater comprehension in the paper format compared to the digital format. Interestingly, under self-regulated timing, digital readers were grossly overconfident regarding how they expected to perform on the comprehension test. On the basis of their results, Ackerman and Goldsmith (2011, p. 29) concluded that individuals "perceive the printed-paper medium as best suited for effortful learning, whereas the electronic medium is best suited for fast and shallow reading of short text such as news." Taken together, these findings imply that

contextual factors might have an effect on the relative utility of print versus digital reading formats.

However, other research has offered evidence regarding the benefits of digital reading. For instance, Sackstein, Spark, and Jenkins (2015) discovered that the majority of South African University and high school students read text faster from an iPad when compared to paper. The researchers also found no significant differences in the comprehension of informational text between the two reading format groups, implying increased efficiency from digital reading. Other studies have also found evidence for enhanced comprehension and understanding among individuals who read digital versus printed text (see e.g., Ross, Pechenkina, Aeschliman, & Chase, 2017).

In a recent comprehensive literature review that included over 50 studies and involved more than 170000 participants, Delgado, Vargas, Ackerman, and Salmerón (2018) found that overall, there was a substantial comprehension advantage for printed material compared to digital material – evidence suggesting a *screen inferiority effect*. Furthermore, these researchers considered a series of potential moderating variables, finding three to be especially important: time frame, text genre, and publication year. In particular, reading printed material had more pronounced effects when there were time constraints for reading, when the material was focused on information relative to a narrative, and in more recently published papers.

The present research aims to advance existing work by addressing two important new issues. As a primary aim, we consider whether a printed book or digital medium has different effects on comprehension depending upon the content of written material. Adapting findings from the social psychological literature on matching effects and persuasion, we test whether written material emphasizing *traditional* versus *modern* content is differentially processed as a function of whether it is read in a print

versus digital medium. As a secondary aim, we address how reading medium and material format impact the degree to which readers become immersed with written material. Do readers become more immersed in material depending upon its presentation format? Does this depend upon the information's content?

The Integration Of Reading Medium And The Content Of Written Information

Previous research assessing the implications of print versus digital text has used a range of reading stimuli. Some studies have used academic text information (e.g., Noyes & Garland, 2003), whilst others have used social policy issues (e.g., Ackerman & Goldsmith, 2011; see Delgado et al., 2018). In this paper we focused on two different types of written material: short stories (Study 1) and magazine-format articles (Study 2). We selected these formats given their popularity as predominant forms of printed reading and as digital material. Of course, the content of short stories and magazine articles can differ on a number of important dimensions. In this research, we considered whether *traditional* versus *modern* written content influences whether the reading medium impacts comprehension. In particular, we tested whether readers would demonstrate greater recall when written information emphasizing a traditional theme was read in the more traditional book format compared to when the same material was read on an electronic device. Conversely, we also tested whether written information with a modern theme would elicit greater recall when read on a modern digital device compared to a printed format. Put differently, we considered whether readers differentially process and evaluate different types of written information as a function of the medium in which the information is read.

Our reasoning is based upon social psychological findings on *matching effects* in persuasion. This research has addressed how persuasive appeals are more (or less) effective depending upon how aspects of the message match (or mismatch)

characteristics of the message recipient. For example, numerous studies (e.g., Haddock, Maio, Arnold, & Huskinson, 2008; Mayer & Tormala, 2010; see Haddock & Maio, 2018) have shown that individuals who base their attitudes on affective information (their feelings about attitude objects) devote more attention to, and are more persuaded by, cogent affect-based appeals (e.g., the taste of a beverage). Similarly, people who base their attitudes on cognitive information (their beliefs about attitude objects) devote more attention to, and are more persuaded by, cogent cognition-based appeals (e.g., information about a beverage's nutritional value). Similarly, in a review of matching effects in the domain of health, Rothman, Bartels, Wlaschin and Salovey (2006, p. 202) concluded that "gain-framed appeals are more effective when targeting behaviors that prevent the onset of disease, whereas loss-framed appeals are more effective when targeting behaviors that detect the presence of a disease" (see Maio, Haddock, & Verplanken, 2018, for a more detailed review of different types of matching effects).

