High-Low Split: Divergent Cognitive Construal Levels Triggered by Digital and Non-digital Platforms

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ABSTRACT
The present research investigated whether digital and non-digital platforms activate differing default levels of cognitive construal. Two initial randomized experiments revealed that individuals who completed the same information processing task on a digital mobile device (a tablet or laptop computer) versus a non-digital platform (a physical print-out) exhibited a lower level of construal, one prioritizing immediate, concrete details over abstract, decontextualized interpretations. This pattern emerged both in digital platform participants' greater preference for concrete versus abstract descriptions of behaviors as well as superior performance on detail-focused items (and inferior performance on inference-focused items) on a reading comprehension assessment. A pair of final studies found that the likelihood of correctly solving a problem-solving task requiring higher-level "gist" processing was: (1) higher for participants who processed the information for task on a non-digital versus digital platform and (2) heightened for digital platform participants who had first completed an activity activating an abstract mindset, compared to (equivalent) performance levels exhibited by participants who had either completed no prior activity or completed an activity activating a concrete mindset.

Author Keywords
Construal level; digital versus non-digital platforms; information processing; reading comprehension

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
Speculative reports of the potential long-term impact of modern technology on human cognition have become increasingly ubiquitous in popular press outlets, with many mass media journalists sounding warning bells about the deterioration of attention spans brought about by technology-induced multitasking and a growing shallowness of thought and communication catalyzed by our increasing reliance on mobile devices and social media platforms [15]. A common theme in such reports is the fear that the modern world's information inundation is killing humans' capacity for contemplative, abstract thought and, indeed, permanently altering the wiring and circuitry of our brains [1]. Despite the often sensationalist and alarmist nature of these accounts, there is growing evidence that they may not be far from the truth. For example, neuroscience researchers comparing experienced Internet users with novices found significant changes in the neural circuitry of the latter group, particularly in areas of the brain associated with short-term memory and rapid decision-making, after just a matter of five days' exposure to the web [17; see also 5, 18, 19].

Moreover, a substantial body of work since the 1980s comparing electronic and print reading has shown relative determents in comprehension levels and depth of processing [12, 13, 23]. Nonetheless, more recent reviews of the literature have revealed that such investigations have provided inconsistent results, precluding the drawing of any definitive conclusions about the differences between reading from screens and paper [3, 16]. In addition, a majority of the published research has focused on identifying features of digital platforms that may affect the quality or depth of processing or retention of information [3, 14, 22]. Comparatively less attention has been devoted to studying the distinct cognitive processes which, all other factors being equal, might be triggered by digital versus non-digital information processing platforms. Has the human mind evolved to the point that the mere fact that information is being processed on a digital device be sufficient to activate a distinct mindset or pattern of processing? This fundamental question provided the impetus for the present work.

Our interest in this question was spurred by the results of our own exploratory pilot work in the domain of game design and research. Specifically, a prior investigation [10] compared player performance in a public health strategy game of which participants were randomly assigned to play either a digital instantiation (a mobile app) or non-digital analog (a physical board game). This game centered on the key issues of disease spread and immunization. This investigation showed that significant differences emerged in players' success in the game as well as the game's efficacy at promoting higher levels of systems thinking. Specifically, players of the digital version exhibited strategies prioritizing

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immediate, localized solutions (e.g., deploying vaccinations nearby an occurring outbreak) rather than maintaining a "big picture" view (e.g., considering the presence of more vulnerable characters elsewhere on the board).

These divergent patterns of decision making and strategizing led us to predict that digital technologies may, in fact, "prime" or activate differing default levels of *construal* in individuals. Construal-level theory (CLT), posited by psychologists Trope and Liberman [20], posits that the more psychologically close versus distant individuals perceive themselves to be from a stimulus or event, the more likely they are to think of it in terms of concrete details versus abstract, higher-level interpretations. According to CLT, the likelihood of utilizing more concrete versus abstract construal levels may shift depending on a number of factors (e.g., temporal or spatial distance between people and objects, hypotheticality of events, etc.) that are "primed" or activated by the current situation or one's current mindset. Moreover, psychologists have identified a number of key benefits of utilizing more abstract, high-level construals, including higher levels of self-control resulting from more abstract construals of self- or goal-related information [8] as well as higher levels of creativity and insightfulness [6].

