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# The Effects of Color and Layering on Comprehension of Multi-Layered Email Messages

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## Abstract

This paper reports preliminary study and its findings concerning the use of color-coded layering and the use of angle brackets on users' comprehension of relatively complex email messages. Subjects were randomly assigned to groups who viewed color-coded messages and messages that were not color-coded. In addition, the messages were structured such that the email messages had one to six layers. In this aspect of the study, total reading times and the total time required to answer questions about messages were recorded. In general, the preliminary results indicate that there are significant differences between the various groups with respect to reading times but not with respect to the amount of time to answer questions about the messages. Specifically, the use of color-coded messages seems to make the message easier to read and understand.

## 1 Introduction

With the continuing advance in computing technology, and the increasing numbers of people who have access to that technology, email has become one of the primary ways in which individuals communicate with each other. It is estimated that in 2000, the ratio of emails sent to more traditional methods of mail was 2 to 1. Marketing research has shown that in North America, the telephone has taken second place to email as the chosen means of communication, and in 2003 the number of active email users was estimated at approximately 140 million. Indeed, the trend seems to be growing, with a three percent increase in demand for web-based email services in just an eight-month period in 2004. Email is one of the primary reason people go online, outranking research. The popularity of email is not just limited to personal use; it is a valuable tool in business as well. A majority of executives surveyed believe that in 2005, email will be the main method by which they gather business-related information.

In addition to the communicative uses of email, it has become more and more apparent that email is also used as a repository of information that people wish to keep. People tend to use email to send themselves reminders, ideas, and other bits of information they have yet to commit to a more traditional storage method. As people use email more and more for this purpose, so do web-based email services continue to offer more and more space to accommodate this increasing trend.

When considering the ever-increasing use and application of email, it becomes important to examine the methods and means by which users read, interpret, and recall information presented in those messages. In addition, it is important to examine methods by which those email messages are presented and techniques that are used to make the message easier to read, easier to follow, easier to interpret, and easier to recall. For the purposes of this study, the term 'layer' is used to represent the initial message, as well as alternating responses and contributions by those involved in the conversation. Some approaches to these issues include the use of a sequentially increasing number of brackets that preface each layer of the conversation. Some programs allow for each of these layers to be presented in a different color, while some allow for both. Yet there has been very little research to examine whether or not these techniques are effective, and there has been very little research on the ways in which users respond both cognitively and behaviorally to these messages. It is the purpose of this investigation to begin to answer some of these questions.

## 2 Background

Reading and comprehending written material is a basic cognitive process [1, 2]. In his classic paper, Miller presents the fundamental cognitive process that he termed chunking [10]. This chunking process focuses on an individual's natural ability to organize and group information into logical units, i.e. chunks. This natural cognitive process is key to how an individual processes and understands complex information passages [3, 4, 9].

It has also been shown that this cognitive process of chunking plays a key role in computer usage. It has been suggested by numerous studies that one's ability to organize information presented by a computer is directly related to the scheme with which the information is presented [13, 14].

The use of email has become ordinary and has had a great effect on the way people work and even socialize in the modern world [11]. Consequently, it is not surprising that email messages have become increasingly complex as email messaging becomes more natural to larger segments of society and across all age groups [12]. However, it has been known for some time that individuals typically read more slowly from CRTs than when reading paper documents. In a series of masterful studies Gould has shown that this phenomenon is quite ordinary [6, 8]. However, it has also been shown that techniques are available to remedy this difficulty [7, 14].

The purpose of this study is to examine these issues with respect to layering complex email message by using combinations of color-coded imbedded messages and angle-bracketed segments. By using these aids, the email messages are naturally chunked into logical units. Therefore, the goal of this preliminary study is specifically to examine the effects of these visual aids on a user's ability to comprehend relatively complex email messages.

## 3 Methodology

A browser-based application was developed to automate the process and eliminate the concerns. The application collected the respondents' demographic data and answers about the mail. The email was displayed in a simulated Poco Mail 3.2 application. The total read time and total answer question time was captured based on the system time. No information was collected that would identify respondents.

The application was developed using Active Server Pages (ASP) running on Windows Server 2000 platform and Internet Information Services 5.0. The data was stored in Microsoft Access 2003. The choice of using ASP and MS Access was based on the simplicity of the application and database as well as the server's operating system.

A 4x5 design is used with the Color/Brackets and the Number of Layers as the independent variables. There are four levels of Color/Brackets; they are: Color, Brackets; Color, No Brackets; No Color, Brackets; and No Color, No Brackets. There are five levels of layering; they are: 2, 3, 4, 5, and 6 layers.