As applied to the present context, we address a different type of matching effect. Whereas previous research has demonstrated that matching occurs when information is integrated with an individual's needs and/or dispositions, we examine whether matching the content of information integrates with the medium in which the information is presented. One core distinction between different forms of media reflects the degree to which they can be described as *traditional* (e.g., books, magazines) versus *modern* (e-readers, tablets). We adopted this temporal component as the foundation for our research, and subsequently used narratives that also had a temporal distinction. For example, stories can be differentiated on the degree to which they highlight traditional versus modern themes or ideas. We integrated these distinctions in the studies presented in this paper. Specifically, we test whether written information with a more traditional theme would best match the older, more traditional paper

medium, whereas information with a more modern theme would be more likely to align with a modern digital reading medium.

Reading Medium And Transportation

In addition to considering the effects of written content and reading medium on comprehension, one can also ask whether reading *engagement* differs between reading from a printed versus digital medium, and whether this depends on content. Gerrig (1993) coined the term *transportation* to refer to how immersed a reader becomes into a narrative world. When an individual becomes transported into a story, they become highly engaged into the story, leaving the real world behind (Green & Brock, 2000). Research on narrative persuasion has revealed that narratives can have a substantial impact on readers' attitudes and beliefs, an effect that is mediated by transportation (e.g., Dal Cin, Zanna, & Fong, 2004; Green & Brock, 2000, 2005; Mazzocco, Green, Sasota, & Jones, 2010; Thompson & Haddock, 2012).

In the context of reading from a printed versus digital format, very few studies have explored the impact of reading format on transportation. In a library study assessing the possible utility of e-readers in higher education, Behler (2009, p. 58) analyzed students' attitudes towards e-readers and concluded that students "read differently when using their Sony Readers (e-readers) instead of books: They *felt* more immersed in the text." More recently, Mangen and Kuiken (2014) had participants read a fiction or non-fiction story from a printed booklet or from an iPad. These researchers found that the digital format reduced transportation, but only among individuals who read non-fiction. In the present research, we consider whether reading medium and content type impact a reader's level of immersion, such that individuals become more immersed into information when the theme is more aligned with the reading medium.

Further, we consider whether any effects of written content and reading medium on comprehension might be mediated by transportation.

STUDY 1

In this study, participants read either a traditional or modern themed short story from a printed book or using an Amazon Kindle Fire. After reading their story, participants completed a reading comprehension measure, along with measures of transportation, a measure assessing aspects of literary attitudes (the Literary Response Questionnaire; LRQ, Miall & Kuiken, 1995), and measures assessing their experience of using digital reading devices. We tested whether comprehension and transportation differed as a function of reading medium and story type. We also tested whether any effect on comprehension was mediated by differences in transportation.

Method

Participants

112 undergraduate students (102 females; M_{age} = 19.9 years) from a British university participated in return for course credit or payment. Data were collected through the course of an academic year, with the aim of recruiting at least 20 participants per cell.

Materials

Short Stories. Participants were randomly assigned to read one of two short stories. Our key criterion was using narratives that differed in the extent to which the story concerned more traditional versus modern content. The traditional *(*i.e., classical*)* story was *At Home (*Chekhov, 1887/2000). The story tells of a father trying to explain to his son why he should not smoke. The modern (i.e., technological) story was *The Veldt* (Bradbury, 1951/2008). This story tells of parents who have spoilt their children with futuristic technology. The two stories share similarities in that they both focus on

family dynamics, as well as issues faced by parents raising and communicating with their children. That said, a key distinction between the stories is how their content diverges with respect to technology. At Home is traditional in focus (and includes references to paper, pens, and pencils), whereas The Veldt includes many references to technology and the use and importance of screens. The stories were comparable in terms of their readability (Flesch Reading Ease scores between 74 and 79), as well as the number of words per sentence (10.1 versus 8.7), characters per word (both 4.3) and syllables per word (both 1.4; from www.online-utility.org/english/readability_test_and_improve.jsp).

Reading Medium. Participants read their assigned story in one of two formats. Some participants were randomly assigned to read a book version of their selected story, whereas participants in the digital condition read a version of their story on an Amazon Kindle Fire*.* The device we used has a 7" display screen and employs touch screen technology.

Measures

Story Comprehension Questionnaire*.* For each story, comprehension was assessed by having participants respond to seven multiple choice questions that assessed factual information and primary themes within the assigned story. A higher score represents greater comprehension. A recent literature review examining the implications of printed versus digital reading highlighted that multiple choice recall questions are a common measure of comprehension (Singer & Alexander, 2017).

