Recommended Citation: **Djamasbi, S.**, Wyatt, J. Luan, X., and Wang , H. "Augmented Reality and Print Communication," in Proceedings of the 20th Americas Conference on Information Systems (AMCIS), Savannah, Georgia, 2014, pp.1-9.

Augmented Reality and Print Communication

Research-in-Progress

Abstract

The print medium serves as a major communication channel in organizations. One way to increase the richness of print media is by using augmented reality (AR) technologies. Because AR can provide a richer experience, it is likely that AR can make a viewer's interaction with the print media more engaging. A more engaging communication in turn is likely to improve learning as well as other important organizational outcomes such as increased awareness of organizational activities and opportunities for improvement. Embedding AR in print medium may also have negative consequences, for example, AR may divert attention from key information provided in textual information. Our research project addresses these possibilities. In this paper, we examine whether AR can 1) affect attention to textual information and 2) affect engagement with a print medium. In our follow up studies, we plan to examine the impact of AR enabled print media on organizational outcomes.

Keywords

Augmented Reality, User Experience, Human Computer Interaction, Corporate Communication, Generation Y, Engagement, Attention to Information

Introduction

With the rapid advances in mobile technologies, users are becoming increasingly accustomed to accessing rich information anywhere and anytime. This rise in digital information may have a negative impact on traditional print communications, which lack the connectivity and richness of mobile technologies. The print medium, as a matter of fact, is still a commonly used corporate communication channel. One way of embedding a multimedia rich experience in traditional print media is through augmented reality (AR) technologies. The addition of AR technologies to print medium is likely to make this mode of communication more engaging. Engagement impacts learning (Jerardi et al 2013), thus, a more engaging communication in an organization is likely to improve learning as well as other important organizational outcomes such as willingness to share the provided information.

The logic behind this research is that in order to achieve any positive communication outcomes, we first need to engage people in the act of communication. Paying attention to effectiveness of corporate communication becomes particularly important as Generation Y employees are becoming more prevalent in the workforce (Holley 2008). Research shows that Generation Y is not necessarily fond of print medium and does not like to read text (Djamasbi et al 2011). Augmented reality may make print communications more appealing to younger employees.

Previous research suggests that augmented reality is likely to affect user engagement positively (Arvanitis et al., 2007; Klopfer & Squire, 2008; Freundlieb & Teuteberg, 2012). Grounded in this literature, we argue that AR enabled print media are likely to be more engaging than their traditional paper based counterparts. Thus, AR enabled corporate communication is likely to be more effective in delivering organizational messages.

To achieve our research objective, we plan to conduct a series of studies. We start with this current study, which focuses on designing an AR enabled prototype and test its impact on attention to textual information. Prior research shows that including images of faces on webpages can impact attention to textual information adjacent to them (Djamasbi et. al 2012). Because text is an important mode of communication on posters, we test to see whether presence of AR enabled features on a poster can affect viewers' attention to text. We also test the impact of AR on engagement. That is, we examine to see whether our AR enabled prototypes are significantly more engaging than their paper based counterparts. In our follow up experiments, we plan to test the impact of AR enabled communication on organizational outcome such as increased learning about the organizational activities, and increased level of interest to share a message with colleagues and peers.

Background

This section provides the definition for augmented reality (AR). It also provides explanation for the argument that AR applications are likely to enhance user engagement with the print communication. The section also discusses why AR enabled content may have the unintended negative impact on attention to textual information on the poster.

Augmented Reality (AR)

Augmented Reality (AR) refers to a technology that can overlay computer-generated virtual information onto a real-world environment in real time (Azuma, 1997). While in AR the environment experienced by a user is real (as opposed to being virtual), this environment is extended to include information and imagery from a computer system. In other words, AR can create an enhanced experience by creating a connection between the virtual and real worlds (Bronack, 2011; Klopfer & Squire, 2008).

Research in education provides evidence for opportunities in learning through AR because simultaneous access to virtual and real objects provides a unique opportunity to visualize abstract and complex concepts and/or spatial relationships that often cannot be found in real world environments (Arvanitis et al., 2007; Klopfer & Squire, 2008). AR is considered as one of the key emerging technologies in education (Johnson, Levine, Smith, & Haywood, 2010a, 2010b; Martin et al., 2011). In particular, mobile AR applications are becoming increasingly popular as a medium for enhanced learning and engagement (Poitras et. al 2013).

