The Impact of Working Memory, Tags and, Tag Clouds on Search of Websites

by

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A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved June 2011 by the
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ARIZONA STATE UNIVERSITY

August 2011

ABSTRACT

Although there are many forms of organization on the Web, one of the most prominent ways to organize web content and websites are tags. Tags are keywords or terms that are assigned to a specific piece of content in order to help users understand the common relationships between pieces of content. Tags can either be assigned by an algorithm, the author, or the community. These tags can also be organized into tag clouds, which are visual representations of the structure and organization contained implicitly within these tags. Importantly, little is known on how we use these different tagging structures to understand the content and structure of a given site. This project examines 2 different characteristics of tagging structures: font size and spatial orientation. In order to examine how these different characteristics might interact with individual differences in attentional control, a measure of working memory capacity (WMC) was included. The results showed that spatial relationships affect how well users understand the structure of a website. WMC was not shown to have any significant effect; neither was varying the font size. These results should better inform how tags and tag clouds are used on the Web, and also provide an estimation of what properties to include when designing and implementing a tag cloud on a website.

ACKNOWLEDGMENTS

This Thesis would never have been written if not for the help of the following:

Christopher Sanchez my wonderful and knowledgeable advisor who showed me the path and aided me in creating this thesis. My parents who believed in me and aided in whatever ways they could. My loving girlfriend Teresa who gave me the strength to focus get the work done that needed to get done to create this thesis. All of my fellow graduate students of the Applied Psychology program, who through sharing have helped me become a better graduate student.

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Chapter 1

LITERATURE REVIEW

Working Memory, Tags and, Tag Clouds Impact on Search of Websites.

Although the world-wide-web provides access to large and rich sources of data, this information is presented and organized in many different ways across the web, and often scattered across several pages, links, etc. The organizational structures may vary but websites often have a variety of aids for the user to assist them in understanding the structure of the website. These aids are there to inform the user of the structure, so that they can more effectively search and navigate each site for the information they need. One of the aids that has been developed to aid users search and navigate various websites are tags and tag clouds. Tags are a non-hierarchal structure, which uses a keyword or term to identify a concept or reference in a specific article, webpage, image, bookmark, or other types of content found online. These tags allow us to see common links and relationships between web pages and articles which can give us a much better understanding of the presented topic (Macgregor & McCulloch, 2006).

Understanding and searching a website

While using a website there are inherently two types of knowledge we are acquiring, one of those is conceptual knowledge (i.e., the facts on the site), and the other is structural knowledge (i.e., the navigational structure of the site; Mcdonald & Stevenson, 1999). When a user is interacting with a site, they will be often be learning about both, and sometimes the distinction between what is conceptual and what is structural is hard to make (Kim & Hirtle, 1995). Since websites can have many different forms of organization, different aids have been implemented to help users search and navigate each site and better appreciate its organizational structure. These aids can be simple, such as simply listing the webpages that appear on the site, or they can be more complex such as a sitemap, which more explicitly shows the user the connections between the various pages (Nilsson & Mayer, 2002). Though the complexity of the aid can vary, they each afford different advantages when searching or browsing a website.

Tags and Tag clouds

Tags are an example of a very popular aid that can be used to convey website organization. Tags are able to function as both a cue to the structure and conceptual nature of the material, and can be easily placed on pages to aid the user in search and navigation. Tags can be assigned in many ways; for example, either by the author of the content, or by the readers of the material. Either way, these tags represent another's perception on how the site is organized, giving a potential cue for novices who may not have much experience with the site. By using the tags to search we can see the relationships that others think exist on the site, and also see how one topic relates to another (Sinclair & Cardew-Hall, 2008). When users focuses their attention on the frequency and overlap of tag usage, they can potentially infer what relationships exist between the tags, and thus the concepts the tags are representing. As the same tag can appear on multiple pages, co-occurring with other related tags, this builds a web of interconnecting ideas between the various tags that provide some insight on how the ideas they represent are also intertwined. Importantly, however, tags can be wrong or misinterpreted (Hoe-Lian Goh, Chua, Chei, & Razikin, 2008), and thus can mislead or misdirect users, which would naturally affect their views on the structure of the site (Macgregor & McCulloch, 2006). Thus, it is critical to understand how users utilize tagged information to help guide their understanding of various websites.