To date, the construct of construal levels and the implications of construal for information processing have not significantly informed HCI theory or research. The present work aimed to begin to fill this gap by investigating whether the aforementioned divergences in information processing in digital versus non-digital platforms could be due, at least in part, to the default level of construal triggered by the two. Specifically, might digital platforms have created a mental "habit" of triggering a more detail-focused mindset, one that prioritizes processing local, immediate information rather than considering more abstract, decontextualized interpretations of information [20]? The four studies reported here sought to investigate this possibility, both by comparing information processing between digital and non-digital delivery platforms (Studies 1, 2, and 3A) and testing the impact of priming either an abstract or concrete mindset in individuals prior to their completion of an information processing task on a digital device (Study 3B).

STUDY 1

As a first step toward investigating whether digital platforms activate lower levels of construal compared to non-digital platforms, an initial study administered a standard measure of construal level preference to participants on either a digital device (i.e., a 2nd generation Apple iPad) or a non-digital platform (a physical print-out of the same materials).

Participants

Seventy-seven participants (45 female, 32 male, mean age = 24.2 years) enrolled in the study in exchange for a small monetary compensation. Participants were recruited for the study via word of mouth from friends and colleagues in the campus community, printed flyers and postings on social media outlets, and direct solicitation of visitors to the academic building in which the study was conducted.

Materials and Procedure

All study sessions took place in an academic laboratory, and each participant completed the study individually. Prior to their arrival, an experimenter randomly assigned participants to either the digital platform condition ($N = 40$) or non-digital platform condition ($N = 36$). In both conditions, participants completed the Behavior Identification Form [21], a validated, widely used measure assessing individuals' *current* preference for low versus high levels of construals of everyday behaviors and events. This self-report measure presents respondents with a list of twenty-five items, each representing a particular behavior (e.g., "making a list"), along with two alternative descriptions of the target behavior, one high-level and abstract in nature (e.g., "getting organized") and the other low-level and concrete in nature (e.g., "writing things down"). Respondents are asked to mark which of the two descriptions they would currently prefer to use to describe the given behavior.

In creating the digital and non-digital implementation of the Behavior Identification Form for use in the study, great care was taken to keep nearly all features of the presented stimulus materials constant between the two platforms. For example, the same font size and layout of the screens/pages were utilized between the two delivery platforms and the contextual setup for participants' reading of the information were standardized (with participants presented the digital device or print-out on a flat surface in front of them), in order to help rule out any alternative explanations for differences in outcome observed between the two platforms. In addition, participants' means of indicating their selected alternative was equivalent as possible, with participants in the digital platform condition clicking a box to make a check mark appear, and participants in the non-digital platform condition physically using a pen to mark their chosen option.

Next, participants in all conditions were administered a brief survey measuring their gender, age, and frequency of use of iPads or related mobile tablet devices. For the latter items, participants were asked to indicate whether or not they had used tablets in the past and, if so, how frequently (on a 5-point Likert scale, with 1 = "once or twice" and 5 = "daily").

Results and Discussion

Each response to the twenty-five items included in the Behavior Identification Form is scored "0" if respondents selected the low-level description and "1" if they selected the high-level description. Each participant's responses were summed to form an overall Behavior Identification score, with higher scores indicating a higher preference for abstract construals. Between-condition differences in preference levels were analyzed using a one-way analysis of variance (ANOVA). Results revealed that, in line with predictions, participants in the non-digital platform condition exhibited a significantly higher level of preference for abstract construals ($M = 18.56$, $SD = 10.31$) than did participants in

the digital platform condition (M = 13.75, SD = 8.23), F(1, 76) = 4.78, p < .03, d = .50. Importantly, there were no significant differences between conditions in frequency of prior use of digital tablets, with a vast majority of participants in both the non-digital and digital platform conditions indicating either weekly or daily use of tablets. Thus, the observed difference in construal level cannot easily be accounted for by a lack of familiarity with mobile devices; at the same time, the restricted range of responses exhibited by participants prevents us from determining the level of correlation between frequency of tablet use and construal level preferences. In addition, a similar pattern of response on the device use frequency items emerged in Studies 2 and 3. Furthermore, no significant main effects of gender or platform x gender interactions were observed in this study or the subsequent two studies. Thus, neither of these variables will be discussed further.