Transportation Scale (Green & Brock, 2000). This scale assesses how transported an individual is into a particular narrative. The measure includes items such as "I was mentally involved in the narrative while reading it" and "I found my mind

wandering while reading the narrative" (reverse scored). Participants responded to the individual items on a scale ranging from 1 (not at all) to 7 (very much); with a high score indicating greater transportation (α = 74).

Literary Response Questionnaire (LRQ; Miall & Kuiken, 1995)*.* This measure assesses various aspects of readers' response toward literary texts. The measure includes items such as "When I have a spare time my favorite activity is reading a novel" and "In literature I sometimes recognize feelings that I have overlooked during my daily life". Participants responded to items on a scale ranging from 1 (not at all true) to 5 (extremely true). Because the items correlated highly (α = .86), they were combined to form a single index, with higher scores representing greater interest and enjoyment of reading. This measure was used for two reasons. First, it was considered to be important as a covariate in analyses on story comprehension and transportation. Second, in supplemental analyses we wanted to assess whether LRQ scores are associated with preferences for book or digital reading.

Digital Reading Experience and Preferred Reading Format*.* To assess participants' reading habits and preferences, they indicated their e-reader experience/ownership (among items assessing experience with other technologies) as well as their preferred reading format. E-reader experience was assessed by asking participants to indicate (a) how often they used an E-reader (1 = never; 7 = everyday) and (b) previous experience with an E-reader (1 = have never used before; 3 = own). These items were standardized and combined into a single item, as they were highly correlated, r (112) = .77, p < .001. Preferred reading format was measured by asking participants whether, when reading a book, they preferred a hard copy of the text to an electronic one (1 = strongly disagree; 7 = strongly agree).

Procedure

Participants completed the study individually. They were informed that the study would involve them reading a short story and answering some questions. They were told to read the story at their own pace and alert the experimenter once they had finished. Once participants had read the assigned story they were given the Transportation Scale, the Literary Response Questionnaire, and answered questions about reading experiences. Finally, they were given the appropriate story comprehension questionnaire to complete (this measure was completed at the end in order to have a small gap between reading the story and answering questions on its contents). On completion of the study participants were debriefed and thanked.

Results

The Impact of Content Type and Reading Medium on Comprehension

To address whether content type and reading medium impacted reading comprehension, a 2 (Content type: traditional versus modern) x 2 (Reading medium: printed versus digital) ANCOVA was conducted, with the LRQ score and reading time as covariates. The analysis revealed a significant main effect of content type, $F(1, 106) = 4.49$, $p = .036$, $n_p{}^2 = .041$. Overall, comprehension scores for the modern story ($M = 6.09$) were greater than those for the traditional story ($M = 5.66$). This effect might simply represent differences in the difficulty of the two question sets that we generated. Of greater relevance, there was also a significant main effect of format, $F(1, 106) = 11.01$, $p < .001$, $n_p{}^2 = .094$. Overall, comprehension scores were greater among participants who read their story from a printed book ($M = 6.16$) compared to those who read their story via the digital reader ($M = 5.59$). Moreover, there was a marginally significant interaction between content type and reading medium, $F(1, 106) = 2.95$, $p = .089$, $n_p{}^2 = .027$. Among participants who read the traditional story, comprehension was significantly greater when it was read in printed form ($M = 6.07$) relative to digital form

(M = 5.25), $F(1, 53)$ = 13.85, $p < .001$, $n_p{}^2$ = .210. Among participants who read the

modern story, comprehension did not differ as a function of format, $F(1, 53)$ = 1.01, p

=.320.

The Impact of Content Type and Reading Medium on Transportation

To address whether content type and reading medium had an effect on

transportation, a 2 (Content type: traditional versus modern) x 2 (Reading medium:

printed versus digital) ANCOVA was conducted, with LRQ score and reading time as

covariates. The analysis revealed a marginal main effect of content type, $F(1, 106)$ =

3.66, p =.059, $n_p{}^2$ = .033. Overall, participants were more transported into the modern

story (M = 4.16) compared to the traditional story (M = 3.93). Interestingly, there was

no main effect of reading format on transportation, $F < 1$, p = .656. Of greater relevance,

there was a significant interaction between content type and reading medium, $F(1, 106)$

= 5.51, p =.021, $n_p{}^2$ = .049. Among participants who read the traditional story,

transportation was greater when it was read from a printed book (M = 4.04) relative to

the digital form (M = 3.82), $F(1, 53)$ = 4.78, p =.033, $n_p{}^2$ = .083. Among participants who

read the modern story, transportation did not differ as a function of reading medium,

$F(1, 53)$ = 1.55, p =.219.

