THE EFFECTS OF TEXT DENSITY LEVELS AND THE COGNITIVE STYLE OF FIELD DEPENDENCE ON LEARNING FROM A CBI TUTORIAL

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ABSTRACT
The purpose of this study was to investigate the effects of variations in text density levels and the cognitive style of field dependence on learning from a CBI tutorial, based on the dependent measures of achievement, reading comprehension, and reading rate, and of lesson completion time. Eighty college undergraduate students were randomly assigned to text density levels, after being assigned to three cognitive style groups: field dependent, field neutral, and field independent, based on their Group Embedded Figure Test scores. Instruction was delivered by means of two versions of a CBI tutorial: low density text and high density text. A two-way analysis of covariance was used to investigate whether there are main effects and interactions between the cognitive style of field dependence and text density levels. In order to control statistical power and to equate the treatment groups, Nelson-Denny Reading Comprehension Test scores were used as a covariate. The analysis of regression coefficients between text density type and dependent variables and between field dependence and dependent variables were shown in tables. Although the findings show non-significance in formal tests of hypotheses, a preference for the high-density level was found. Then, the interaction effects between field dependence and text density levels on dependent measures were clarified. Six research questions converted to statistical hypotheses were tested according to the factorial design model. Specifically, the tests of hypotheses generated discussion and conclusions were given at the end of the study.
Keywords: Text density, Cognitive styles, Field dependence, Computer-based instruction, Learning

INTRODUCTION
Theoretical and technological advances in the areas of psychology, learning, and computer technology have intertwined to produce the developing field of computer based instruction (CBI), which is a delivery format that teaches via a computer program. Early CBI tutorials were created according to behavioral models. However, tutorials based solely on the behavioral model did not account for individual differences in terms of aptitudes or cognitive styles. The move toward the use of cognitive models by psychologists has resulted in the need to find new methods of presenting information, in particular, the need for designing text layout that facilitates the learning process (Grabinger & Amedeo, 1988) and text density in learning objects (Akpinar & Simsek, 2007).

Recently, text design levels from print materials to computer screens have been developed to find new methods of presenting information strategies and text content that provide an effective visual design with new technologies. As a part of screen design, text density on the computer screen is vital to providing an effective learning environment in CBI and network systems, such as the World Wide Web (WWW) or hypertext and hypermedia systems (Wiebe & Annetta, 2008). A computer has a limited screen to present data or information. Computer text offers less flexibility than books do in the presentation of text (Morrison, Ross, O'Dell, & Schultz, 1988a; Morrison, Ross, & O'Dell, 1988b; Ross, Morrison, & O'Dell, 1989; Grabinger, 1983; Grabinger & Amedeo, 1985, 1988). Because of these reasons, designers and technologists must be aware of these technological and instructional needs for designing text density levels as well as presenting information. Text presentation and writing styles are important points for designers. Principles for using text in hypermedia emphasize clear communication, legibility and motivation (Grabe & Grabe, 2007).

Text density is a construct for manipulating and reducing the number of words in a text without loosing its main idea. In this study, text density is defined as the number of words and meaningful information in a text (Schultz, 1989; Morrison et al., 1988b). In general, high-density text contains more words than low-density text but may convey the same basic meaning (Ipek, 1995a). Variations in text density levels may effect the interaction between perception and communication, which deals with the reduction of information time and the number of words in a text. Text density is significantly related to manipulating the content, the presenting time, and reading skills. Furthermore, there is no research on learning from CBI tutorials to indicate a relationship between text density type and field dependence for instructional variables. Recently, there is no research on web based instruction or internet based instruction related to text density concepts as indicated here.

These limitations suggest that research is needed regarding variation in text presentation levels on the computer screen. Further research is also needed to investigate how learners with different cognitive styles are affected by different text density displays according to their reading, comprehension, and perception skills (Ipek, 1995a, 2001). To develop text density levels, we need a clear definition of text density in CBI and multimedia systems for future software and instructional designers (Pastore, 2008; Veronikas, S. & Maushak, N. 2005; Yang, 2000). This study may result in an acceptable definition of text density for the future research, instructional, and technological environments with new technologies.

Different Approaches of Text Density Levels in the Literature

Text density consists of two or more levels, such as low density and high density, or control levels. These density levels are determined based on how much the information content has been reduced or the percentage of information that has been presented. In brief, the number of characters or number of words is used as density criteria in a text (Schultz, 1989; Morrison et al., 1988b). Low-density text materials are generated from conventional text by 1) defining a set of rules for shortening the text, 2) having different individuals apply the rules to the rewriting of the text, and 3) requiring those individuals to arrive at a consensus on the final content (Morrison, O'Dell, Ross, Schultz, & Wheat, 1989a; Morrison et al., 1988a, 1988b). Low-density text is modified text based on the number of characters or the number of words in a text. High density indicates the actual text, but it can also refer to text reduced from print materials, because research indicates that text density levels are on a continuum (Schultz, 1989; Morrison et al., 1988b). Learner control is an important factor to investigate when exploring the effectiveness of the text density variable, because "the text density variable represents a contextual lesson property that primarily influences how lesson material appears without changing its basic informational content" (Morrison, Ross, O'Dell & Schultz, 1988c, p. 68). Text layout goes beyond writing style and statement length to encompass the placement of text on the screen and the appearance of the text itself. Text design is based on special characteristics (fonts, bold type size) and text display (Grabe & Grabe, 2007).

In another study, Grabinger & Amedeo (1988) suggested that the idea of text density is related to the meanings among words between the actual text (nominal stimulus) and a reader's representation (effective stimulus). Effective stimulus refers to the integration of information, either within an existing schema or by creating a new schema (Grabinger & Amedeo, 1988; Morrison et al., 1988b; Neisser, 1976). Nominal stimulus refers to the environment (actual text) and to meaningful information in a text. Written text presented on a computer screen is an example of a nominal stimulus that is also high-density text (Morrison et al., 1988c; Grabinger & Amedeo, 1988).