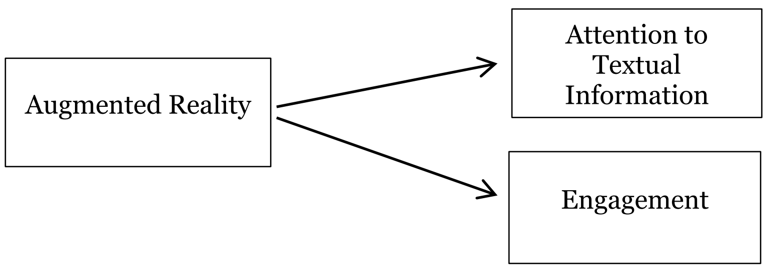
A recent study suggests that AR may also be effective in communicating cooperate information (Freundlieb & Teuteberg, 2012). For example, Freundlieb & Teuteberg (2012) have shown that AR enabled sustainability reports are more likely to be utilized by users because they tend to increase the perceived usefulness and enjoyment of these reports.

AR and Attention to Textual Information

Designers use various visual elements to guide a user in viewing a stimulus (Faraday 2000, Djamasbi et. al 2010). For example, web designers use a combination of perceptual elements such as text and images to convey information (Djamasbi et. al 2011). A recent study shows that certain perceptual elements may be more engaging than other elements and because of that they may have a negative impact on attention to information that is placed next to them. For example, images of faces, compared to non-face images (e.g., logos) were shown to have a significant negative impact on performance of a task that relied on textual information placed adjacent to them (Djamasbi et. al 2012). AR enabled perceptual elements are typically designed to be distinguishable from other elements. Because these features provide connectivity and interaction, they may divert a user's attention from textual information that is placed around them.

Research Questions

Previous research suggests that salient perceptual elements can have a negative impact on attention to information that is placed adjacent to them (Djamasbi et. al 2012). Because AR enabled features are naturally salient, we are interested to see whether AR enabled features on a poster can affect attention to textual information that is next to them. Literature also suggests that AR applications are likely to enhance user engagement with a stimulus (Poitras et. al 2013; Freundlieb & Teuteberg 2012). Thus, we are interested to see whether AR can have an impact on a viewer's engagement with the poster.



Research Method

To address the above research questions we conducted a controlled laboratory experiment. The laboratory setting was suitable for our investigations because it allowed us to observe participants and their reactions as they were viewing the posters in a controlled environment. The controlled setting was important because we used viewing time as a measure of engagement; hence we needed to conduct our experiment in an environment with minimal distractions. In the following paragraphs, we explain the method we used to conduct this part of our research project.

Experimental Materials

First we designed the paper based poster, which provided information about a newly developed eye tracking research lab in a technical university. The poster was designed using the principles of visual hierarchy (Faraday 2000) to ensure an effective visual communication. In other words, using various attributes of visual objects (font, size, style, color contrast, pictures, white space, etc.), we designed a poster to communicate the opening of a new research laboratory and two new courses that were offered through this laboratory. Because we were interested to see whether AR can have an impact on attention to textual information we designed our poster in a way that it included two main blocks of text with two different levels of visual hierarchy, that is, we made one of the main textual blocks visually more prominent than the other (Figure 1).

Next we used Layar, a commercially available application to develop the AR enabled version of the poster, which allowed users to interact with the poster. For example, when viewed with a mobile device, rather than looking at the picture of a completed heat map, the users has the option to view a short video showing how the heat map was generated. Figure 1 displays the snapshots of the paper based as well as the AR enabled poster in our study.

To incorporate the AR items into the poster, as mentioned above, we used the commercially available AR mobile application, Layar. We used the Layar design tool to overlay AR content into a previously uploaded image of our poster. When a user loads the Layar application on his or her internet connected mobile device, and points the device's camera towards the poster, Layar is able to recognize the image and display the AR information on the device. We downloaded Layar on an iPad 3 running iOS 6, which was used in the experiment.