In sum, Study 1 provided initial evidence that digital mobile devices may indeed trigger a lower level of construal, compared to the level triggered by non-digital displays, for individuals processing the same information. Study 2 sought to extend these findings to a new domain of information processing – the reading of a fictional short story – and another digital platform, a laptop computer.

STUDY 2

Participants

Eighty-one participants (47 female, 33 male, 1 unspecified, mean age = 21.2 years) enrolled in the study in exchange for a small monetary compensation.

Materials and Procedure

Most elements of the procedure from Study 1 were maintained in Study 2, including the study setting, means of recruitment, and efforts to standardize conditions between the digital and non-digital platform conditions. In this study, participants were asked to read a short story (written by author David Sedaris) describing a fictionalized account of a main character's memories of a holiday visit to his family home. The story was selected for the study due to its high level of rich detail and deeper inferences about the broader meaning of the narrative events and their implications for the main character. In the non-digital platform condition (N = 39), participants were presented the story as a physical print-out; in the digital platform condition (N = 42), participants read the same story as a PDF displayed on the screen. As in Study 1, efforts were taken to standardize the parameters of presentation between the two conditions.

After they finished reading the story, all participants were administered a surprise paper-and-pencil reading comprehension test. This assessment instrument included twenty-four multiple-choice items, with twelve items gauging participants' memory of specific details presented in the narrative interspersed with twelve items gauging participants' understanding of higher-level inferences that the author intended readers to glean from the story. Participants' performance on the detail-oriented and inference-oriented comprehension items

Results and Discussion

Participants' responses to each of the reading comprehension was scored either 0 (incorrect) or 1 (correct) and summed to form overall scores for the detail-oriented and inference-oriented questions. Between-condition differences in scores for each category of comprehension item were analyzed using a one-way ANOVA. Results revealed that, in line with predictions, participants in the non-digital platform condition exhibited higher scores on the inference items (M = 7.91, SD = 3.32) than did participants in the digital platform condition (M = 5.74, SD = 3.15), F(1, 80) = 9.13, p < .01, d = .67. The opposite pattern emerged for the detail-oriented questions, with digital platform participants exhibiting a better average score on these items (M = 8.79, SD = 3.78) compared to their non-digital platform counterparts (M = 7.00, SD = 4.01), F(1, 80) = 4.37, p < .04, d = .46. These findings corroborate the results of Study 1 and extend their generalizability to a new domain of information processing (the reading of a fictional narrative) and a second form of digital technology (a laptop PC). The final two studies to be reported sought to replicate the pattern of results from Studies 1 and 2 using a novel problem-solving task requiring abstract processing (Study 3A) and, further, to investigate whether activating a higher-level mindset prior to that task might help improve performance for participants completing the task on a digital platform (Study 3B).

STUDY 3A

Participants

Sixty participants (35 female, 25 male, mean age = 20.9 years) enrolled in the study in exchange for a small monetary compensation.

Materials and Procedure

In the focal information processing task, adapted from a version used in previous research [9], all participants were presented with a table of information about various fictitious Japanese car models; each cell in the table listed a particular category of attribute (e.g., leg room or gas mileage) and a particular model's standing on that attribute (e.g., "adequate" or "excellent"). Participants were randomly assigned to read the table on either a PC laptop screen (N = 32) or paper print-out (N = 28) and were given exactly two minutes to scan the table of information, after which they were immediately asked to select which of the four car models they believed to be the superior one. This task is constructed such that one particular model is objectively superior to all others based on the significance of the attributes and the "winning" model's standing on the most important of those attributes. Discerning this pattern, however, is made significantly more challenging by the state of "information overload" that individuals face when presented with the table of attributes. Importantly, prior work has confirmed that individuals employing high-level (i.e., top-down) "gist" processing (focusing primarily on the categories of attributes to discern

the most important features on which to derive a judgment) performed significantly better than individuals employing low-level (i.e., bottom-up) detail-oriented processing.

Results and Discussion

Participants' responses were scored either 0 (incorrect) or 1 (correct) for purposes of analysis. A chi-square test revealed that a significantly higher proportion of participants in the non-digital platform condition reported the correct answer (66%) compared to the digital platform condition (43%), $\chi^2(N = 60) = 4.16$, $p < .05$, $d = .54$. This pattern of results provides additional support for the notion that the default mindset triggered by digital devices is a lower level of cognitive construal. In a final study, we investigated whether performance on this task might be improved on digital platforms by utilizing a pre-task activity activating an abstract construal level.