Koroghlanian & Sullivan (2000) studied the effects of audio and text density levels such as text only, full text-full audio, or lean text-full audio in achievement. They found no significant difference in achievement between the three treatment groups, however there was a significant difference in learning efficiency, with the text only group requiring significantly less instructional time and achieving as well on the posttest as each of the other two groups. In addition, both high text density and relevant animation seemed to create high load conditions for visual attentional distribution in multimedia instruction (Pastore, 2010; Wiebe & Annetta, 2008). In addition, presenting learners with audio and visuals is preferred to presenting text and visuals when the verbal and non-verbal representations explain for one another (Low & Sweller 2005).

Meaningful learning in the classroom is based on the learning environment, instructional materials, learner perceptions, and course objectives. Moreover, interactions based on theoretical research findings need to be considered. According to two different approaches in text density studies, the interactions in text density levels were found to be similar and to support each other to make connections between past and current research. These connections are given in Figure 1 (Ipek, 1995a).

Chunking separates a sentence into phrases or idea units through the use of increased space or special cues. The aim of the chunking process is to facilitate the connections of meanings among words between high-density (actual) and low-density (modified) text (Grabinger & Amedeo, 1988). For the purposes of this study, our understanding of actual text and modified text can remain as high density and low density respectively. Paragraph organization deals with hierarchical organization and systematic organization. As indicated by Reynolds (1979), "comprehension will be affected not only by the content of text, but also by its visibility and perceptibility and by the verbal capacity and intelligence of the reader" (p. 312).

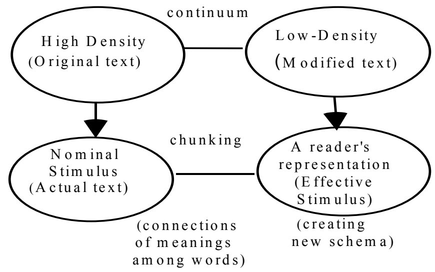

Figure 1 Interaction of Different Approaches in Text Density levels

When information in CBI is presented in a format that must be read, reading speed and reading rate are important learner characteristics in the learning process and multimedia design (Stemler, 1997; Veronikas & Maushak, 2005). The meaning among words must be held constant to manipulate the context of the information presented (Morrison et al., 1988a, 1988b). Grabinger & Amedeo (1988) indicated that "reading, being a perceptual skill, involves not only attending to a stimulus, but also encoding that stimulus in a meaningful manner and cognitively integrating its information with existing knowledge or prior experience for assessing its meaning" (p. 190).

The research on text format variables has focused primarily on the attention phase of the perceptual process. But certain limitations are imposed on comprehension when the main text is read from a computer screen, because perception is a cycle that reacts to nominal and effective stimuli (Neisser, 1976). According to the view of Neisser (1976), the perceptual action consists of three factors: available information (actual environment), schema, and exploration. These factors provide the perceptual cycle, which includes modifications, directions, and samples in this process (Neisser, 1976). Based on these considerations, the "cognitive link between reading and perception is important because it defines a psychological area that may be used to identify processes used by readers in perceiving CRT text, and it sets as a design objective the accurate translation of a nominal stimulus into an effective stimulus" without losing its original idea in a text (Grabinger & Amedeo, 1985, p. 2).

Information Processing and Cognitive Style in Text density Research

One of the most important aspects of visual communication is perception. Perception deals with the awareness of objects in a learning environment. The act of human information processing in psychology provides a foundation for interface design. The human-computer interface is a communications channel between the user and the computer. The interface includes both physical and conceptual components. Physical components include input devices such as mice and touch panels and output devices such as visual displays and sound. Conceptual components include selection methods, such as menus or direct manipulation and representation schemes such as screen layout and mixtures of graphics and text (Marchionini, 1991). During information processing, 1) learners have a working memory limited in the information it can store, 2) learners must have their attention refreshed frequently, and 3) recalling information requires more cognitive effort than recognizing information (Ipek, 2010).

The present study follows and supports the investigations conducted by Ross, Morrison & O`Dell (1989, 1988a, 1988b). A high density version of the CBI, patterned after all of the original textbooks were reviewed. Its total length was 147 (card) frames in a HyperCard program. Within each lesson, the basic instructional orientation involved the definition of the main idea and its application with several examples. For this reason, several criteria were described: text should have a main idea, and its content should be interesting for the learner and should be tested by a given test item. Based on these rules, a text on volcanoes and volcanic activity was designed, in terms of the development of the CBI tutorial, to provide an interaction between text and reader (O'Dell, 1988a, 1988b; Morrison et al., 1988a, 1988b). Both this study and old studies deal with the effects of text density levels on achievement and instructional displays. However, Ross et al. (1988a, 1988b) and Morrison et al. (1988a, 1988b) were interested in print and computer material as group levels. This study, however, focuses on the interaction between the cognitive style of field dependence and text density levels in CBI lessons. To accomplish this, cognitive styles of college students were classified to determine their individual learning characteristics. Then, the combination of CBI text density considerations was analyzed to examine student achievement in reading comprehension, completion time, and learning from a CBI tutorial.

In another study, Ross et al. (1988a) suggested that text density level in content information provides attributes in organization and elaboration for different cognitive styles. When learners witness an event, it is likely that each learner will describe a somewhat different experience. Their responses are a result of their individual perceptions, which are influenced by differences in gender, cognitive styles, social interactions, interests, achievements, learning styles, and abilities (Witkin, 1976). The individual differences in the ways in which information is organized and processed are known as cognitive styles.

Messick (1976) identified more than 20 cognitive styles. This study will deal with only one style: field dependence. According to Messick (1976), a field-independent person tends to articulate figures as being discrete from their backgrounds and can more easily differentiate objects from the embedded context, whereas a field-dependent person tends to experience events globally. Similarly, Jonassen (1989) indicated that the field-dependent learner views information on the computer screen globally. This definition of field dependence suggests a link between text design—specifically, text density layout—and the cognitive style of field dependence.