Does Transportation Mediate the Comprehension Effect?

Given the impact of reading medium and story type on transportation, we tested

whether transportation mediated the observed interaction on comprehension scores.

This mediated moderation model was tested using Hayes' (2013) PROCESS procedure.

Confidence intervals were derived using 5000 bootstraps. The results of this analysis

revealed that transportation significantly mediated the effect of reading medium and

story type on comprehension (95% CI: .043 to .774).

Preferred Reading Format

Finally, we considered whether LRQ scores and dedicated e-reader experience predicted participants' preferred reading format. There was a small but significant correlation between the predictors, such that higher LRQ scores were associated with greater e-book experience, r (112) = .21, p = .03. In the regression, the two variables accounted for 27.8% of the variance in format preference; this proportion of variance was significantly greater than zero, F(2, 109) = 20.97, p < .001. Dedicated e-reader experience was a significant predictor of preferred reading format, β = -.44, p < .001. Individuals with greater e-book experience were more likely to prefer reading in that format. LRQ scores were also a significant predictor of preferred reading format, β = .39, p < .001. Overall, individuals who scored high on the LRQ were more likely to prefer a hard copy of a book over a digital copy.[1]

Discussion

The primary aim of Study 1 was to address whether content type and reading medium influence reader comprehension and transportation. Based on findings regarding matching effects in persuasion, we anticipated that the manipulated variables would jointly impact comprehension and transportation. Specifically, we considered whether readers would show greater comprehension and have a more absorbing reading experience when a story with a traditional theme was read in the printed book format compared to on an electronic device, and whether there would be a corresponding effect when participants read a story with a modern theme. In addition to testing the impact of content type and reading medium on comprehension and transportation, the study also considered a possible mediating role of transportation.

The primary results of Study 1 revealed that overall, comprehension was greater when participants read their story in the printed book medium compared to the digital medium. This is consistent with the results of Delgado et al.'s (2018) recent meta-

analysis. This effect was marginally moderated by story type, such that the effect was found only when participants read the story with the traditional theme. This pattern of effects implies that the classical content was better processed when read in traditional book format, whereas the modern content was equally well processed when read in traditional book format or on an electronic device. These results bear similarity to effects on matching effects within the attitude change literature. In the present context, it is plausible that reading a classical story in a book format leads to greater engagement compared to when the same story is read in a digital medium. Indeed, consistent with this argument, we found that individuals who read the classical story were more transported into the story when it was read in a book medium relative to a digital medium. Further, we found that transportation significantly mediated the observed effects on comprehension.

While these results offer a number of interesting insights, they also generate other questions worthy of investigation. Study 1 was conducted using *real* short stories that differed in their thematic emphasis, while at the same time being comparable on a series of indices regarding readability. Nonetheless, it is possible that the stories could have differed on other dimensions. In Study 2, we moved away from story-based content to consider whether comparable effects are demonstrated with a different form of written material – health-related information. Is it the case that the matching effects are found in other domains, for other types of reading material? In addition, in Study 2 we developed written stimuli, in order to provide better control over the precise content of the written information.

STUDY 2

In Study 2, we moved away from a short story format to asking people to read a popular magazine style article. The focus of the article was about improving physical

health, an issue that is likely to be relevant to most student participants. From our perspective, targeting health promotion in the context of different reading formats offers an important applied test of the joint impact of written content and reading format. In this study, our primary outcome variable represented people's interest in acting upon improving their health. This is important as individuals' interests and intentions are a good predictor of their behavior (see Maio et al., 2018).

In Study 1, we found that transportation was impacted by content type and reading format and also mediated the interactive effect of content type and reading format on comprehension. Given our move away from short stories to an article emphasizing health promotion, we would argue that transportation per se is less relevant as a variable of interest. This is because the transportation construct is relevant to engagement with *stories*, not how people respond to information in a persuasive appeal.