STUDY 3B

Participants

One hundred nineteen participants (65 female, 57 male, 7 unspecified, mean age = 21.7 years) enrolled in the study in exchange for a small monetary compensation.

Materials and Procedure

In this study, prior to the administration of the problem-solving task used in Study 3A on a PC laptop, a third of the participants ($N = 40$) were randomly assigned to complete a priming activity intended to activate a high cognitive construal level, a third ($N = 40$) completed a parallel activity intended to activate a low construal level, and a third ($N = 39$) completed neither of these activities. The high-level task instructed participants to think of successive reasons *why* they would pursue the goal of "improving one's health and fitness"; the low-level task had participants think of successive reasons *how* they would pursue the same goal. This "how/why" task has been used extensively in prior research to activate either a more abstract (why) or concrete (how) mindset [7]. As employed in the present study, this task was intended both to provide additional evidence for the default low-level construal level predicted to be triggered by digital platforms (as indicated by *equivalent* levels of performance on the car judgment task in the how-task and no-task conditions) as well as to illustrate one possible means of *improving* performance on tasks requiring abstract processing on digital platforms (as indicated by superior performance in the why-task versus no-task condition).

Results and Discussion

Participants' responses were scored either 0 (incorrect) or 1 (correct) for purposes of analysis. Results revealed an equivalent level of success at identifying the correct car model as the superior one in the "how-task" condition (25% correct) and "no-task" (30%) conditions. In contrast, a chi-square test revealed that a significantly higher proportion of participants in the "why-task" reported the correct answer (48%), $\chi^2(N = 119) = 6.15$, $p < .05$, $d = .37$. This pattern of results provides additional support for the notion that the default mindset triggered by digital devices is a lower level of cognitive construal (as evidenced by the parity in performance between participants who completed the concrete mindset-priming activity and those who completed *no* prior activity). Furthermore, this study builds on the results of Studies 1 and 2 by demonstrating that triggering a more abstract mindset in individuals prior to an information processing task on a digital platform could be one viable means of facilitating better performance on tasks requiring higher-level construals.

GENERAL DISCUSSION

Taken together, these results provide strong evidence for a potential divide in the default level of construal activated by digital versus non-digital platforms. This work builds on prior research exploring cross-platform differences in cognition (the majority of which has focused on differences in experiences and comprehension in the domain of reading retention and comprehension) by controlling for most confounding factors that differentiate digital and non-digital displays and investigating the mindset or information processing frame that is activated by the digital platform itself.

There are several explanations for why mobile digital technologies may prime or trigger a lower-level, concrete mindset in individuals. As noted earlier, prior work has shown that even brief experiences with digital technology for newcomers can have significant effects on neural networks associated with working memory and rapid decision making. Likewise, a growing number of accounts attest to particular information processing habits, such as quick scanning and skimming [4, 24], and expectations, such as immediate gratification, that individuals come to associate with their interactions with digital platforms [18]. The ever-increasing demands of multitasking, divided attention, and information overload that individuals encounter in their use of digital technologies may cause them to "retreat" to the less cognitively demanding lower end of the concrete-abstract continuum. The present work suggests that this tendency may be so well-ingrained that it generalizes to contexts in which those resource demands are not immediately present.

These results are not intended to be an indictment of digital technology and its impact on cognition. Indeed, there is great value in utilizing lower-level, concrete construals of information, particularly in domains requiring the careful consideration of lower-level details, such as analytical problem solving [6] and risk assessment [11]. At the same time, if the increasing accessibility and ubiquity of digital technologies is causing a shift toward the prioritization of concrete construals of information, it is important to consider the ramifications of this trend. Thus, the present work may provide an impetus for HCI designers and researchers to consider strategies for encouraging users to see the "forest" as well as the "trees" when interacting with digital platforms.

