Is there any Use in Stereoscopic Slide Presentations?

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ABSTRACT
Stereoscopic display technologies are becoming increasingly commonplace in cinemas, homes and offices. It appears that this form of presentation, also referred to as 3D, is more and more supplementing and substituting monoscopic (2D) forms. However, there is only little evidence for the actual usefulness of stereo presentations.

We are investigating users' preferences for stereoscopic PowerPoint-style slide presentations, in particular which presentation elements are perceived as useful.

In an empirical within-subject study with 20 participants comparing monoscopic with stereoscopic slide presentations we found early evidence that there is only little difference in the users' preferences, that text and images are preferred to be watched monoscopically and that graphs, diagrams and 3D models might be preferred in stereo, but may confuse the viewers.

Author Keywords
3D, 2D, PowerPoint, stereo, mono, perception, preference, shutter glasses, 3D glasses

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces [Evaluation/methodology, Screen design]

INTRODUCTION
Slide presentations are used virtually everywhere. PowerPoint alone is loaded onto roughly 400 million computers worldwide, is used to make 30 million presentations each day, and of the total lectures on the web it is responsible for over 4 million of them (James, Burke, & Hutchins, 2006).

Given this high number of slide presentations, techniques that could enhance the satisfaction and usefulness of slide presentations would be extremely important. Stereoscopic imaging, when incorporated into slide presentations, could increase the effect of slide based lectures in an educational setting, and also help businesses to communicate more effectively.

Three-dimensional (3D) stereoscopic technology is becoming more and more commonplace. Although stereoscopic imagery was first introduced in 1838 by Sir Charles Wheatstone, it is now being used in many areas from Hollywood movies all the way to medicine and virtual reality applications (Holliman, 2005). There has been much development in this field and new displays are allowing for greater levels of realism and interactions with many accompanying benefits to users (Holliman, 2005).

Although stereoscopic imaging is used in different settings, its use is still relatively uncommon in slide presentations. Woods (2000) states that stereoscopic slide presentations offer many improvements when compared to the standard two-dimensional (2D) presentation, such as visual impact and improved image understanding. Unfortunately, because of difficulties in gathering additional equipment and changing the presentation from 2D to 3D, there are relatively few slide presentations which incorporate 3D effects (Woods, 2000).

Several studies have been conducted to demonstrate the advantages of using 3D effects in various settings. Cockburn and McKenzie (2001) investigated the difference a third dimension might have in a document management system. The authors found that the average task completion time for all of the storage and retrieval exercises were higher with the 3D interface than with the 2D interface. However, these differences were not statistically significant. From their questionnaire, however, the authors found significant results. They found that users preferred a 3D interface in a document management system when compared to a 2D interface.

Furthermore, Levy, Zacks, Tversky, and Schiano (1996) found that in certain situations, students preferred 3D graphs over 2D graphs. This included situations where memory was needed and when the information depicted in the graph would have to be communicated with others and was not just for personal understanding. 3D graphs were also preferred when examining the data for details rather than trends (Levy, et al., 1996).

One of the main areas where stereoscopic visualisation has been researched is in the educational realm. This is especially true for science related disciplines. Due to some perceived disadvantages in 2D representations, such as an inclination for viewers to underestimate the distance of an object (Price & Lee, 2010), the use of stereoscopic and 3D representations for learning have been widely studied. Across studies, one of the main benefits of stereoscopy in education has been with highly spatial concepts (Price & Lee, 2010).

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Shana Smith (2004) explored the application of stereoscopy in design and graphics education. In order to examine this, anaglyph stereo models were computer generated and then incorporated into an introductory design course. Smith (2004) found that although student's visualisation skills improved on a similar level with both the stereo system and the 2D system, the students (as reported in the survey) enjoyed having the stereoscopic models in a graphics and design learning environment. It was also observed that the students were better able to visualise 3D objects with the aid of stereo models. Furthermore, participating students reported that the stereoscopic system allowed for a more interesting and fun class. While the findings were mostly positive in this study, the quality of the stereo models was an issue. The system was relatively inexpensive which caused the system to perform inconsistently. Furthermore, due to issues with the contrast in the stereo models, some of the students reported eye pain, dizziness, and difficulty in perceiving a 3D effect (Smith, 2004).