Related to how users utilize tags, what is the best way to organize this information effectively so the chance of misuse or misunderstanding is minimized? One increasingly popular way to organize or present tag information visually is a Tag Cloud (Bausch & Bumgardner, 2006; Flanagan, 2003; Coupland, 1996; Deleuze & Guattari, 1992), which allows the user to search through the relevant tags on the site. It has been shown that tag clouds (Sinclair & Cardew-Hall, 2008) and concept maps can aid users in their searches of websites (Puntambekar, Stylianou, & Hübscher, 2003). When building a tag cloud, there are several factors to consider such as the layout of tags, size of tags, and the organization of the cloud itself (Lohmann, Ziegler, & Tetzlaff, 2009).

There are three main kinds of tag clouds, which are distinctive based on the meaning and usage of the tags they represent, but not necessarily their external appearance. The first type deals with the frequency of tags and how often a given tag is applied to a single item. In this way, each item that is tagged has its own tag cloud that contains all the different tags that have been given to that item. The more often a tag is applied to a single item the larger the font that it has within the cloud (Rivadeneira, Gruen, Muller, & Millen, 2007). The second type instead presents the number of items a given tag has been applied to. This shows how popular the tag is on the site. As before, the more popular a tag is on the site, the larger the font of the tag in the tag cloud. While the first and second types are similar, the primary difference is that the first is how often a tag has been used on each specific page, and the second is how many different pages contain the given tag. In the third type of tag cloud, the cloud deals with categories instead of tags. The size of the font of a given tag in the cloud is the number of subcategories under the main category. Thus, in all 3 of these types of tag clouds, font size serves as an explicit cue about the popularity or usage of a given tag.

In addition to font size playing a role in tag clouds, spatial positioning of tags can also be used to provide additional information. If related tags are placed next to each other in the cloud (see Figure 2), then this may provide more information and spatial cues to the user of the tag (Lohmann, Ziegler, & Tetzlaff, 2009). The spatial cues from the tag cloud may even prove to provide more information and aid the user more in determining the structure of the website and the relatedness of the tags that are being used on the website. To date, no one has explored how these different tag characteristics interact and influence usage of a tag cloud. Thus, one of the primary goals of the research was to better understand how these different cloud characteristics interact and ultimately affect the usage of tag clouds for understanding. Further, it is also important to see if individual differences in relevant cognitive abilities affect how tag clouds are used and understood (Ford, Miller, & Moss, 2005).

Working Memory Capacity and Tag Clouds

One important ability that might be relevant for navigating and searching a website is working memory capacity (WMC). WMC is a stable cognitive construct that represents how well an individual can control or focus their attention, and thus maintain relevant information accessible to consciousness. (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). WMC has been used to predict performance across a wide range of tasks, such as reading comprehension (Daneman & Carpenter, 1980), learning science (Geiger & Litwiller, 2005; Sanchez & Wiley, 2006), learning and retrieving simple strings of letters or words from a given set (Conway & Engle, 1994), and other tasks involving higher order cognition, such as assessing fluid intelligence (Engle & Unsworth, 2005).

The working memory system is responsible for processing new incoming information, using already learned information to modify thoughts and behaviors, focusing attention while completing a given task, and also remembering additional information not immediately needed to complete a current task but that might be needed later (Baddeley, 2003). In this way, it goes beyond the traditional theory of short term memory (Daneman & Merikle, 1996) by including the need for executive function (Baddeley, 1996), and could be useful for determining how knowledge is gained from a source, and then related to existing knowledge.