In the study, participants read an article that detailed a solution to increased levels of obesity in the United Kingdom (where the research was carried out). Participants read one of two articles – one article presented a traditional solution to promote health whereas the second article presented a modern solution. Participants read their article either on paper or on an Apple iPad. After reading their assigned article, participants completed a questions regarding their perceptions of their article. Because participants read an article instead of a story, we did not use the LRQ in this study.

Method

Participants

80 undergraduate students (72 females; M_{age} = 19.5 years) from a British university participated in return for course credit. Data were collected throughout an academic year, with the aim of recruiting at least 20 participants per cell.

Materials

Magazine Articles. Participants were randomly assigned to read one of two articles that were developed by the researchers. The articles were presented to participants as appearing in '*Pro Health Magazine'*. The two articles introduced the topic with three identical paragraphs regarding the prevalence of obesity. Following this introductory information, the individual articles contained statements from a university expert describing his opinions on the best solution to obesity. One article – titled *Back to the past: How fat Britain can make a big change* - highlighted a more traditional, classical solution to obesity, emphasising that individuals should simply 'eat less and do more.' For example, in this article the expert is quoted as saying "In order for us to go back to the healthy ways of the past, we need to go back in time ... Forget your protein supplements and your state of the art gymnasiums. Let's get the basics right first. Our fit and able ancestors didn't need such complications and neither do we."

In contrast, the second article – titled *The future is here: How fat Britain can make a big change* - highlighted a modern, technological solution to obesity, emphasizing how modern technology (i.e., mobile-phone apps) should be integrated into health regimes. For example, in this article the expert is quoted as saying "*Downloading fitness apps can expose individuals to vital information and advice for healthy living ... The technology at our disposal gives us great flexibility encouraging people to become more active and re-shaping the UK population.*"

The number and quality of arguments were equal in both the traditional and modern solution articles (as established by a pilot study), and the concluding paragraphs were identical across studies. Embedded within each article was a matched advertisement for a company that offered either a classic or modern approach to weight loss. This was included to determine whether message content and reading format might spillover to influence perceptions of the advertisement. The articles were comparable in terms of their readability (Flesch Reading Ease scores between 51 and 56), as well as the number of words per sentence (17.5 versus 17.6), characters per word (4.7 versus 4.9) and syllables per word (both 1.6; from www.online-utility.org/english/readability_test_and_improve.jsp).

Reading Medium. Participants read their assigned story in one of two formats. Some participants were randomly assigned to read a paper version of their selected article. This was achieved by designing a mock magazine format, with participants provided with a photocopied version of their assigned article. Participants randomly assigned to the digital reader condition read their selected article on an iPad 3. It has a 9.7 inch display screen and uses touch screen technology.

Measures

Once participants read their assigned article, they completed a series of questions in response to the article's contents. Participants who read a paper version of their assigned article completed these items on paper whereas participants who read a digital version of their assigned article completed these items on the iPad.

Story Comprehension Questionnaire. Ten multiple choice questions were developed to assess comprehension of the article's contents. For each question, participants also indicated how certain they were about their response (1 = not at all certain; 7 = extremely certain).

Interest in Weight Loss. We assessed participants' interest in weight loss with four questions. A sample item was "To what extent does weight loss concern you? (1 = not at all; 7 = very much so). The four items were combined to form an advertisement persuasion index (α = .59).

Engagement. Participants specified the extent the article engaged their attention (1 = not at all engaged; 7 = extremely engaged) and how deeply they considered the presented information (1 = not at all deeply; 7 = extremely deeply). As responses were correlated, r (112) = .62, p < .001, they were combined into a single index.

Article convincingness. Four questions assessed how persuasive the participants found the article content. For example, participants were asked "How convinced are you by Dr. Stephenson's argument about the best way to reduce obesity?" As the items were highly correlated they were combined to form a single article index (α = .90).

Advertisement Poster Persuasion. Four questions assessed how informative participants found the advertisement that was embedded within the persuasive message. For example, participants were asked "How much did you like the advertisement poster at the end of the article?" The four items were combined to form an advertisement persuasion index (α = .88).

Digital Reading Experience and Reading Format Preference. Digital reading experience and preferences were established as participants stated how often they read from a digital screen (1 = never; 7 = everyday) and their usual reading format preference (paper or digital screen). Participants were also asked to specify how certain they were of their preference (1 = not at all certain; 7 = extremely certain).