Perry, Cunnigham, Gamage, and Kuehn (2011) investigated whether stereoscopic computer animations improved student learning in surgical procedures. The study specifically looked at the learning outcomes regarding the surgical steps involved in repairing a cleft palate. The authors found that when used as a supplement to standard learning materials, the use of stereoscopic 3D animations enriched the students' understanding of surgical procedures and the anatomy related to the surgery. It was also found that the students themselves believed that the stereoscopic animations had been beneficial and that they would benefit from 3D computer-based models in a learning environment (Perry et al., 2011).

The impact of 3D displays have also been studied in an electronic retail environment. One study, conducted by Ozok and Komlodi (2009) found that a 3D representation of products was preferred by consumers on an electronic commerce website. Although the users did feel they received an adequate amount of information with the 2D product representations, they reported that the 3D representations offered much more in the level of information, attraction, impression, and understanding of the product which they were viewing. The users also reported that they were able to gather information about the products and understand the products' functionality more easily in a 3D display (Ozok & Komlodi, 2009).

While there is evidence to support the use of stereoscopic and 3D visualisation, some studies have found the spatial ability of the user to be an important factor in the usefulness of such visualization techniques. Huk (2006) sought to examine the educational value of 3D depiction of cells in biology education. Specifically, the study examined the influence of interactive 3D models on the understanding of cell biology in a learning environment. It was reported that in a hypermedia-learning environment focusing on cell biology, only the students with high spatial ability benefited from the 3D models. The students with lower spatial ability experienced a cognitive load and did better when dealing with 2D models.

In another study, Keller, Gerjets, Scheiter, and Garsoffky (2006) examined the difference between information visualisations and text-based information representations in terms of knowledge acquisition. Furthermore, the researchers investigated the effect of dimensionality on learning and colour coding. In terms of the investigation into the effects of dimensionality on knowledge acquisition and learning, it was found that a 2D visualization was superior to a 3D visualization. Results showed that "3D information visualizations are associated with higher cognitive processing demands" when compared to other visualization techniques as the learners in this experiment expended more effort when presented with 3D visualizations as reflected in their cognitive load scores (Keller et al., 2006).

Although stereoscopic and 3D visualization may place an extra cognitive load on viewers, such representations may be still preferred. Brown, Hamilton and Denison (2012) studied medical students' satisfaction of stereoscopic visualization of CT scans in an anatomy tutorial. The feedback from the students was usually positive with most of the students reported to have preferred the stereoscopic display of the images. The majority of the students felt that the stereoscopic images afforded an advantage in the anatomy tutorial when compared to a standard tutorial. Furthermore, the effectiveness of the tutorial was rated highly and many students felt the images improved their understanding of the subject matter (Brown et al., 2012).

Given the fact that stereoscopic imaging has been successfully used in other settings and has been shown to be a possibly useful way to present information, it appears that stereoscopic imaging in slide presentations could be the next logical step. However, after a careful review of the related literature, it appears not much research has been done to determine whether a stereoscopic slide presentation would offer any benefit over the standard monoscopic presentation. This leaves some unanswered questions: Is a stereoscopic slide presentation a satisfactory and useful form of visualization, and if so, what slide presentation elements are more satisfactory when displayed stereoscopically versus their monoscopic counterparts?

As already stated, it appears that there is a lack of research that deals with stereoscopic imaging in slide presentations. Furthermore, as illustrated above, some research has yielded results showing the benefits of stereoscopic imaging and other forms of 3D visualization while other studies have shown 2D representation to be better suited. The objective of this study is to establish whether stereoscopic imaging is an effective form of visualization in slide presentations, and if so, the research seeks to determine what elements are more satisfactory when viewed stereoscopically versus monoscopically.