For example, when we are using tags to search for a given target, we are obviously using the concepts that the tags represent to aid our search (Fu, Kannampallil, Kang, & He, 2010). In doing so, we are using the implicit knowledge contained within the tags as a potential knowledge cue to other subsequent relationships. This knowledge of inter-relatedness among concepts is gained by processing relevant cue information (i.e., the frequency at which single tags are being used, and how often tags appear on the same page; Seger, 1994). This information is then used to build a coherent mental model of the overall material in the site, which naturally affects the use and search of the site (Slone, 2002). WMC has been previously connected to how well individuals extract relevant information from text (Engle & Conway, 1998), generate bridging inferences (Calvo, 2001), and pick-up on implicit information that is relevant to task performance (Reber & Kotovsky, 1997). Thus, it is reasonable to expect that the higher a person's WMC, the better they should be able to focus on both learning conceptual and structural information, while performing the concurrent task of searching the website for information. Indeed, preliminary results from a related study do in fact suggest that higher WMC does lead to better appreciation of implicit knowledge gained from the web (Banas & Sanchez, 2011).

To test these relationships, an experiment that manipulates the organization of tag clouds (e.g., font size and spatial orientation) was conducted on individuals who vary in WMC. Several hypotheses were generated before the experiment was conducted. First, if font size alone is driving the effect of tag clouds, it is reasonable to expect that no additional benefit would be realized by adding the additional spatial organization. However, if spatial organization is critical to the benefit of tag clouds, an additional benefit should also be observed when this information is included. Finally, as WMC has been connected to the sensitivity of learning implicit structure and connecting relevant information, it is expected that tag clouds of any type should benefit lower WMC individuals more. Similarly, those conditions which include as much relevant information as possible (e.g., both font and spatial information) should produce the maximal benefit for this group due to the cognitive offloading of the processing of these relationships to the tag cloud itself.

Chapter 2

METHODOLOGY

Participants

The participants were undergraduates recruited from the Applied Psychology subject pool, and were compensated with course credit. Since the participants were drawn from the subject pool, the male to female ratio was about fifty-fifty, the mean age was approximately 19 years old, and the WMC capabilities were roughly normally distributed. The participants also were self reported frequent Web users on a self ranking score of 1 to 5, with 5 being they use the Web multiple times a day ($M=4.67$, $SD=0.64$).

Materials

Website and Tags. The website that was used contained 30 pages, and each page contained ~420 words about the European Theater of World War 2. Each of the pages was on a specific topic that relates to either a specific social, political or military aspect of the European Theater of World War 2. Some examples of topics used on the website were: Victory in Europe Day, The Nazi Party, and Operation Overlord. In addition to each page pertaining to a specific topic, each page also contained various tags.

The tags on the website were allocated so that each page had between 3 to 5 tags associated with that page's content. The website contained three levels of tags; each level corresponded to how many times the tag was used, and the depth of the content on the page. There were three tags on the first level as they are used the most and are the most general keywords on the site. There were ten tags on the second level as they are less general then the top level, but still core concepts that were used on the site. There were eighteen tags on the third and most specific level. These tags were the most specific and represented ideas that only show up once or twice on the site. These three levels of tags provided a structure to the website and the relationships between the different pages.

The pages in the experiment were initially tagged and aggregated by the author and 3 other novices (i.e., non-history majors). After this initial tagging was complete, the pages and tags they contained were reviewed by three history majors for accuracy of material and the tags. They made recommendations, to add or subtract tags, and ranked the current tags. The history majors agreed on 95% of the tags and where they disagreed the majority opinion was used. The tags that they recommended were added and the ones that they subtracted or ranked low were removed. Once all of that was done the list of tags was complied and completed. All of the above insured the accuracy of the tags.

There were four conditions in this experiment, each of them contained the website with tags on each page, but each of them contained a different variation of a tag cloud. Because the study objective was to better understand which aspects of a tag cloud matter the most, in each of the conditions the two main aspects of tag cloud, those being font size and spatial layout, were varied. In one condition the tag cloud did not vary the font size or spatial relationships and thus was no more than a single random list of the tags that existed on the website. It should be noted that this random list did not change between subjects and all subjects who were in condition one saw the same random list. Two of the conditions contained one aspect of the tag cloud, but not the other, meaning one had spatial relationships, and the other contained font sizes that varied based on tag usage. In the fourth condition, the tag cloud was a full tag cloud and contained both tags that varied font size based on usage, and that were arranged spatially to convey the closeness of various conceptual relationships that exist between the tags. This fourth condition's tag cloud allowed the participants to access to the greatest amount of information that can be given by a tag cloud.