DEFINITION OF TERMS

Cognitive Style: Messick (1976) described cognitive styles as "information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering" (p. 14). Moreover, "they are conceptualized as stable attitudes, preferences, or habitual strategies determining a person's typical modes of perceiving, remembering, thinking and problem solving" (Messick, 1976, p. 5). This study is concerned with the cognitive style of field dependence.

Field Dependence (FD): According to Goodenough & Witkin (1977), field dependence is "the tendency to rely on external referents", whereas field-independence is "the tendency to rely upon internal referents" (p. 189). Field dependence is marked by a propensity for making intuitive responses that are affected by contextual factors, without determining the relevance of these factors. For this study, field dependence levels were determined as field dependent (FD), field neutral (FN), and field independence (FI), based on GEFT scores. Students who achieved one-half standard deviation below the mean were classified as field dependent, and those in the middle were classified as field neutral (FN) (Dwyer & Moore, 1991, 1992, 1994; Ipek, 1995b; Lee, 1994; Moore & Dwyer, 1991).

Field Independence (FI) is marked by a tendency to distinguish and coordinate items extracted from complex backgrounds that may be confusing to others. For this study, students who achieved one-half standard deviation above the mean were considered to be field independent (FI).

Achievement: is the level of knowledge or skill assessed by individual pretest and posttest scores on a CBI tutorial, by completion time of lessons, and by reading comprehension and rate.

Screen Design: "Screen design is defined as the purposeful organization of presentation stimuli in order to influence how students process information" (Hannafin & Hooper, 1989, p. 156).

Text Screen Design*:* Text screen design is a part of computer screen design. It consists of two parts: text density and screen density (Morrison et al., 1989a, 1989b, 1988a, 1988b, 1988c; Ross et al., 1988a, 1988b).

***a. Text Density**:* Text density manipulates the context of the information presented. It deals with the relationship between characters and blank spaces on a computer screen (Schultz, 1989). Text density variables include such attributes as length of material (number of words), redundancy of ideas, and depth of conceptual support for the main ideas (Morrison et al., 1989a, 1989b). For this study, text density criteria include details of content, richness, the main idea, key words, and correct responses for each test item in the CBI.

***b. Screen Density**:* Screen density indicates how much information the expository frame should contain on the screen. It considers the "measurement of the amount of information presented at one time on the screen" (Morrison et al., 1989a, 1989b).

Time Spent for a CBI tutorial*:* is the amount of time for completing a CBI geology tutorial. It includes how much time each student spent on learning from the CBI tutorial. Time spent for CBI lessons was recorded on a computer.

Creating Text Density Levels

A low-density text version of CBI, patterned after all rules for the text density were examined. The low-density version was developed by (a) defining a set of general rules, (b) having at least three graduate students who were interested in geology discuss the rules and the interaction between objectives and test items in a text, and (c) reviewing all materials until consensus was achieved that all criteria were satisfied. The rules in this study were as follows:

- Reduce sentences to their main ideas.
- Delete sentences or words that summarize without presenting new information.
- Use available words or articles to reduce text information without loosing the main idea.
- Discuss details, ideas, and objectives of lessons.
- Present information to be tested by administrated, objective test items.

Finally, a presented text has enough density to be correctly responded to for each test item in two versions (Morrison et al., 1989a, 1989b, 1988b).

The completed low density version consists of 147 modified frames in a HyperCard tutorial. The CBI version of low density lessons was prepared directly from the high density version. Objectives of lessons, a number of practices, pretest, and posttest items were conducted via the same strategy. This study did not deal with the content of geology or its contexts. Also, the amount of learning from different text density types in the tutorial permitted the testing of the research questions that were converted to hypotheses.

A high density version of the CBI, patterned after original textbooks, was reviewed. Its total length was 147 (card) frames in a HyperCard program, in a low density version. Within each lesson, the basic instructional orientation involved defining the main idea and its application with several examples. For this reason, several criteria have been given for both text density styles: a text should have a main idea, its content should be interesting for the learner, and its content should be tested by a given test item. Based on these rules, a text about volcanoes and volcanic activity was designed, in terms of the development of the CBI tutorial, to provide an interaction between text and reader. The study was limited to variation in low density and high density styles.

Low-Density (modified) Text: Low density text indicates computer text that is modified and reduced from the original text. It refers to the integration of meaningful information without losing its content (Grabinger & Amedeo, 1988; Morrison et al., 1989a, 1989b, 1988b). For this study, the CBI version of low density text was created by the researcher from a high density version, by controlling the text-density criteria mentioned before; it was reviewed by three graduate students and was validated by faculty members who taught a fundamental geology course and who are experts in the development of CBI tutorials. In general, high density text was modified from 35% to 40% for each low density text frame.

High-Density (actual) Text: High density text, in general, refers to meaningful information and printed text. Printed text is an example of high density text. In print media, pages are usually arbitrary points for dividing text (Grabinger & Amedeo, 1988; Morrison et al., 1988b, 1989a). High-density text is defined as a nominal stimulus that indicates environment (actual text). The difference between nominal stimulus and effective stimulus is based on the amount of information in a perceptual cycle (Neisser, 1976; Grabinger & Amedeo, 1988). For this study, the CBI version of high density text was created by the researcher from the printed materials.

RESEARCH METHODOLOGY

Purpose: The purposes of this study are to determine if a main effect exists between variations in text density levels on achievement in a CBI tutorial, on the completion time of CBI lessons, and on reading comprehension and reading rate scores. Furthermore, to determine if an interaction exists between variations in text density levels and the cognitive style of field dependence (1) on achievement levels in a CBI geology tutorial, (2) on completion time of the CBI tutorial, and (3) on reading comprehension and reading rate.