The elements to be tested are: Text, Images, Graphs, 3D Models, and Diagrams.

It was hypothesized that:

1. Graph and 3D model objects will be more satisfactory in a 3D representation in comparison to a 2D representation.
2. For textual and image content there will be no significant difference in satisfaction for a 3D representation in comparison to a 2D representation.
3. Overall, study participants will enjoy, prefer and find the stereoscopic presentation more useful than the 2D presentation.

METHOD

Participants

Twenty students from the University of Otago were recruited for this study. There were 11 males and 9 females, aged between 20 and 36 years old (M = 23.00, SD = 3.79). The participants were recruited by asking fellow students in the department and around the university if they would like to participate. They were rewarded with a $10 grocery voucher for their time and effort.

Materials/Apparatus

The study was run in an office & lab space (refer to figure 1). The participants were seated at the end of a table located 4 meters from the projection screen. The size of the projection shown to the participants was 1.36 meters horizontally and 1.02 meters vertically. During the stereoscopic portion of the presentation, each participant wore a pair of active shutter glasses and sat in an adjustable office chair throughout the experiment. The heating was kept at an appropriate level and the lights were turned off while the presentation was playing and turned back on while participants filled out their questionnaires. Environment and background noise were kept to a minimum.

Figure 1. Participant watching the slide presentation - stereoscopic condition shown, where shutter glasses and a stereo projection is used.

Task: The objective of this study was to determine whether a stereoscopic slide presentation was satisfactory to participants and which elements they preferred to view stereoscopically and monoscopically. The task scenario in this study was that of watching a slide presentation. In order to test this, a slide presentation, with both a monoscopic and stereoscopic portion was developed.

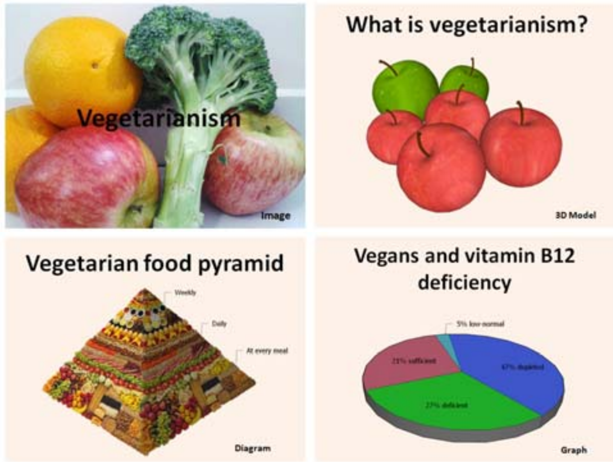

Figure 2. Examples of slides used in the presentation - monoscopic version shown.

Slide Set: The slide set was produced using Microsoft PowerPoint 2010. The stereoscopic elements were added to the presentation and viewed using Presente3D (http://www.presente3d.com), a plug-in for Microsoft PowerPoint which allows for stereoscopic slide presentations. The graphs, diagrams, and 3D models were produced using Google Sketchup (http://www.sketchup.com). Some of the 3D models were downloaded from Google 3D warehouse (sketchup.google.com/3dwarehouse/), which is an open source online repository of 3D models. The left and right pair images needed to produce the stereoscopic images were taken using a standard camera. In order to produce the stereoscopic text, the camera setting within Presente3D was used. The slide presentation was a total of 17 slides with 7 slides in the first portion and 10 slides in the second portion. The first portion had slightly less slides as there was a transition of topics in the presentation after slide 7. It seemed the most natural to have the viewing methods also change with this topic transition. Pilot testing confirmed this. Depending on the grouping of the participants, the first portion was presented as either monoscopic or stereoscopic as was the second portion. The topic of the presentation was an overview of Vegetarianism and Veganism and also explored the advantages and disadvantages of each of these diets. This topic was chosen as food related topics are easily understood and relatable for most people. The elements included in the presentation were: images, text, graphs, diagrams, and 3D models. These elements were evenly distributed throughout both portions of the presentation and were kept as consistent as possible. The nature of the elements chosen was determined by a search of existing slide presentations covering Vegetarianism and Veganism. In order to better automate the experiment, the slide presentation was recorded using Microsoft Expression (www.microsoft.com/expression). The audio of the presentation was also recorded. The screen recording and audio were made into a video using Windows Movie Maker (windows.microsoft.com/en-nz/windows-live/movie-maker). The video was shown to participants using Stereoscopic Player (www.3dtv.at) version 2.0.7.