Pre-Post Test. The pre and post-test were similar so that the learning over the course of the experiment could be measured. The test contained two different parts, because the participant learned about both conceptual knowledge of World War 2, and also the structural organization of the website. The tests were designed to reveal how much the participant understood about the relationships that existed between the various tags and how much factual knowledge they learned about World War 2, compared to their previous knowledge of the subject. The pretest began with questions about how familiar the participant was with tags, websites that use tags, the Web, and computers in general. After those initial questions, the participant answered the structural questions. These questions revealed how much the participant knew about the relationships between the tags within the website. These questions were in the form of multiple choice analogies, where all the words being compared were tags, and were supposed to be difficult for the participants given they had not yet viewed the websites or the tags before they took the pretest. An example of a structural question would be: Poland is to Occupied as France is to (blank)? The structural questions examined how well participants knew the relationships between tags were balanced based on the levels of the tags, where each of these questions makes a comparison between the different levels of tags. There were two questions that compared levels 1 and 2, four that compared levels 1 and 3, three questions that compared level 2 tags with other level 2 tags, four questions that compared levels 2 and 3, and two question that compared level three tags with other level 3 tags. These tested how well participants know the overall tag structure of the website. The second set of questions was the conceptual questions, which tested how much each participant knows about World War 2 before searching through the website. These questions took the form of standard multiple choice questions.

The posttest had a similar structure and questions, though the order of the multiple choice answers and the order of the questions varied from the pretest. It should also be noted that no feedback was given to the participants about how well they did on the pretest. The posttest was designed to show how much conceptual knowledge of World War 2, and how much structural knowledge about the relationships between tags on the website, the participant gained while completing the search questions.

Search Questions. There were 20 short answer search questions that each participant completed while searching and navigating the website. They were constructed in such a way that the participants had to use the whole site to find the answers. There was almost one question for each of the pages, and these questions exposed the participant to all the tags on the site, since they had to use every page at least once. This way the participant had some experience with each tag and webpage.

Working Memory Measure. All the participants completed a WMC measure known as the AOSpan task (Unsworth & Engle, 2005; Unsworth, Heitz, Schrock, & Engle, 2005). In the AOSpan task, participants were shown a simple equation followed by a letter (e.g., IS (8/4)-1=1? C) and asked to evaluate the correctness of the equation while remembering the letter for a later test. Equation-letter strings were presented in sets that contained between two to seven strings and participants completed 3 trials of each set size. Three trials of each set were presented and the sets of those trials were randomized.

Procedure

Participants were given 15 minutes to complete the pretest. After completing the pretest participants were given 40 minutes to complete the search questions with one of the four randomly assigned versions of the website. After the search questions, the post test was given, and the students had 15 minutes to finish it. Participants were then be debriefed and dismissed. Participants completed the WMC measure in a separate half-hour session.

Chapter 3

DATA ANALYSIS AND RESULTS

Previous Knowledge

In terms of participants' self-rating of their knowledge of WW2, most participants rated themselves as low knowledge, and not experts in the field (M= 2.64, SD = 0.84). A 2X2 between groups ANOVA was also run on the font and spatial variables to ensure that there were no differences in prior knowledge across the conditions. Results indicated that there were no differences in prior knowledge for either the font learn $F(1, 52) = 0.21$, $MSe=1.03$ $p > .05$, or spatial $F(1, 52) = 1.20$, $MSe=5.97$ $p > .05$, variables, and there was also no significant interaction $F(1, 52) = 2.37$, $MSe=11.76$ $p > .05$. This suggests that the participants were well matched on their knowledge of the content.