### 3.1 Database

The database is comprised of eight tables. Some are used to display data about the study and others are used to collect data about the study. These tables are:

- 1) Table Layer contains the number of layers: six total;
- 2) Table IV contains the color and bracket combinations: no color no brackets, color no brackets, no color and brackets, and color and brackets;
- 3) Table LayerIV contains the twenty possible combinations of color, bracket, and number of layers;
- 4) Table LayerText contains one paragraph of text for each layer;

- 5) Table QA contains two questions for each layer;
- 6) Table Major contains the list of majors. This was used to display a select list on the Demographic screen;
- 7) Table Respondent contains the respondents' LayerIV id, start read time, end read time, start question time, end question time, and demographic data;
- 8) Table RespondentQA contains the respondents' answers to the question about each layer displayed.

Queries were created to display data on completed records. These queries calculated the total read time, total answer time, the read time by layer, and the answer time by layer.

## 3.2 Procedure

First, respondents are asked to sign the consent form; and secondly, all subjects are asked to complete the color blindness test. If the test was successfully completed, each subject is directed to click the "Start Study" button on the application's Welcome screen. This event triggers a processing script that queries the Respondent table. The script returns a count on the total completed responses on table LayerIV.

The next process determines the number of layers, color, and bracket combination to display to the respondent. This process starts with an outer loop, 1 to 7, which represents the total number of respondents required for each possible combination.

The next process uses the count from the above query and an inner loop, 1-20, representing each possible combination. If the inner loop number's count was less than the outer loop number, the participant is assigned the id for that particular combination. This script purpose is to evenly distribute respondents across all possible combinations of layers, colors, and brackets.

After the combination is determined, the next script inserts the LayerIV id into the Respondent's record and redirects the respondent to the Demographic screen.

The Demographic screen collects the respondent's gender, age, whether English is her/her native language, class rank, major, years of computer experience, and overall level of computer experience. All questions require an answer. Once the questions are completed, the respondent selects the "Submit" button. This triggers a script that validates that all questions are completed and age is greater than or equal to years of computer experience. If any responses are missing or invalid, the application displays a message promoting the respondent to correct errors. If the data is valid, it is inserted into the Respondent table and the respondent is redirected to the Email screen.

The Email screen simulates a Poco Mail 3.2 email message; the experimental task is to read an email message. Upon page load, a client side script captures the system time and stores it as the "begin read time". After reading the email, the respondent selects the "Answer Question" button. This displays the list of questions about each layer displayed in the email and captures the system time and stores it as the end read time and begin question time.

After completing the questions, the respondent selects the "Submit" button. This triggers a script that validates each question for an answer. If not, the respondent is prompted to answer the question(s) he/she did not complete. If the questions are complete, the script captures the system time and stores it as the end question time. The script then inserts time values into the Respondent table and the answers into the RespondentQA table. The respondent is redirected to the Complete Survey screen.

The Complete Survey screen displays a thank you for participating message. The respondent selects the "Finish Study" button and the application returns to the "Welcome" page.

## 4 Results

A total of 55 subjects participated in this study. Subjects were randomly assigned to each group in the design as they reported to participate in the study. The number of subjects in each category is presented in Table 1.

**Table 1. Categorization of Participants**

	2 Layers	3 Layers	4 Layers	5 Layers	6 Layers	Totals
No Color, No Brackets	3	3	3	2	2	13
No Color, Brackets	3	3	3	3	3	14
Color, No Brackets	3	3	3	3	2	14
Color, Brackets	3	3	3	3	2	14
Totals	12	12	12	11	8	55

The amount of time subjects spent reading the messages was recorded. These time are presented in Table 2. Analysis of variance was conducted to determine if there were significant differences in Total Reading Time between the groups with color-coding and brackets. These results are presented in Tables 3.

**Table 2. Total Reading Time**

	N	Mean	Std. Deviation
No Color, No Brackets	13	1.5969	1.00427
No Color, Brackets	14	1.4507	.66029
Color, No Brackets	14	1.4643	1.20571
Color, Brackets	14	1.2621	.70364
Total	55	1.4407	.90142

**Table 3. ANOVA: Color/Brackets and Total Reading Time**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.773	3	.258	.305	.822
Within Groups	43.105	51	.845		
Total	43.878	54			

These analyses indicate that there are significant differences between these groups with respect to Total Reading Time.

The amount of time subjects spent answering questions about the messages was also recorded. These time are presented in Table 4. Analysis of variance was conducted to determine if there were significant differences in Total Answering Time between the groups with color-coding and brackets. These results are presented in Tables 5.

Tukey Post Hoc tests indicate that all four groups are significantly different from each other. In other words, subjects in the groups with Color and Brackets have significant lower reading times that the other three groups. This is followed by the subjects in the group with Color and No Brackets, followed by the group with No Color and Brackets; and lastly, subjects in the groups with No Color and No Brackets.