Questionnaires: The instruments used to study the viewers' satisfaction were the monoscopic and stereoscopic satisfaction questionnaires. The two questionnaires were filled out by the participants after each portion of the presentation (monoscopic and stereoscopic).

Both questionnaires were adapted from the VPRQ developed by Ozok and Komlodi (2009). The satisfaction questionnaires were presented to the participants as a pen and paper questionnaire. Two slightly different versions of the satisfaction questionnaires were given to the participants after each portion of the presentation. This was due to the fact that some questions were not applicable to monoscopic viewing. The monoscopic satisfaction questionnaire contained 23 questions and the stereoscopic satisfaction questionnaire contained 28 questions. Each questionnaire had two questions at the end which asked the participants for additional comments. Besides these two questions, all the questions were comprised of 5-point Likert scales. The questions were in the form of sentences (For example: "I was overall satisfied with the 2D text in the presentation"), and the scale was arranged in a positive direction with 1 corresponding to "strongly disagree" and 5 corresponding to "strongly agree". However, in order to maintain an accurate measurement of viewer attitudes some questions (for example: "I think the information I received from the stereoscopic diagrams was excessive") were reverse coded. For the open-ended questions, participants were able to leave the questions blank or write as much as they liked. According to Ozok and Komlodi (2009) the Cronbach's alpha internal reliability coefficient of the VPRQ (on which the questionnaires used in this study are based) was calculated as 0.887. As Ozok and Komolodi (2009) concluded in their study, the questionnaires were reliable tools. The demographics questionnaire was used to collect general participant information. This questionnaire consisted of questions about age, gender, presence of colorblindness, and how often the participant viewed any type of 3D media. The demographics questionnaire also included a question about whether participants perceived a series of images as 3D.

Design

This study used 20 participants in a within subjects design. Each test session was completed individually with each participant or in groups of two or three. Each subject viewed both the monoscopic and the stereoscopic portions of the presentation. The order in which the portions were viewed was counterbalanced with 10 participants first viewing the monoscopic portion followed by the stereoscopic version, and 10 participants first viewing the stereoscopic portion followed by the monoscopic portion. Therefore, the order of each of the two treatments was counterbalanced using the design shown in Table 1.

Table 1. Order of Side Presentation Portions

Group					
1	Demographic Questionnaire	Monoscopic Presentation	Monoscopic Satisfaction Questionnaire	Stereoscopic Presentation	Stereoscopic Satisfaction Questionnaire
2	Demographic Questionnaire	Stereoscopic Presentation	Stereoscopic Satisfaction Questionnaire	Monoscopic Presentation	Monoscopic Satisfaction Questionnaire

The independent variable was the distinction between the stereoscopic and monoscopic portions of the presentation. The dependant variables were the usefulness of the elements and the satisfaction of each element in the presentation when viewed both stereoscopically and monoscopically. A within subjects design was selected as it presented a key advantage to this study. One of the primary advantages of a within subjects design is that it reduces the possibility that there may be a difference between the groups as participants are participating in both conditions.

Procedure

Upon arrival, participants were greeted and asked to take a seat in a standard office chair in front of the projection screen. The participants were instructed to read the Participant Information Sheet which included an overview of the experiment and the study objectives. The rights of the participant, including the guarantee of anonymity, were explained in a separate consent form which participants were instructed to read and then sign before beginning the experiment. Following this, a demographics questionnaire was completed by the participant. In addition to demographics information, the participants were also shown a series of three stereoscopic images and instructed to answer a question inquiring about whether participants perceived these images as 3D. The images were shown to the participants while they were answering the demographic questionnaire.