 Procedure

Participants completed the study individually. Participants read the assigned article and then completed the outcome measures. Individuals in the paper reading condition were asked to alert the experimenter once they had completed each task, so they could be presented with the next materials. Digital condition readers were asked to inform the experimenter once they had completed reading the article and answering the questions. Participants were encouraged to take their time and complete each task at their own pace. Once they had completed their questionnaire, they were debriefed and thanked for their participation.

<div align="center">**Results**</div>

The Impact of Content Type and Reading Medium on Comprehension and Certainty

To address whether content type and reading medium impacted reading comprehension, a 2 (Content type: traditional versus modern) x 2 (Reading medium: paper versus digital) ANOVA was conducted.[2] The analysis revealed a small but non-significant main effect of content type, $F(1, 76) = 2.70$, $p = .104$, $n_p{}^2 = .034$. Overall, comprehension scores for the traditional solution article ($M = 5.80$) were slightly higher than those for the modern solution article ($M = 5.15$). This effect might simply represent differences in the difficulty of the two question sets that we had generated. Of greater relevance, there was a marginally significant main effect of reading format, $F(1, 76) = 3.13$, $p = .081$, $n_p{}^2 = .040$. Overall, comprehension scores were greater among participants who read their article on paper ($M = 5.82$) compared to those who read their article digitally ($M = 5.12$).

Regarding certainty, the analysis revealed a significant main effect of reading format, $F(1, 76) = 6.23$, $p = .015$, $n_p{}^2 = .076$. Overall, participants who had read their

article on paper (M = 4.26) were more certain regarding their comprehension compared to participants who had read their article on the iPad (M = 3.80).

The Impact of Content Type and Reading Medium on Interest in Weight Loss

To address whether content type and reading medium impacted interest in our primary outcome variable - weight loss, a 2 (Content type: traditional versus modern) x 2 (Reading medium: paper versus digital) ANOVA was conducted. The analysis revealed a marginally significant main effect of content type, F(1, 76) = 3.90, p =.052, $n_p{}^2$ = .049. Overall, participants showed greater interest in weight loss after having read the modern solution (M = 4.66) compared to the traditional solution (M = 4.23). This effect might simply represent differences in the effectiveness of the two passages we generated. Of greater relevance, there was a marginally significant interaction between content type and reading medium, F(1, 76) = 3.47, p =.067, $n_p{}^2$ = .044. Among participants who read the modern solution, interest in weight loss was significantly greater when it was read in digital form (M = 4.95) relative to printed form (M = 4.38), F(1, 38) = 4.13, p = .049, $n_p{}^2$ = .098. Among participants who read the traditional solution, interest in weight loss did not differ as a function of format, F(1, 38) < 1, p =.453.

The Impact of Content Type and Reading Medium on Engagement, Article Convincingness, and Advertisement Poster Persuasion

To address whether content type and reading medium impacted engagement, appeal strength, and advertisement strength, 2 (Content type: traditional versus modern) x 2 (Reading medium: paper versus digital) ANOVAs were conducted. The analysis on engagement scores revealed no significant effects (all ps < .380). The analysis on appeal strength revealed a significant main effect of content type, F(1, 76) = 7.77, p = .007, $n_p{}^2$ = .093. Overall, the traditional solution article (M = 4.67) was seen as

more persuasive than the modern solution article (M = 3.91). The analysis on advertisement poster persuasion revealed a significant main effect of content type, $F(1, 76) = 5.19$, $p = .026$, $n_p{}^2 = .064$. Overall, the advertisement in the traditional solution article (M = 3.86) was seen as more persuasive than the advertisement in the modern solution article (M = 3.30).

Preferred Reading Format and Digital Reading Experience

The vast majority of participants (80%) favored paper reading over digital reading. Supplemental analyses were conducted assessing how participants' level of experience with digital reading impacted their engagement with the article they read. Separate correlations were computed for participants in the iPad and magazine format conditions. Within the iPad condition, greater experience with digital reading was associated with greater engagement with the article, $r(40) = .39$, $p = .012$. There was no significant correlation between these variables among participants in the magazine condition, $r(40) = -.16$, $p = .340$. These correlations were significantly different from each other, $z = 2.47$, $p = .014$.