Traditional Print Poster

AR Enabled Poster viewed with a mobile device

Figure 2: Snapshots of Posters

Participants

A total number of 30 graduate and undergraduate students in a major technical university participated in this study. Participants' age ranged from 18 to 30 (mean=22.57, SD= 2.62). Of these 30 Generation Y participants, 13 were female and 17 male students.

Design

We used the between groups experimental design, that is, participants in our study were randomly assigned to either an experimental or a control group. The participants in both groups were asked to read a poster as they normally would view a poster. Participants in the control group viewed a traditional poster while the participants in the experimental group viewed an AR enabled poster.

Measurements

In order to measure the impact of AR on attention to textual information, as in prior research, we asked users questions, the answers to which were embedded in the textual information placed next to the AR enabled content (Djamasbi et. al 2012).

We measured engagement by tracking the time that was spent viewing the posters. One may argue that because the AR poster had links to video clips, it is natural for participants to view the AR enabled poster for a longer time. This argument assumes that because AR provides a richer medium and thus more content than print, participants will spend more time viewing the additional content (in this case, they would view all the videos and/or the entirety of videos). In other words, this argument assumes that people view or use information as long as it is available to them. Literature, however, provides ample evidence that this is not always the case. For example, while incorporating more pieces of available information can improve accuracy of rational judgments, decision makers often use only a small subset of information that is readily available to them (e.g., Djamasbi 2007). Similarly, research shows that despite the information rich environment of web medium, people often pay attention to only a small portion of available information (Djamasbi et. al 2011, Djamasbi et. al 2010). People, however, are willing to spend more time viewing visual displays that are interesting or engaging to them (Djamasbi 2014). Thus, viewing time for posters serves as a suitable measure of engagement in our study.

While longer viewing time is an indication of engagement with stimuli (Djamasbi 2014), it may not always indicate a positive experience. For example, longer viewing time could also mean confusion. Thus, as recommended, we used information gathered through observation to help interpret viewing time (e.g., interest vs. confusion) as well as the overall results (Djamasbi 2014).

Procedure

Participants were assigned randomly to a control (traditional poster) or experimental (AR enabled poster) group. The participants in the experimental group used an iPad 3 running iOS 6 to view the AR enabled poster. At their designated sessions, the participants were asked to view our prototyped posters for as long as they wished to look at it. The experimenter, timed participants while viewing the poster. This time measurement was done manually. That is, the experimenter started a timer once a participant started viewing the poster and stopped the timer once the participant stated that he or she was done viewing the poster. Time measurement was done discretely in a way that participants were not aware they were being timed. After completing viewing the poster, participants were asked to answer a few questions about themselves as well as a few questions regarding the content of the posters through an online survey.

Results

An objective of this study was to test whether AR had an impact on attention to textual communication. In order to achieve this objective we asked participants to answer two questions about the textual content of the poster after they finished viewing the poster: 1) How many courses are offered through the lab? 2) What does "UXDM" stands for? The answers to both of these questions were embedded in the two main textual blocks on the poster. The answer to the first question was embedded in the bottom textual block, which had a more prominent visual hierarchy than the top textual block. The answer to question 2 was embedded in the top textual block. This answer was made bold to make it more prominent in the top textual block.

As displayed in Table 1, there were no significant differences in regards to answering these questions between the two groups. The majority of users in both groups (64% in the AR treatment and 79% in the control treatment) provided correct answers to the question about the number of courses offered through the lab. Less than half of participants in each treatment (33% in the AR treatment and 47% in the control treatment) were able to provide correct answer to question 2, which was embedded in the top textual block with a less prominent hierarchy.

The above results are consistent with the theory of visual hierarchy, which suggests that prominent visual hierarchies cue importance and thus they are likely to be viewed more attentively (Faraday 2000). The results displayed in Table 1 suggest that AR did not have a significant impact on attention to textual information on the poster.

	Participants in the AR enabled poster treatment	Participants in the traditional poster treatment	p-value
How many courses are offered through the lab?	64%	79%	0.37 (ns)
What does UXDM stands for?	33%	47%	0.44 (ns)

Table 1: z-test for the proportion of correct answers in each treatment

We also looked at the impact of AR on engagement. As mentioned earlier, engagement was measured by tracking the amount of time spent on viewing the poster. The results of a t-test showed that the experimental group, compared to the control group, spent significantly longer time to view the poster. As displayed in Table 2, the experimental group spent more than 4 minutes to view the AR enabled poster while the control group viewed the poster in less than a minute. The average time that participants in our study spent viewing the traditional poster is consistent with the average time that users view a webpage, namely less than a minute (Nielsen 2011). Because participants in both groups were instructed that they can look at the posters as long as they wish to view it, the difference in viewing time between the two groups suggests that the AR enabled poster design was significantly more engaging to our participants (Djamasbi 2014).