RESEARCH QUESTIONS

This study focuses on the effects of variations in text density levels on student achievement in a geology tutorial, on reading comprehension, and on completion time of lesson outcomes. The following research questions were formulated after a review of the relevant literature:

1. Is there a significant main effect between text density levels (a low density versus a high density) on achievement in a CBI tutorial?
2. Is there a significant main effect between text density levels (a low density versus a high density) on the completion time of a CBI tutorial?
3. Is there a significant main effect between text density levels (a low density versus a high density) on the reading comprehension scores?
4. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) as measured by achievement in a CBI geology tutorial?
5. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) in terms of completion time of the CBI geology tutorial?

6. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) in terms of reading comprehension scores?

RESEARCH DESIGN

Procedures: This study utilizes a (2x3) ANCOVA factorial design. Each research question was analyzed by factorial experiments and correlations. To accomplish this, a design model was used to test hypotheses, without which the analysis may not have been controlled between parameters.

A two-factor experimental research design was employed (Freed et al., 1991). In this case, one factor is the treatment variable of text density level, which includes low density (LD) and high density (HD). The second factor is the level of cognitive style. The cognitive style levels were identified as field independent (high), field neutral-FN, and field dependent (low). Field dependence (low) is demonstrated by achieving scores (low scores (scores $< 6(X-0.5\sigma)$) on the Group Embedded Figure Test (GEFT), and field independence (high) is demonstrated by achieving scores (scores $\geq 11(X+0.5\sigma)$ students achieving scores $(6\leq$ scores$<11(X\pm0.5\sigma)$ were considered to be field-neutral in the study. The test takes approximately 20 minutes for a participant to complete. Materials created by the researcher were used to facilitate and examine the performance of students. The GEFT results are summarized in Table 1. The study employs a randomized blocks design and assumes three cognitive style blocks of participants in the experiment as a fixed-effect model. Stratified randomization was used to assign participants to treatment groups.

Evaluation of the CBI geology tutorial was done in three steps: quality check list, pilot testing, and validation (Alessi & Trollip, 1991; Ipek, 2001). The CBI geology tutorial was reviewed by 20 graduate students who were taking a CBI development and applications course in the School of Education at the University of Pittsburgh and by 15 undergraduate students at the Faculty of Humanities and Letters and the Faculty of Business Administration at Bilkent University in Turkey. In addition, pretest and posttest instructional materials were pilot tested using a group of five graduate students. The process was conducted based on formative evaluation.

Participants: Eighty college freshman students at Bilkent University in Ankara, Turkey, were randomly assigned to text density levels, after being assigned to three cognitive style groups (FD, FN, and FI). The GEFT was used to determine their cognitive style levels as FD, FN, or FI. All participants were volunteers. They were in different programs and not in a geology program, their native language was Turkish, and English was their second language. Instruction at the University was in English.

Table 1. Means and standard deviations on GEFT scores (n = 80)

	n	Mean	Std. Dev.	Std. Error	Min.	Max.
Sex						
male	20	9.65	4.63	.598	1	18
female	60	7.71	4.63	1.221	1	18
TD						
LD	40	8.2	5.0	.798	1	18
HD	40	8.1	4.8	.757	1	18
FDI						
FD	29	3.4	1.4	.261	1	5
FN	26	7.7	1.9	.371	6	10
FI	25	14.2	2.7	.533	11	18

Research Variables: Independent variables of the study were the levels of field dependence and text density levels. Dependent variables were achievement in geology, completion time of lessons, and reading comprehension.

RESEARCH MATERIALS (Instruments)

CBI Versions of Lessons (Tutorial): CBI versions of the high- and low-density lessons were prepared directly from the print materials for a fundamental geology course in general studies at the University of Pittsburgh. For this research, the geology tutorial included three lessons covering types of volcanoes and volcanic eruptions. To create CBI lessons, a hyperCard/hypertalk program was used. Each lesson included subcategories to elaborate the instructional menu. The final versions of the low- and high-density CBI lessons consisted of 147 modified (low density) and 147 actual text (high density) frames, respectively. The CBI tutorial materials were used to measure dependent variables and their effects.

Group Embedded Figure Test (GEFT): This is a version of the Embedded Figures Test (EFT). It can be used for group administration to measure the FD of students (Witkin et al., 1971; Goldstein & Blackman, 1978). For this study, GEFT was administered in a 20-minute testing session. The test contained 3 sections: the first section, with 7 simple items, and the second and third sections, each of which contained 9 more difficult items. The reliability was r= .82. The validity with criterion variable was found to be in the range of .63 to .82.

Pretest: A pretest was given to determine the learner's experience in the fundamentals of geology. To provide additional support for this, learners' backgrounds and experiences with related courses was used to ascertain their knowledge about the subject. The pretest and other criteria were used to control and eliminate these negative effects between treatment groups. The test consisted of ten items. These items are considered to test prior knowledge and incoming information about a text. As a result, the internal consistency reliability of the test was calculated by the KR-20 formula and reached this result: (r_{xy}=.52).

Reading Test: The Nelson-Denny Reading test (form E or F) (Brown, 1981) was administered to assess student reading comprehension and reading rate.

Posttest*:* A posttest was used to define improvements and achievement levels in geology for text density in the CBI tutorial. Field dependent learners have different achievement scores in class, according to the literature. There is a factor that is defined such as text density levels. The posttest results were evaluated to define the effects of text density levels in learning for field dependent learners. There were a number of indications for the content, text style, objectives, and cognitive effects in the instructional process. Additionally, the posttest questions were written and adapted from the test banks of fundamental geology textbooks for the general studies program. For this reason, test items for this study had high reliability and validity. KR-20 Internal consistency reliabilities of the total test were calculated. The reliability of the posttest was found to be r_{xy}=.65. The total test consisted of 15 items. To prepare the posttest, the crosstabulation table was conducted in two dimensions for objectives and content. After writing objectives, the researcher decided how many test items were necessary to control for objectives reached for a text in CBI. In accordance with the testing literature, each objective was examined by at least one or more test items to support a text density approach. Each CBI version of high and low density lessons was developed based on the cognitive objectives of the text.