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REFERENCES

1. Nicholas Carr. 2010. *The Shallows: What the Internet is Doing to Our Brains*. WW Norton & Company, New York.
2. Andrew Dillon. 1992. Reading from paper versus screens: A critical review of the empirical literature. *Ergonomics*, 35, 10: 1297–1326.
3. Andrew Dillon, John Richardson, Cliff McKnight. 1990. The effect of display size and paragraph splitting on reading lengthy text from screen. *Behaviour and Information Technology*, 9, 3: 215-227.
4. Geoffrey B. Duggan, Stephen J. Payne. 2011. Skim reading by satisficing: Evidence from eye tracking. In Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems (CHI '11) Vancouver, BC, Canada.

   http://dx.doi.org/10.1145/1978942.1979114
5. Yoram Eshet-Alkalai, Eran Chajut. 2010. You can teach old dogs new tricks: The factors that affect changes over time in digital literacy. *Journal of Information Technology Education: Research* 9, 1: 173-181.
6. Jens Förster, Ronald S. Friedman, Nira Liberman. 2004. Temporal construal effects on abstract and concrete thinking: consequences for insight and creative cognition. *Journal of Personality and Social Psychology* 87, 2: 177-189.
7. Antonio L. Freitas, Peter Gollwitzer, Yaacov Trope. 2004. The influence of abstract and concrete mindsets on anticipating and guiding others' self-regulatory efforts. *Journal of Experimental Social Psychology* 40, 6: 739-752.
8. Kentaro Fujita. 2008. Seeing the forest beyond the trees: A construal-level approach to self-control. *Social and Personality Psychology Compass.* 2, 3: 1475-1496.
9. Jun Fukukura, Melissa J. Ferguson, Kentaro Fujita. 2013. Psychological distance can improve decision making under information overload via gist memory. *Journal of Experimental Psychology: General* 142, 3: 658-665.
10. Geoff Kaufman, Mary Flanagan. 2013. Lost in translation: Comparing the impact of an analog and digital version of a public health game on players' perceptions, attitudes, and cognitions. *International Journal of Gaming and Computer-Mediated Simulations*, 5, 3: 1-9.
11. Eva Lermer, Bernhard Streicher, Rainer Sachs, Martina Raue, Dieter Frey. 2015. The effect of construal level on risk-taking. *European Journal of Social Psychology* 45, 1: 99-109.
12. Anne Mangen. 2008. Hypertext fiction reading: haptics and immersion. *Journal of Research in Reading* 31, 4: 404-419.
13. Cliff McKnight, Andrew Dillon, John Richardson, J. 1990. A comparison of linear and hypertext formats in information retrieval. In *Hypertext: State of the Art*, Ray McAleese and Catherine Green (eds.). Intellect, Oxford, UK, 10-19.
14. Thierry Morineau, Caroline Blanche, Laurence Tobin, Laurence Guéguen. 2005. The emergence of the contextual role of the e–book in cognitive processes through an ecological and functional analysis. *International Journal of Human–Computer Studies* 62, 3: 329–348.
15. John Naughton. 2010. The Internet: Is it changing the way we think? *The Guardian*. Retrieved September 15, 2015 from www.guardian.co.uk/
16. Jan M. Noyes, Kate J. Garland. 2008. Computer– vs. paper–based tasks: Are they equivalent? *Ergonomics* 51, 9: 1352–1375.
17. Gary W. Small, Teena D. Moody, Prabha Siddarth, Susan Y. Bookheimer. 2009. Your brain on Google: Patterns of cerebral activation during Internet searching. *American Journal of Geriatric Psychiatry* 17, 2: 116–126.
18. Betsy Sparrow, Jenny Liu, Daniel M. Wegner. 2011. Google effects on memory: Cognitive consequences of having information at our fingertips. *Science* 333, 6043: 776-778.
19. Don Tapscott. 2009. *Grown up digital*. McGraw-Hill: New York.
20. Yaacov Trope, Nira Liberman. 2010. Construal-level theory of psychological distance. *Psychological Review* 117, 2: 440-463.
21. Robin R. Vallacher, Daniel M. Wegner. 1987. What do people think they're doing? Action identification and human behavior. *Psychological Review* 94, 1: 3-15.
22. Erik Wästlund, Torsten Norlander, Trevor Archer. 2008. The effect of page layout on mental workload: A dual–task experiment. *Computers in Human Behavior* 24, 3: 1229–1245.
23. Maryanne Wolf. 2008. *Proust and the squid: The story and science of the reading brain*. Harper Perennial: New York.
24. Maryanne Wolf. 2010. Our 'deep reading' brain: Its digital evolution poses questions. *Nieman Reports* 64, 2: 7-8.