	Mean (min)	SD
Experimental Treatment (AR enabled poster)	4.27	1.87
Control Treatment (traditional poster)	0.42	0.17
	df= 28, t-Stat= 7.91, p=0.000	

Table 2. Poster viewing time, mean (SD), in minutes

We also conducted a post hoc analysis to see if there were any differences in survey completion time between the two groups. To our surprise this post-hoc analysis was almost significant, showing that people in the experimental group spent almost significantly longer time answering the post task questions which included an open ended section for their comments about the lab. As shown in Table 3, people in the AR enabled poster group spent almost 6 minutes entering their answers to our post poster viewing questions, while the control group spent less than 4 minutes to do the same.

	Mean (min)	SD
Experimental Treatment	5.89	3.41
Control Treatment	3.72	2.67
	df= 28, t-Stat= 1.94, p=0.06	

Table 3. Survey completion time, mean (SD), in minutes

Because AR is a richer medium, it is possible that people in AR group, had more information to report in the open ended question and thus they took longer to answer the open ended question. To explore this possibility we conducted a post hoc t-test that compared the number words in the open-ended question between the two groups. However, our analysis did not support this possibility. Our post hoc analysis showed that on average people in the AR group used 13.67 words to answer the open-ended question while the control group used 14.17 words to do the same. These differences were not significant.

Discussion

The results show that the majority of people noticed the more prominent textual information on the posters. This was the case in both the experimental and in the control group. Thus, these results suggest that textual information with prominent visual hierarchy is likely to attract attention of viewers regardless of AR enabled features.

Web research shows that despite the information rich medium of websites, people spend very little time (often less than a minute) browsing a page (Nielson 2011). For this reason, web developers put a great deal of effort in creating effective designs to entice users view webpages for a longer period. Similar to web viewers, here, participants were free to look at the poster as long as they wished to do so. Interestingly, the participants in the traditional poster treatment exhibited a viewing behavior similar to web users; they spent less than a minute viewing the traditional poster. The participants in the AR enabled condition, however, spent more than 4 minutes to view the poster.

The results showing significantly longer viewing time in the experimental group suggests that the AR enabled poster was significantly more engaging than the traditional poster. Longer time can also mean more confusion or inefficiency in accessing information (Djamasbi 2014). Our observations of participants viewing the AR enabled poster, however, does not support this interpretation. User in the AR enabled poster group exhibited more interest in viewing the content. For example, they could have scanned the poster without clicking on the links or without watching the videos (as many web browsers do). Instead, the majority of participants in the AR group clicked on links and viewed the videos in their entirety.

Limitations and Future Research

One limitation of our study is its sample size. To increase confidence in generalizability of our results, we need to conduct additional experiments with a larger pool of participants. For example, the percentage of correct answers in the AR group was slightly lower than the percentage of correct answers in the control group. While these differences were not significant, a larger sample size can help us determine whether AR can help users improve their understanding of print media or it distracts user attention away from the provided textual message. We also need more tests with different AR enabled features to assess the impact of AR on visual communication of various perceptual elements.

Another limitation of the study is its population. The participants in our study were all Generation Y users, who tend to be more tech-savvy than older users (Djamasbi et. al 2011). Future studies are needed to test whether the results of this study are generalizable to older users.

As in previous research (Djamasbi 2014), we measured engagement objectively using the amount of time that a user took to view the poster. We did not capture subjective experience of engagement. Because subjective experiences can have a significant impact on behavior, in our future studies we will also capture engagement subjectively via survey instruments and interviews.

Our exploratory analysis showed that people in the AR treatment, compared to their control counterparts, spent more time completing the post task surveys. This behavior, which suggests that the impact of AR on behavior lasted even after exposure to AR, warrants further investigations. Further research is needed to provide insight for why and how AR can impact behavior after viewing the poster.