Discussion

The aim of Study 2 was to test the impact of content type and reading medium in the context of reading a persuasive appeal. In this study, we developed appeals that were identically structured, but differed in whether their arguments highlighted a more traditional versus modern solution to the issue of obesity. As in Study 1, we found that comprehension was enhanced when participants read written information in a printed format (though in this study the effect was marginally significant). Participants also expressed greater certainty in their responses when they read the information in a printed format. Of greater relevance, content type and reading format impacted respondents' interest in weight loss. Specifically, when participants read a modern

solution to reduce obesity, they showed greater interest when this information had been read in a digital format compared to a print format. This offers support for the role of matching in understanding how readers respond to information presented in a printed versus digital format. It might also reflect the integration between the message's use of mobile technology (using an app) and the digital device used to read the message.

We should note that that the interplay between the content of the health information and reading format did not impact engagement or evaluations of a message-relevant advertisement. With respect to engagement, this finding might reflect our decision to use a topic that was expected to be personally relevant among our sample. Such relevance might override any effects on perceived engagement with the message per se. With respect to evaluations of a message-relevant advertisement, the finding suggest that there was no spillover on judgments. This suggests that the impact of message content and reading format might be limited to judgments that are most pertinent to the message. Alternatively, participants might have devoted little attention to the advertisement.

General Discussion

Digital reading is now an important component in how individuals consume information, be it reading novels, newspapers, or magazines about their hobbies. Integrating lines of research from different literatures (e.g., education, human factors, and social psychology), the current research offers, to our knowledge, the first empirical test of whether the impact of digital and printed reading differs as function of the content of the reading material. Specifically, building upon research on the matching effect in persuasion (see Haddock & Maio, 2018) we tested whether reading digital versus printed text differs as a function of the content of the material. This proposal

was tested in two studies, one assessing comprehension of information from a short story, the second assessing comprehension and intentions to act upon the information with the text.

The results of Study 1 showed that overall, comprehension of story material was enhanced when participants read their short story in the printed format compared to a digital format. Consistent with findings on the matching effect, there was evidence that comprehension advantage depended upon the content of the story, such that traditional story content was better remembered when read in the printed relative to digital format. A similar pattern of results was found on a measure of transportation, with evidence of mediation.

The results of Study 2 were consistent with the primary findings reported above. In this study, participants' comprehension of health-relevant information was (marginally) greater when the information was presented in a printed format than a digital format. Similarly, information content and reading format interacted in predicting participants' interest in weight loss, such that participants who read a modern solution to reduce obesity showed greater interest when this information has been presented in a digital format compared to a print format.

It is also relevant to note that across the two studies, the effect of matching content and format was most pronounced in conditions when article comprehension was lower (i.e., in Study 1's traditional story condition and Study 2's modern solution condition). This raises of the question of when matching effects might be more or less likely to arise. As noted in the introduction, there is strong evidence for matching effects in persuasion (see Haddock & Maio, 2018; Maio et al., 2018), and future research can continue to more directly consider whether the magnitude of these effects is linked with factors such as attention, text difficulty, and relevance.

Taken together, the findings are novel and important in a number of ways. First, the texts used in both studies were longer than those used in the majority of studies comparing digital versus print reading formats (cf. Mangen & Kuiken, 2014; Mangen, Olivier, & Velay, 2019), offering evidence of generality of the screen inferiority effect. Second, the current results clearly build upon previous research by offering a key insight into the *conditions* under which the reading medium influences reader comprehension, by addressing how message content and message format can jointly influence message comprehension. Of course, it is worth noting how the current results integrate with extant research examining variables that influence the screen inferiority effect. A recent meta-analysis (see Delgado et al., 2018) found evidence that the comprehension advantage after print reading was more pronounced when reading under time restrictions and for informative texts, though none of the studies in the meta-analysis examined the role of matching content and format (to the best to our knowledge). Both of the present studies allowed for self-paced reading, and the texts were purely narrative (in Study 1) or included narrative and informative components (in Study 2). To the extent that the meta-analytic conclusions about reading time and text style can be applied to the current work, it is conceivable that the observed matching effect could have been more pronounced had participants' reading time been restricted, or had we used texts that were purely informative. Specifically, with respect to restricted reading time, given that our effects were most pronounced when comprehension was low, increased attentional load, via time pressure, might be expected to increase the magnitude of the matching effect, to the extent that the effect is linked with processing heuristics (see Haddock & Maio, 2018). Of course, this is speculative, and additional research is warranted to address such a view.