**Table 4. Total Question Time**

	N	Mean	Std. Deviation
No Color, No Brackets	13	4.7615	3.27268
No Color, Brackets	14	4.7857	3.15242
Color, No Brackets	14	4.7786	2.45273
Color, Brackets	14	5.0000	4.29414
Total	55	4.8327	3.26646

**Table 5. ANOVA: Color/Brackets and Total Question Time**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.530	3	.177	.016	.997
Within Groups	575.637	51	11.287		
Total	576.167	54			

These analyses indicate that there are significant differences between these groups with respect to Total Question Time.

The amount of time that subjects spent reading the message were also recorded with respect to that number of layers. Analyses of variance were conducted to determine if there are significant differences in Total Reading Time and Total Question Time between the Layering groups. These results are presented in Tables 6 and 7.

**Table 6. Layering and Mean Reading Times**

	N	Mean	Std. Deviation
2	12	.9833	.61768
3	12	1.0317	.44964
4	12	1.8258	1.19290
5	11	1.5300	.84848
6	8	2.0400	.87392
Total	55	1.4407	.90142

**Table 7. ANOVA: Layering and Total Reading Time**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.259	4	2.315	3.343	.017
Within Groups	34.619	50	.692		
Total	43.878	54			

The amount of time that subjects spent answering question about the message were also recorded with respect to that number of layers. Analysis of variance was conducted to determine if there are significant differences in Total Question Time between the Layering groups. These results are presented in Tables 8 and 9.

**Table 8. Mean Question Times**

	N	Mean	Std. Deviation
2	12	1.9758	.84033
3	12	2.9842	1.75072
4	12	5.0758	1.99897
5	11	7.5945	3.13515
6	8	7.7288	3.81314
Total	55	4.8327	3.26646

**Table 9. ANOVA: Layering and Total Question Time**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	290.657	4	72.664	12.725	.000
Within Groups	285.510	50	5.710		
Total	576.167	54			

These analyses indicate that there are no significant differences between these groups with respect to Total Question Time.

## **5 Conclusions**

This is a preliminary study and analysis of the effects of color-coding and the use of bracketed layers on user comprehension of relatively complex email messages. The results suggest that aids assist users in meaningful ways the more complex email messages become. Specifically, these results indicate that coloring the layers of embedded messages reduces the amount of time that a subject needs to read the contents of the message; and organize its contents into memory. Likewise, these results also indicate that the use of brackets that delineate layers of the messages assist a subject's processing of relatively complex messages.

These results are not surprising; they are entirely consistent with previous research in reading and comprehension of complex materials. The obvious reason that can be suggested for these results is that they are manifesting the chunking process which is fundamental to reading, comprehension, and the cognitive processing of information [5, 10, 15]. Any visual aids that assist the subject, i.e., any person reading complex email messages, are beneficial because they enhance the person's ability to chunk the message into their cognitive memory stores. There is an enormous literature that supports this model of human information processing.

This series of studies are far from complete. This report is the first in a series of on-going studies that are examining various techniques and procedures that assist users in comprehending complex information that is presented through email messages, the web sites, and the cognitive structures of software engineers.

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## Appendix A: Fully Layered and Bracketed Email Messages

>>>>>There aren't too many software applications for this, however there >>>>>is one called DVD Organizer that will compare prices of various >>>>>websites to find the best price overall, show coverscans, and what >>>>>have you. You can download it at [dvdorganizer.com](http://dvdorganizer.com) for free, or you >>>>>can buy the software which removes advertisements and lets you >>>>>contribute to the online database. I believe the current version is 1.1 >>>>>(0.98b for the Mac), but they are always releasing updates.

>>>>Thanks, these recommendations will help out a great deal. I will be >>>>sure to take a look at both of them and see what they have to offer. >>>>Speaking of DVD's, you wouldn't be able to recommend a software >>>>I've used a spreadsheet, but since my collection now numbers over >>>>one hundred I would like to find dedicated software that would keep >>>>track of what I have.

>>> selection and they have many monthly and seasonal specials (you >>>know, horror movies are discounted in October, Christmas movies in >>>December, etc.). On the other hand, if you are looking for director's >>>cuts and special editions, you may have more success with >>>dvexpress.com. They tend to cater to the connoisseur by offering >>>Superbit DVD's, collector's editions, as well as high-end DVD players.

>>Thanks for your response. While I mainly prefer comedy, I also enjoy >>drama, horror, and action movies. The only types of movies I don't care >>for are teen romance and legal dramas. I'm usually pretty interested in >>anything besides those two genres, which is why I'm looking for a >>different site that is focused solely on DVD's. I'm assuming a focused site >>would have better prices.

>Hank, there are other sites out there, but it depends on what type of movie >you're looking for. Did you have any specific genre in mind, or are you >looking for a more general site that carries everything? Additionally, if >you're interested in such things as accessories and players, that would >affect my answer as well.

Hey Joe, I'm wondering if you know a good DVD website. I usually buy from Amazon.com, however I've heard that they may not be the cheapest website out there. I'd like to compare prices, but I'm not aware of any other websites. If you have any recommendations, I'd appreciate it.