This study is part of a larger project. Thus, to continue this effort, we plan to examine the impact of AR on positive organizational outcomes such as learning and willingness to share the message of a poster with peers.

Conclusion

The objective of this study was to test the impact of AR 1) on viewers' attention to textual information on the poster and 2) on viewers' engagement with the poster. Our results show that AR did not have a negative impact on attention to textual information. Our results also show that AR had a positive impact on engagement. We also found evidence of engagement, even after the AR manipulation was completed, during the post task questionnaire. This behavior suggests that AR may have an enduring effect on engagement.

REFERENCES

Arvanitis, T. N., Petrou, A., Knight, J. F., Savas, S., Sotiriou, ,S., Gargalakos, M., et al. (2007). "Human factors and qualitative pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities," *Personal and Ubiquitous Computing*, 13(3), 243–250. http://dx.doi.org/10.1007/s00779-007-0187-7.

Azuma, R. T. (1997). "A survey of augmented reality," Presence-Teleoperators and Virtual Environments, 6(4), 355–385.

Bronack, S. C. (2011). The role of immersive media in online education. Journal of Continuing Higher Education, 59(2), 113–117. http://dx.doi.org/10.1080/07377363.2011.583186.

Djamasbi, S., Eye tracking and Web Experience" AIS Transactions on Human-Computer Interaction, 2014, forthcoming.

Djamasbi, S., "Does Positive Affect Influence the Effective Usage of a Decision Support System?" Decision Support Systems, August 2007 (43:4), p. 1707-1717

Djamasbi, S., Siegel, M., Skorinko, J., and Tullis, T. "Online Viewing and Aesthetic Preferences of Generation Y and Baby Boomers: Testing User Website Experience through Eye Tracking," International Journal of Electronic Commerce, Summer 2011 (15:4), p. 121-158

Djamasbi, S., Siegel, M., and Tullis, T. "Faces and Viewing Behavior: An Exploratory Investigation," AIS Transactions on Human-Computer Interaction, September 2012, (4:3), pp. 190-211.

Djamasbi, S., Siegel, M., and Tullis, T. Generation Y, Web Design, and Eye Tracking

International Journal of Human-Computer Studies, 68, 5 (May 2010), 307-323

Faraday, P. Visually Critiquing Web Pages, In Proceedings of the 6th Conference on Human Factors and the Web, Austin, Texas, 2000, pp. 1-13.

Freundlieb, M., & Teuteberg, F. (2012). Augmented Sustainability Reports: A Design Science Approach. AIS Transactions on Human-Comupter Interaction, 4(4).

Holley, J. "Generation Y: Understanding the Trend and Planning for the Impact," In 32nd Annual IEEE International Computer Software and Applications Conference, 2008, pp. 2.

Johnson, L. F., Levine, A., Smith, R. S., & Haywood, K. (2010b) "Key emerging technologies for postsecondary education," Education Digest, 76(2), 34–38.

Klopfer, E., & Squire, K. (2008). Environmental detectives: the development of an augmented reality platform for environmental simulations. Educational Technology Research and Development, 56 (2), 203–228. http://dx.doi.org/10.1007/s11423-007-9037-6.

Karen Jerardi, Lauren Solan, Dominick DeBlasio, Jennifer O'Toole, Christine White, Connie Yau, Heidi Sucharew, Melissa D. Klein (2013). Evaluating the impact of interactive and entertaining educational conferences, Perspect Med Educ.2 (5-6): 349–355. doi: 10.1007/s40037-013-0074-z

Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M., & Peire, J. (2011). "New technology trends in education: seven years of forecasts and convergence," Computers & Education, 57 (3), 1893–1906. http://dx.doi.org/10.1016/j.compedu.2011.04.003.

Nilesen, J. (2011) "How Long Do Users Stay on Web Pages?", Nielsen Noramn Group, Avilable at http://www.nngroup.com/articles/how-long-do-users-stay-on-web-pages/

Poitras, E., Kee K., Lajoi, S. P., and Cataldo, D. (2013)"Towards Evaluating and Modelling the Impacts of Mobile-Based Augmented Reality Applications on Learning and Engagement." In Artificial Intelligence in Education, pp. 868-871. Springer Berlin Heidelberg