Working Memory

All of the subsequent analyses were initially run with WMC as a covariate; however WMC failed to demonstrate any significant main effect, interaction or correlation with the font or spatial variables in any of the analyses. As such, these analyses are not reported. In addition to that a 2X2 between groups ANOVA was also run on the font and spatial variables to ensure that there were no differences in WMC across the conditions. Results indicated that there were no differences in WMC for either the font learn $F(1, 52) = 1.41$, $p > .05$, or spatial $F(1, 52) = 0.69$, $p > .05$, variables, and there was also no significant interaction F (1, 52) = 2.78, p >.05. This suggests that participants WMC levels were evenly spread out among the four conditions.

The analysis that was done for the below results was a repeated measures ANOVA. In this ANOVA the participants pretest score and their posttest score was used as a within subjects variable. Font and spatial variables were used as between subject factors. The variable of tag cloud memory, which measured how well a participant memorized and remembered the tag cloud, was used as a cutoff point for the analysis. Only participants who scored 4 out of 7 or above were included in the analysis. Intercorrelations are available in Table 1.

Search Questions

On average, participants answered ~75% of the search questions correctly (M= 13.66, SD = 2.88). This performance does not appear to be a function of difficulty, as the proportion of correct answers (correct answers/attempted) was quite high (M=.91 , SD = 0.11), and may instead be a function of failing to have enough time to address all the questions. Importantly, performance on the search questions was not significantly correlated with WMC (r(56)=.010, p>.05), nor prior knowledge of World War 2 (r(56)=.03, p>.05). This suggests that the search questions were more less the same difficulty for all participants regardless of prior knowledge or WMC. As visible in Table1, both of the posttest scores were significantly correlated with search score, suggesting that the knowledge gained through search was significantly related to both posttest measures.

Differences in Structural Questions

The structural questions tested how well the participants remembered the implicit relationships within the website, as portrayed by the tags. The first result that was examined was whether the participants made gains between the pre and post test on the structural questions. These can were measured by subtracting the participant's posttest score from their pretest score to see how much they learned while completing the experiment. As we can see from the analysis the answer is a very strong yes they did learn F (1, 52) = 30.11, MSe=58.71 $p < .05$, η^2= .37 power= 1.00. However, font was not significantly related to structural performance F (1, 52) = .48, MSe=2.58 $p > .05$, η^2= .01 power=.10, but spatial cues were F (1, 52) = 6.79, MSe=36.39 $p < .05$, η^2= .12 power=.73. This suggests that the spatial elements of the tag clouds did impact how much the participants learned about the structure of the website. This is further elaborated as we look at the interaction between the spatial tag clouds and how much participants learned about the structure of the website (F (1, 52) = 3.33, MSe=6.48 $p < .10$, η^2= .06 power=.43; Figure 3). The results are significant which shows that the spatial properties did have an effect on how much the participants learned over the course of the experiment. Neither the font interaction term F (1, 52) = .50, MSe=.98 $p > .05$, η^2= .01 power=.11, nor the three way interaction term

F (1, 52) = .69, MSe=1.35 $p > .05$, η^2= .01 power=.13 was significant in this analysis.

Differences in Conceptual Questions

The first main effect that needs to be examined is whether or not performance increased between the pre and posttest. It was found that learning did occur F (1, 52) = 110.38, MSe=325.58 $p < .05$, η^2= .68 power=1.00. The other main effects of font F (1, 52) = .18, MSe=1.28 $p > .05$, η^2= .004 power=.07 and spatial F (1, 52) = 1.66, MSe=11.60 $p > .05$, η^2= .03 power=.24, both were not significant. The two way interaction effects between time of testing and font F (1, 52) = .03, MSe=.09 $p > .05$, η^2= .001 power=.05 or spatial F (1, 52) =.001, MSe=0.002 $p > .05$, η^2= .000 power=.05, were both not significant. Only the three way interaction suggested any type of effect F (1, 52) =2.05, MSe=6.05 $p = .16$, η^2= .04 power=.29. It is possible that with more statistical power this result could become significant, which would show that having both spatial and font size changes would aid participants in learning conceptual knowledge.