DATA GATHERING PROCEDURES

Learners were provided with either a low density (LD) text or a high density (HD) text presentation. A computer lab at Bilkent University was used to complete the study and gather information. Before beginning the lessons, participants were given the GEFT to define their cognitive styles. This test has a firm research base, is inexpensive, and is usable for group administration. Researchers have found high validity and reliability sores on the GEFT (Witkin et al., 1971; Witkin & Moore, 1974). Participants were then randomly assigned to treatment groups, as seen in Figure 2. The pretest was administrated before presenting the CBI lessons. The CBI lessons were then presented and taught for an hour in a week at the computer lab using Macintosh computers. The lesson time varied across participants. No time limitation was imposed for studying with either CBI version. The time was recorded by the program. The reading comprehension tests were given to determine student reading comprehension and reading rates. Upon completion of the CBI lessons, participants took an achievement test in the CBI tutorial. The computer program automatically recorded lesson completion time and the scores of the posttest achievement on each multiple-choice item.

DATA ANALYSIS

The first step in analyzing the results of a factorial experiment is usually to gather complete descriptive statistics for a group representing each combination of factors. The mean score of the students on problems representing each of the six combinations (cells) of factors are shown. In addition, correlations between variables and treatment groups were calculated by the Pearson-product-moment correlation matrix.

The next step in analyzing the results of this experiment was to perform an analysis of covariance (ANCOVA) and—using the Nelson-Denny Reading Comprehension Test (N-DRCT) score as a covariate—regression analysis to determine whether the differences between mean scores were statistically significant. If there were differences between at least two groups, according to F ratios, the t test was used to compare treatment groups. As a result, all null hypotheses were tested by F tests to consider the effectiveness or effects of independent variables on dependent variables in the study.

Based on these considerations, a series of two-way analysis of covariance (ANCOVA) was used to test the mean differences of achievement, reading comprehension, reading rate, and lesson completion time for the cognitive style of field dependence (FD/FN/FI) and the text density level (LD/HD) as two independent factors. In order to control statistical power and to equate the treatment groups (LD/HD), the Nelson-Denny Reading Comprehension Test (N-DRCT) scores were used as a covariate. The correlation between the N-DRCT and achievement scores and the GEFT scores were used to interpret reading comprehension scores for predicting the scores of dependent variables and the effectiveness of independent variables on dependent variables.

For the present study, all statistical analyses were done using a statistical package for Social Sciences (SPSS for Unix version 6.1) on the mainframe, at the Bilkent University Computer Center. To check the validity and the power of prediction, simple regression and Pearson-product-moment correlation coefficients were calculated for the two measured variables using StatView 512+™. In addition, reliability and validity were reviewed for the instructional materials using a covariate measure and judge validity, respectively. The mean differences of dependent measures were analyzed to clarify the main effects by using regression analysis, ANCOVA, and ANOVA. Next, the interaction effects between field dependence and text density levels on dependent measures were clarified. The six research questions converted to statistical hypotheses were tested according to the factorial design model.

RESULTS AND FINDINGS

The purpose of the study was to investigate the effects of text density levels and the cognitive style of field dependence on learning from a CBI tutorial, based on the dependent measures of achievement, reading comprehension and reading rate, and completion time of lessons. Materials created by the researcher were used to facilitate and examine the performance of students. The independent variables were the levels of cognitive styles (FD/FN/FI) and text density levels (LD/HD). Table 2 presents the means and standard deviations achieved by students in the different treatment categories on the criterion measures such as pretest-posttest (gain) and reading comprehension.

Table 2. Means and standard deviations on criterion measures for participants in treatments

Field Dependence			**Achievement Scores**		**N-DRCT Scores**	**Time (sec.)**
			Gain	**Post**		
LD						
FD	N=14	M	1.50	3.86	31.0	2432
		SD	1.78	2.14	8.22	552
FN	N=13	M	1.69	4.92	33.3	3378
		SD	1.84	1.44	6.39	1194
FI	N=13	M	2.46	5.46	34.0	2637
		SD	2.33	1.85	7.83	861
Total	N=40	M	1.88	4.72	32.75	2806
		SD	1.99	1.92	7.46	968
HD						
FD	N=15	M	2.47	4.93	32.13	3088
		SD	1.80	1.75	5.31	729
FN	N=13	M	2.08	5.31	26.76	2636
		SD	2.10	2.09	6.08	1235
FI	N=12	M	3.33	5.75	30.50	2236
		SD	2.23	1.42	5.72	596
Total	N=40	M	2.60	5.30	29.90	2802
		SD	2.04	1.77	6.00	900
	N=80	M	2.24	5.01	31.32	2804
		SD	2.03	1.85	6.78	935

According to the results of the analysis, a Pearson correlation coefficient of .05 between N-DRCT and achievement test scores was obtained. The regression equation for relating the dependent variable is [y = .014x + 4.588] indicating a very low positive relationship between N-DRCT and achievement scores (r_x = .05). The regression equation for relating pre-posttest difference (gaining) scores to the N-DRCT score is [y = -.129x +31.612], indicating a negative relationship between the gaining score and N-DRCT score (r_x = -.04). The correlation is not meaningful enough to explain information for N-DRCT scores and GEFT scores. Because no interaction was found between factors, I preferred to compare relationships among variables using the posttest achievements of the CBI geology tutorial. The main effects can be interpreted directly. The regression equation for relating the N-DRCT and GEFT scores is [y =.101x +30.497], indicating a positive relationship between N-DRCT and GEFT scores (r_x= .07).