Next, depending on their group, the participants were shown either the monoscopic or stereoscopic portion of the slide presentation. The order of the presentation portions (monoscopic, stereoscopic) was randomized in order to circumvent any possible bias that could arise due to the order in which the presentation portions were viewed. The participants were instructed to view the presentation as they would normally view a slide presentation. After the participants viewed the first portion of the presentation, the presentation was paused and the participants were given a questionnaire about their satisfaction and preferences regarding the portion of the slide presentation they just viewed. While the participants answered the questions, the projector and the video player were adjusted for either stereoscopic or monoscopic viewing. Following the completion of the first questionnaire, the participants watched the next portion of the questionnaire and then filled out another questionnaire regarding their satisfaction and preferences. The data was collected via the monoscopic satisfaction questionnaire and the stereoscopic satisfaction questionnaire. The questionnaires were nearly identical, but did have some slight differences among the questions based on the applicability of some questions to monoscopic and stereoscopic viewing. Following the viewing of both portions of the presentation and the completion of the questionnaires corresponding to each portion of the presentation, the participants were given their compensation and thanked, after which they left the experimental room. From the pre-experiment introduction to the conclusion of the experiment, each test took roughly 20 to 25 minutes to complete.

Results

All data analysis was performed using SPSS version 19. For all the data analyzed, significance was determined to be at the 95% confidence interval. The 5-point Likert scale data gathered in this study was considered to be ordinal data. Descriptive statistics were used to analyze the demographics and the Wilcoxon Signed-Rank Test was used to analyze the ordinal data obtained from the questionnaires. For the five questions found only in the stereoscopic satisfaction questionnaire, the one sample Wilcoxon Signed-Rank Test was used. The data obtained from all 20 participants was included in this analysis.

The majority of the subjects were in the 18-24 (15) age group, with 4 in the 25-34 age group and 1 in the 35-44 age group. Most of the participants (17) reported that they watch 3D movies or view other types of 3D media once to a few times a year, 1 reported they watch 3D movies or view other types of 3D media several times a month, and 2 participants reported they had never viewed any type of 3D media. None of the subjects reported they were colour-blind. The demographic items are summarized in Table 2.

Table 2. Participants' demographics items.

Variable	Number	Percentage (%)
Gender		
Male	11	55.0
Female	9	45.0
Age, year (mean and SD)	23	3.8
Stereoscopic image perception		
Yes	17	85.0
No	1	5.0
I don't know	2	10.0
Stereoscopic viewing frequency		
Never	2	10.0
Once to a few times a year	17	85.0
Several times a month	1	5.0
Colour blindness		
Yes	0	0.0
No	20	100

The analysis was mainly performed on the questionnaires. When answering the questionnaires, the participants recorded their response on a 5-point Likert scale. Except in the cases where reverse coding was used, a high score indicated a positive impression. The data was tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The results of these tests indicated the data was not normally distributed. As the study design was within-subjects and the data lacked normality the Wilcoxon Signed-Rank Test was selected to analyze the data. All corresponding questions (21 in total) across the two viewing methods were paired and analyzed. No significant difference was found for any of the questions which directly asked about satisfaction. Significant results were, however, detected for three pairs of questions. These questions dealt with the meaningfulness of the text, the need for monoscopic or stereoscopic text, and the ease of which the stereoscopic pictures were able to be observed. The results showed the participants found the monoscopic text more meaningful than the stereoscopic text. Also, when presented with stereoscopic text, the participants felt there was a definite need for monoscopic text. Furthermore, the participants found the monoscopic pictures easier to observe when compared to stereoscopic pictures. The results are summarized in Table 3.

Table 3. Significant Results.