Chapter 4

DISCUSSION

This research suggests that tag clouds are related to better understanding the structural nature of a website and potentially better understanding the concepts on a website. The original hypothesis that was proposed in this paper was if font size alone is driving the effect of tag clouds, it is reasonable to expect that no additional benefit would be realized by adding the additional spatial organization. However, if spatial organization is critical to the benefit of tag clouds, an additional benefit should also be observed when this information is included. However, results of this study suggest that only spatial properties provide benefit to the user, and only for how well the user understood the website structure. Though it should be also noted that potentially with more power and further research it could be found that font size variance could increase the amount of conceptual knowledge gained.

Though the hypothesis was not supported, it is important to examine why it was not supported, and how each property of the tag clouds affected the learning that took place. In the experiment, only structural learning showed any significant knowledge gains from the pretest to the posttest, and this was aided by those tag clouds which contained spatial relationships. It is thought that the spatial relationships among different tags within a tag cloud allows users to gain a better sense of how the different tags relate, which aids them in constructing a better mental map of the site, and thus knowing more about the website's structure. In regards to conceptual learning, the spatial relationships in the tag clouds did not aid users in learning. It is thought that this is because the spatial relationships did not show the users any conceptual information that was not already in the text. Font size variance was shown not to have any effect on how well users learned structural knowledge of the website. Font size alone was shown to have no effect on learning of conceptual knowledge and it is believed that the enlarged tags did not show any information that was not already contained with the text, and added little that the user did not already know. It is interesting that an interaction was found between learning conceptual knowledge and having access to a tag cloud that contains both spatial and font size properties. Though the result is not significant it is believed with more power it could show that having both properties does yield gains more so then just having spatial properties when it comes to learning the concepts on a website. The important thing to take away from the research is that spatial relationships in tag clouds do aid users in gaining structural knowledge of the website and seeing the connections between various tags in the tag cloud.

Working memory was found not to impact tag cloud usage in any significant way, in either learning structural or conceptual knowledge. The WMC hypotheses might work out with more power, but based on the research that was done, no interaction was shown between working memory and the various properties of tag clouds. Low and high WMC individuals did not yield different results while using different tag clouds. This suggests that more research should be conducted in this area.

In conclusion, with more a larger sample size this study might be able to better show the effects that the various aspects of tag clouds have on users learning of structural and conceptual knowledge. In conclusion, this study has suggested some benefits and uses of the different components of tag clouds. It has shown how both varying font sizes and spatial relationships aids users in learning two different things, and that having both properties of a tag cloud may allow the user to learn the maximum structural and conceptual knowledge while using a given website. In general the results should show that having access to a complete tag cloud allows learners to better search and locate the answers they are looking for, rather than just having a list of the tags on the site. This suggests that properly constructed tag clouds are useful and should be implemented around the web. This knowledge should aid developers in deciding whether or not to add a tag cloud to their website since it is important to consider what kind of knowledge they are trying to convey and what kind of help they wish the tag cloud to provide to the users of their website.

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APPENDIX A

TABLES AND FIGURES

Table 1

		1	2	3	4	5	6	7	8	9
1	OSPAN Total									
2	WebUse	.020								
3	Knowledge of WW2	-.028	.271*							
4	Pretest Analogies	.222	.069	-.116						
5	Pretest Conceptual	.064	.141	.135	.287*					
6	Cloud Memory Score	-.204	.046	.079	.084	.026				
7	Search Score	.101	.227	.168	.399**	.341*	.026			
8	Posttest Analogies	.111	.069	.156	.504**	.306*	.248	.318*		
9	Posttest Conceptual	.085	.083	.198	.434**	.409**	.151	.452**	.529**	