The positive relationship between N-DRCT and lesson completion time (rx=.19) is indicated with the equation [y = 25.041x + 2019.779]. It is important to note that reading comprehension and reading rate are closely related to how learners read a text from a computer screen. Both the reading and the reading rate test indicate very low positive relationships among GEFT scores and FDI levels (r_x = .07, r_x = .04, respectively) (see Table 3). Table 3 indicates the correlation matrix for all measures. The table is important to carry information for future research and to indicate positive and negative relationships in order to clarify how much variables can be changed within and between the groups. These scores can be used for predicting the other criterion variable, when needed. For example, the correlation coefficient between two measures would be used to predict another test performance. The regression coefficient equals the covariance between dependent and independent variables divided by the variance of the independent variable. The absolute value of the regression coefficient will always be larger than the absolute value of the correlation coefficient, when there is more variability of scores on the criterion variable than on the predictor variable. Table 4 indicates means and standard deviations of variables to illustrate their variances in the population.

The study shows the analysis of regression coefficients between text density levels and dependent variables (r_x=.27, $F_{3,79}$ = 1.94, p>.05; $F_{4,79}$ = 1.522, p>.05; $F_{5,79}$ = 1.202, p>. 05). When the standard deviations are equal, the regression and correlation coefficients are equal. These groups have different standard deviations (see Table 4); therefore, the regression and correlation coefficients are not equal. The result indicates a variance of the groups. The magnitude of the regression coefficient is directly proportional to the correlation coefficient. The study shows regression coefficients between field dependence and dependent variables (r_x = .32, $F_{3,79}$= 2.292, p > .05); ($F_{4,79}$ = 1.808, p > .05; $F_{5,79}$= 1.661, p> .05).

R-Squared (R^2) provides an index of how well the independent variables predict the dependent measure. R^2 is the proportion of the variation in the dependent measure that is accounted for by the prediction made from the independent variables. As shown in study, approximately 10% variance may be explained from the field dependence groups. This means that 10% prediction would be possible for a factor. In other words, the standard error of estimate would be the same between observed and predicted values of the dependent measures. These results indicate that N-DRCT, as a covariate, may not indicate enough power to explain its purpose with dependent variables, because the relationship is not strong enough, and the covariate is used to reduce the estimate of random or error variance in the dependent measure. ANCOVA assumes that the relationships between the covariate and the dependent measure are statistically equivalent within all groups or cells in the design. In this table, the relationships between all variables and measures can be named as text density (TD), field dependent-independent (FDI), time, group embedded figure test (GEFT), pretest (Pre), posttest (Post), reading comprehension (R.Com), reading rate (R.R) and difference between pre-post test (Gain) consequently. The cross-tabulation of the variables indicates amount of correlation and significance for instructional variables as follows.

Table 3. Correlation coefficients matrix for all variables (measures)

	TD	FDI	Time	GEFT	Pre	Post	R.C.	R.R.	Gain
TD	1.00								
FDI	-.03	1.00							
Time	-.002	-0.56	1.00						
GEFT	-.005	-.906	-.04	1.00					
Pre	-.045	.13	.09	.11	1.00				
Post	.156	.26	.18	.25	.25	1.00			
R. Com.	-.21	-.04	.19	.07	.12	.05	1.00		
R. Rate	-.036	-.07	-.08	-.15	-.18	-.05	-.18	1.00	
Pre-P. (gain)	.174	.15	.10	.16	-.46	.75	-.04	-.08	1.00

Table 4. Means, median, and standard deviations on all measures' scores (N= 80)

	Mean	Median	Std. Dev.	Min.	Max.
TD	1.5	1.5	.50	1	2
FDI	1.95	2	.83	1	3
GEFT	8.2	7	4.89	1	18
Pretest	2.8	3	1.39	0	6
Posttest	5.0		1.86	2	10
R. Rate	218.4	209	76.40	60	451
Reading Comp.	31.3	32	6.88	12	44
Time spent	2804.2	2721	929.38	859	5827
Pre-post diff.	2.2	2	2.03	-2	7

1. Is there a significant main effect between text density levels (a low density versus a high density) on achievement in a CBI tutorial?

A two-way analysis of covariance was used with achievement tests (pretest and posttest) on the CBI geology tutorial presentation types, with N-DRCT scores as a covariate. Achievement test results indicated no significant differences between treatment levels using LD and HD levels ($F_{1,\ 79} = 2.566$, $p > .05$).

2. Is there a significant main effect between text density levels (a low density versus a high density) on the completion time of a CBI tutorial?

The study shows the results of the analysis for the completion time of lessons. As shown in the study, on the completion time of a CBI tutorial, no significant differences occurred among the participants at the two levels ($F_{1,79} = 0.139$, $p > .05$). The mean scores for the low-density group (LD) (mean = 2806.37) and high-density group (HD) (mean = 2802.00) are close. The total mean was 2804.19.

3. Is there a significant main effect between text density levels (a low density versus a high density) on the reading comprehension scores?

A two-way analysis of covariance was used with N-DRCT scores as a covariate. According to the analysis, there is no main effect on the reading scores. However, a two-way analysis of variance was used to analyze the effects of treatment groups on reading scores. Reading comprehension scores indicated no significant differences for using the LD and HD levels group (LD/HD) ($F_{1,79}$) = 1.936, $p > .05$). It is interesting that with two-way ANOVA on reading scores, text density (LD/HD) was found to be significant on the reading scores ($F_{1,79}$ = 3.933, $p <.05$). But no interaction was noted between the two factors. As a part of reading scores, reading rate scores were found to be significant with two-way ANOVA ($F_{1,74} = 4.733$, $p < .05$). These findings may provide clues to indicate a significant relationship between the two factors.

4. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) as measured by achievement in a CBI geology tutorial?

A non-significant interaction was noted between text density levels (LD and HD) and the cognitive style of field dependence (FD/FN/FI) ($F_{2,73}$) = 0.274, $p > .05$). The study shows the summary of the analysis for the gain score between the pretest and posttest difference. In addition, the study shows comparison among FDI levels and text density levels on achievement (posttest) in the CBI geology tutorial.

5. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) in terms of completion time of the CBI geology tutorial?

A non-significant interaction was noted between text density levels (LD and HD) and the cognitive style of field dependence (FD/FN/FD) ($F_{2,73} = 3.101$, $p > .05$). In addition, Table 5 shows the cell means and standard errors of cell means for the completion time of the tutorial.

Table 5. Cell means, standard deviations, and standard errors for lesson completion time in the CBI geology tutorial

	Count	Mean	Std. Dev.
LD, FD	14	2432.1	52.6
LD, FN	13	3378.4	119.4
LD, FI	13	2637.1	861.8
HD, FD	15	3088.5	729.8
HD, FN	13	2636.3	1235.4
HD, FI	12	2623.4	596.7

6. Is there a significant interaction between text density levels (a low density versus a high density) and the cognitive style of field dependence (FD) in terms of reading comprehension scores?

A two-way analysis of variance was used with reading comprehension and reading rate scores. A non-significant interaction was noted between treatment groups (LD/HD) and field dependence (FD/FN/FI) levels using N-DRCT scores ($F_{2,74} = 2.347$ $p > .05$). However, the F-value in one factor was found to be a significant separate effect ($F_{1,74} = 3.933$ $p < .05$; $F_{2,74} = 0.710$, $p > .05$). On the other hand, reading comprehension scores were affected in reverse According to findings, post-hoc comparison among FDI levels and text density levels on reading was found to be statistically significant.

DISCUSSION AND CONCLUSIONS

Although the findings show non-significance in formal tests of hypotheses, a preference for the high-density level was found. Specifically, the tests of hypotheses generated the following discussion and conclusions:

1. No significant differences occurred between students receiving the different text density type (LD and HD) on the achievement and learning scores from the CBI geology tutorial. The values for LD students ($\bar{X}$ = 4.72 Std Dev. = 1.921) and HD students ($\bar{X}$ = 5.30 Std. Dev. = 1.177) are without significance. Participants displayed preferences while working. Movement within the CBI screens is different for participants and is based on learners' experiences in using computers and technology. High-density text (HD) takes more time and effort than low-density (LD) text. However, it was not expected that students with the low density text (LD) would spend more time than high-density (HD) text readers. The result is not consistent with previous research. The findings indicate a further need for research that shows preferences for the variations of text density levels in CBI tutorials and CBI lessons on the Internet. As indicated in previous research, 31% density screens were preferred, and low-density text (LD) modified from 35% to 40% from a high density (HD) text such as actual text was also found to be preferred. Because of this result, the current finding is consistent with previous preferences. It is important to note that learning achievement, defined as a pretest and posttest difference score, shows some learning from the CBI geology tutorial, although no significant main effect is indicated statistically. Results, according to descriptive statistics, indicate meaningful relationships in perceptual processes for the learners (see the correlation matrix). For instance, human factors such as simplicity, student-computer dialogue, social amenities, spaciousness and relevance (Rambally & Rambally, 1987), and experience using computers seem to be important for recognizing student learning in CBI tutorial lessons.

On the achievement test, students using the LD text type ($\bar{X}$ = 4.75) achieved scores close to those of students using the HD text type ($\bar{X}$ = 5.30). These results indicate that there are no significant differences between the two text density levels. This present study is consistent with the previous reviews of the literature. In other situations, because of a lack of main effects and interaction, the achievement score (posttest) in the CBI tutorial was taken as a criterion measure to compare the effectiveness of the mean values of dependent measures. This conclusion indicates text based density as low and high level. In addition, instructional designers and students in the multimedia era can adopt all sorts of multimedia displays based on new technologies and multimedia design rules. Although this work is limited to text density design rules as a basic performance, students and educators can develop and present all multimedia displays effectively in their works based on research findings and considerations. We still need conducting and presenting text density research studies of the different levels of text density design in web, internet and multimedia lessons as well as screen design considerations..

2. No significant differences occurred between students receiving the LD text lesson and the HD text lesson treatment on completion time of a CBI geology tutorial. It was not expected that HD-using students would spend less time than LD-using students (time spent LD $\bar{X}$ =2806 sec, HD $\bar{X}$ = 2802). From the experiment with the CBI tutorial, students using the HD text worked more comfortably with it, as expected, than students using the LD text, across all field-dependence groups, except in the FD/LD category (time spent $\bar{X}$ = 2432 sec.). This is an unexpected result that is close to what is recorded for other LD text levels. It may be the result of individual learner characteristics and behaviours such as motivation, attention, time limitation, and leaving early from other classes. Students in the FI cognitive style category using HD text achieved high scores, spending less time than LD text using students with FI cognitive styles and used less time (achievement $\bar{X}$ = 5.75 in the HD/FI group; time spent $\bar{X}$ = 2236 sec., and achievement $\bar{X}$ = 5.46; time spent $\bar{X}$ = 2637 sec.). Gain score means the learning from the CBI tutorial that indicates the same result and so does achievement (post) score. It is possible that the majority of students prefer to work with high density screen design, based on their lack of experience with computers and with reading globally. A lack of computer experience may cause loss of attention and recognition for the lesson material, when participants use a CBI tutorial and related technology. Visual movement in order to vary text density levels would result in complex information processing for students in terms of their perceptions and memories. The situation in this study does consider experience in computer use, in that all classes of participants were taking their first technology and computer applications course at the university at the same time. Thus, there is a problem from one perspective, in that students who received HD text focused on learning from the CBI lessons better than those who received LD text.

3. Reading comprehension from the computer screen was expected to be theoretically different for the cognitive styles and text density levels. As indicated by Baker & Anderson (1982) and Garner & Reis (1981), comprehension may be related to cognitive style. Knowledge of cognitive styles can allow researchers the predictive power to delineate comprehension abilities (Pitts & Thompson, 1984). For example, monitoring abilities such as schema-familiar and schema-unfamiliar text may have important implications for instruction and for the development of CBI computer screens (Pitts & Thompson, 1984). Moreover, as indicated by Spiro & Tirre (1980), field dependent students do not use prior knowledge as efficiently as do field independent students.