The present research also contributes to the literature by considering *how* the reading medium impacts comprehension. Previous research has speculated that readers might find printed text less stressful and interfering (see e.g., Noyes & Garland, 2003; Wästlund et al., 2005). Integrating these speculations with empirical research on narrative persuasion, Study 1 tested the role of transportation as a potential mediator of any observed effects. We found evidence that transportation mediated the effect of reading format on comprehension. This finding is important in increasing our understanding of the types of differences brought about by reading on different media, as well as what underlies differences in comprehension. The mediating effect of transportation on comprehension also bears relevance to Behler's (2009) qualitative observation that college students felt more immersed in the text when reading a traditional printed book compared to a digital version of the same text. We believe that future research should continue to investigate the applied implications of differences in transportation as a function of reading medium. Research has demonstrated that more transported readers are likely to change their attitudes in a manner that is consistent with the narrative's themes, and that readers transported into stories about health (e.g., stories about health risks associated with binge drinking, cancer and cigarette smoking) are more likely to positively change their behavior (see Dal Cin, Gibson, Zanna, Shumate, & Fong, 2007; Green, 2006; Green & Clark, 2013; Kreuter et al., 2007; McQueen, Kreuter, Kalesman, & Alcarez, 2011; Thompson & Haddock, 2012).

A supplemental aim of the research was to consider factors that influence individuals' general preference for reading via the printed versus digital medium. In Study 1, we used individual differences in reading enjoyment (as assessed by the LRQ) and digital reading experience as predictors of preferences. Our results revealed that both variables had a significant unique impact. Perhaps unsurprisingly, participants

with greater e-reader experience were more likely to prefer the digital medium to the printed medium. Regarding the LRQ, the results revealed that individuals who scored high on this measure were more likely to prefer the traditional printed format. These participants, who enjoy reading, may be more sensitive to the sensory perceptions influenced by a printed book, such as the feel of the paper, and the smell of the ink, which could also explain their preference. In Study 2, while participants reported a preference for printed or digital reading, those who read their article on an iPad were more engaged with the article when they had greater experience with digital reading. Taken together, these results highlight a somewhat interesting paradox. Whereas people who use e-readers seem to prefer the electronic format, people who are particularly interested in reading seem to prefer the book format, despite the small positive association between e-reader experience and LRQ scores. High scorers on the LRQ are interested in reading and might therefore be more inclined to purchase reading devices because of their benefit (portability, storage, backlighting, wireless technology), but there is the potential for digital reading to reduce their engagement with particular forms of text. This finding also suggests e-reader companies might focus their advertising attention more onto individuals who do not naturally enjoy reading, perhaps focusing on the novelty and fun of reading from an electronic device.

Although the studies have produced a number of novel and interesting findings, there are limitations. First, young adults were tested in both studies. Almost all of our participants were from a generation where they have grown up with vast forms of technology. As a result, they may be better able to adapt to reading from an electronic device than someone from an older generation. Moreover, because these young adults have grown up with technology, they may be more inclined to have purchased or used an e-reader compared to someone from an older generation. Furthermore, the sample

consisted predominantly of females, and although no gender differences have been reported in transportation (Green & Brock, 2000) or e-book versus printed book preference (Woody et al., 2010), research has noted that female students read more than male students and often outperform males on reading comprehension tests (Logan & Johnston, 2010). Consequently, this sample may have consisted of more regular readers than the general population.

To conclude, our research study makes a novel contribution to our understanding of how the reading medium affects comprehension and engagement. Further, the research builds upon recent perspectives regarding the need to address new questions related to the psychology of reading (see e.g., Delgado et al., 2018; Mangen & van der Weel, 2016; Ross et al., 2017). Returning to the title of our paper, the Canadian communications philosopher Marshall McLuhan (1964, p. 1) famously argued that the "the medium is the message," implying that the contents of the medium play a role in processing the message's meaning. Fifty years later, we can see how the presentation of the same story content in different media can impact how it is processed by its readers.

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Endnotes

1 Interestingly, in both the book and e-book medium conditions, preferred reading format was not correlated with comprehension or transportation (all *p*s < .40).

2 We did not measure reading time in this study.