Figure 1

A Sample Tag Cloud

Figure 2

The Four Tag Clouds Used in the Experiment

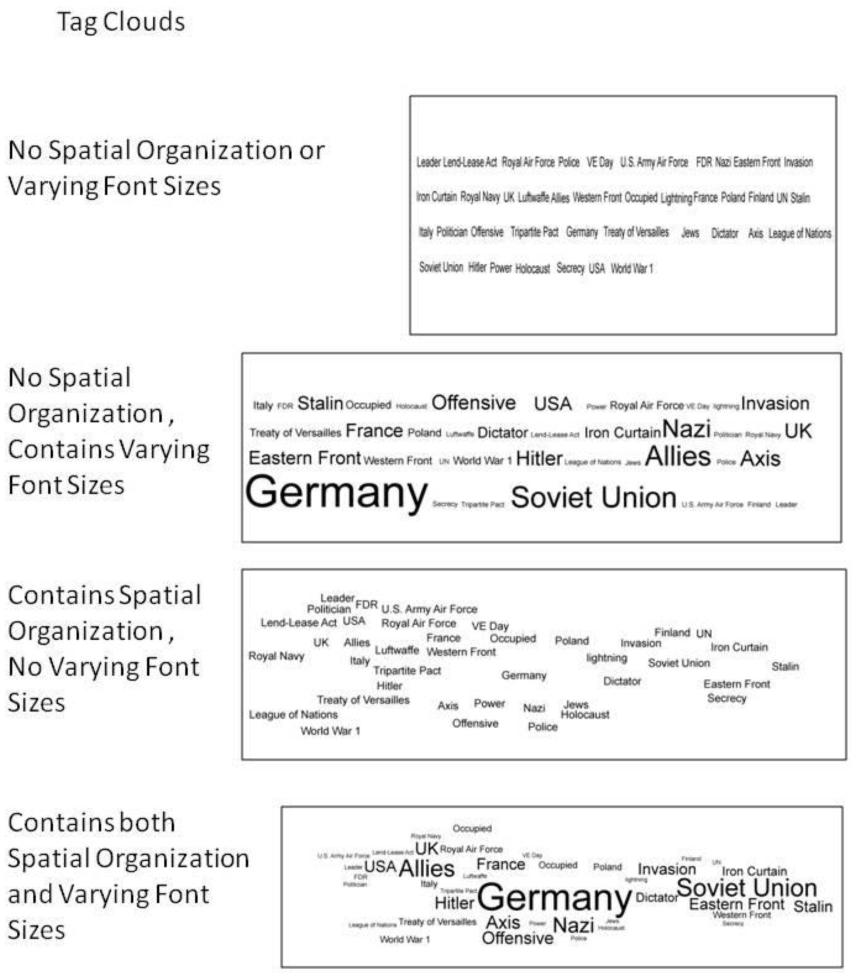

Figure 3

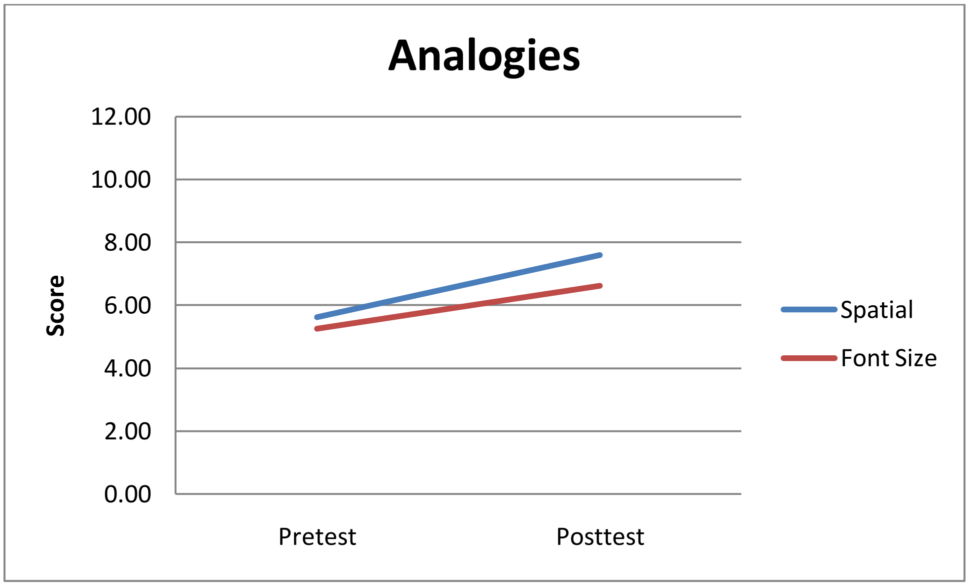

Figure 4