Question	Frequencies	Test statistics	
		Z	P
Text meaningful			
Monoscopic	12		
Stereoscopic	6		
Ties	2	-2.10	0.036
Need for text			
Monoscopic	8		
Stereoscopic	3		
Ties	9	-2.11	0.036
Pictures easy to observe			
Monoscopic	10		
Stereoscopic	3		
Ties	7	-1.97	0.049

DISCUSSION AND CONCLUSION

No significant differences between the viewing methods were found in this study. These findings do not agree with the hypotheses of this study which stated that while textual and image content will produce no significant results, the participants would not only prefer the stereoscopic presentation, but also prefer the graph, diagram, and 3D model objects when viewed stereoscopically. These hypotheses are not supported by the findings of this study. The significant results indicated that text is most preferred when viewed monoscopically. There is also a significant finding which suggests monoscopic images may also be preferred. As one participant commented, this may be due to the graphs, diagrams and 3D models being confusing and distracting when viewed stereoscopically. Other similar comments from participants indicated that the images and information presented was easier to process when viewed monoscopically, and some participants commented that 3D was not needed at all for this presentation. Other participants reported that for some of the slides they had difficulties distinguishing between 2D and 3D. Furthermore, some participants reported the shutter glasses to be uncomfortable and one participant reported the stereoscopic portion gave them a headache which may have reduced their preference for the stereoscopic slides.

Although there were no significant results which support a preference for the stereoscopic portion, there were some comments from participants that indicated a preference for stereoscopic slide presentations. One participant commented that 3D had a strong impact and another commented that the 3D presentation was more intuitive and a 3D visualisation would be useful when memorizing content. Surprisingly, some participants reported that they found the text to be best in 3D. Another participant commented that the text and images were more meaningful in 3D. Another participant felt the 3D text enhanced the diagrams, making each section easier to distinguish. This participant also suggested that a combination of 2D graphs and 3D text may be the best combination. Furthermore, other participants commented that the diagrams were preferred stereoscopically. One participant commented that diagrams which contain many variables would look best in 3D (see figure 3 for an example).

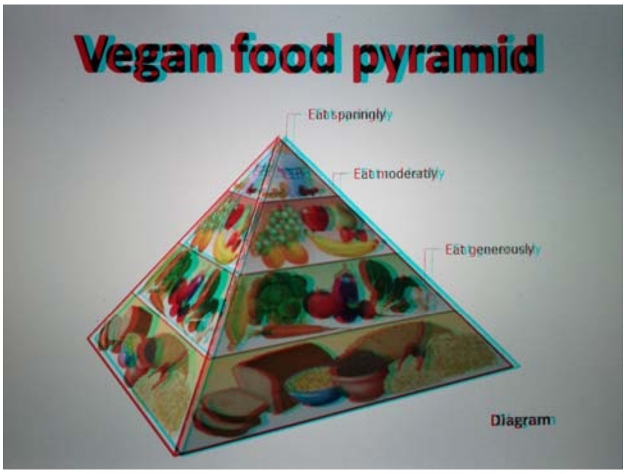

Figure 3. Example stereoscopic slide (here as an anaglyph rendering).

In order to speculate as to why there was no significant preference for the stereoscopic portion of the slide presentation, the limitations of the study must be examined. One of the main limitations was the slide set. All the graphs and diagrams were constructed in Google Sketchup as 3D models in order to allow for a stereoscopic effect. However, some participants commented that it seemed strange to see diagrams and graphs represented as 3D models. The quality of the models themselves may also have been an issue. In the future more time may be needed in the construction of the 3D models. Another limitation was prior to the presentation, the participants' attitudes towards 3D media were not investigated. As people may be biased for or against various types of 3D media, this could have had an impact on the results. Furthermore, the small number of participants (20 in total) was also a limitation. With more participants, there may have been more significant results.

Another significant limitation was the spatial ability of the participants was not measured. Studies have shown that the spatial ability of the viewer has an impact on their ability to benefit from information viewed in 3D or stereoscopically. As mentioned in the introduction, some studies have reported that only those with a high spatial ability benefit from 3D visualization. The spatial ability of the participating students may have influenced the results in this study and should be measured in future studies.

Due to the limitations, especially the small sample size, more studies are needed to investigate when and where stereoscopic elements are useful and preferred.

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