There was no significant main effect among text density levels on reading comprehension scores, monitoring, and operating abilities for successful reading from the computer screen. If students have difficulties with applying general rules for screen interface, they may not display high scores in their CBI lessons. In the correlation matrix, the negative relationship between text density levels and reading comprehension scores was shown (r = -.21).

As shown in the findings, however, both LD and HD text density levels, relative to reading scores, were not found to be significantly different for reading comprehension ($F_{1,79}$= 3.538, p > .05). However, a correlation between the GEFT and reading comprehension was indicated (r = .07). The low correlation would likely be based on a lack of reading comprehension because of the students' second language being English. For this reason, the situation does not indicate expected findings. It was assumed that the FI learning style was better than others at the college education level. As noted previously from the literature, FI students gained higher scores than FD and FN students (Dwyer & Moore, 1991, 1992, 1994; Ipek, 1995b, 1997; Ipek & Bayram, 1996; Lee, 1994; Moore & Bedient, 1986; Moore & Dwyer, 1991).

4. A non-significant interaction was noted between text density levels and field dependence on achievement in a CBI geology tutorial. It would also be possible to see an interaction between two factors working with a large sample and a different content area and grade and with the provision of visual attention for the students (Henderson, 1992; Kintsch, 1980).

Further investigation of the various text density levels in CBI development and applications should be performed to review mean differences and their distributions for effective screen design. The study was limited to investigating only two text density levels. We need a clear definition of the text density levels and their preferred styles, for using CBI tutorial and Web design. Such an investigation would provide strategies for how to effectively support perceptual behaviours and cognitive and technological factors to create an instructionally effective CBI screen design with various text density styles. There was a lack of experimental information to support and clarify the effects of cognitive styles by means of perception, cognition, and learner characteristics. We need to explore how text density levels affect teaching and learning processes for the different grades, levels, and disabilities of learners according to their cognitive style of field dependence. Also, human characteristics such as intelligence, cognitive style, and interests; interface design; and a combination of the effects of the designer, user, and system should be checked in order to develop effective instructional strategies in CBI (Eysenck, 1993; Kintsch, 1980; Reinking, 1988; Rayner, 1992). Further research should focus on variations of text density levels and cognitive styles in psychological foundations that combine the effects of learner characteristics, technological factors, and instructional design systems to achieve high scores with success in our classrooms.

5. No significant interaction was found between students receiving LD text and HD text treatments and the cognitive style of field dependence on completion time of the CBI lesson. According to a two-way analysis of ANCOVA, there were no significant main and interaction effects for the two independent variables. As can be seen in this research, the crosstabulation of field dependence levels (FD/FN/FI) and text density levels (LD/HD) indicated meaningful and logical expected findings, which support earlier research findings for cognitive style (Burger, 1985; Dwyer & Moore, 1991, 1992; Ipek, 1995a, 1995b; Lee, 1994; Moore & Dwyer, 1991; Myers, 1997; Witkin, 1976) and comparison of text density levels by using spent time (Morrison et al., 1988b, 1989a; Ross et al., 1988b). Interestingly, however, high density CBI lessons were preferred by learners.

Increases in time spent on CBI tutorials and interest in cognitive styles have been attributed to the unique technological characteristics of text density levels (LD/HD) as a visual display that can influence interactions between the learner and text density level for reading a text (Reinking, 1988). Students in the FI/LD category spent more time than students in the FI/HD category. However, FI learners had higher achievement scores than students in the FD and FN groups. This finding also supports previous research findings. It means that FI learners focus on the computer display with more attention, thereby spending more time on the CBI lesson. In conventional reading, learners prefer to work with printed materials. This point suggests changing learners' behaviors in order for them to be successful in a CBI environment.

6. In the present study, no significant interaction was observed between the cognitive style of field dependence and text density levels on reading comprehension scores. However, it was expected that instructional conditions with visual effects would be influenced by the level of study, the reading speed, reading comprehension, and student performance. There are significant differences in the treatment of both LD and HD. There is no significance on the reading test, separately.

Notably, there is no interaction between the two main factors. However, reading comprehension scores for both text density levels (LD/HD) were found to be significant. Both reading comprehension ability and the ability to perceive a hidden figure may be related to the effects of eye-movement. We must combine technological, language, contextual, and programming factors to influence a learner's abilities of perception, learning, and memory. We must see and understand the message to learn from it (Pettersson, 1989). All processes may be presented as a perceptual cycle (Gale, 1993; Grabinger & Amedeo, 1988; Neisser, 1976; Woods, 1984). In addition, FI learners achieved higher reading scores than did FD/FN learners in treatments and field dependence levels (LD/FI, HD/FI). It is considered to be a result of the distribution of participants in each category. For the LD/HD category, high minimum and maximum scores were observed, and the findings indicate reading abilities and perceptual processing for each level on the two factors.

RECOMMENDATIONS FOR FUTURE RESEARCH

Previous research results consistently showed field independent students scored significantly higher than field dependent students in similar treatment groups. As noted previously, field dependence is a continuum between two ends (Dwyer & Moore, 1991, 1992, 1994; Moore & Dwyer, 1991; Oltman, 1968). On one end of the continuum, field dependence levels represent different perceptions for creating schema, information, and examples by human visual sense. The results of this study showed no significant differences among FDI groups on dependent measures, achievement in a CBI geology tutorial, reading comprehension, and time spent to complete lessons in a CBI tutorial. There were no significant main effects for the main factors, according to analysis of covariance (ANCOVA). However, the study found no significant difference in reading comprehension scores using two-way variance analysis (ANOVA) among field dependence levels and text density levels. The result is not consistent with previous research (Schwarz et al., 1983). The result of this study shows no significant interactions between factors on dependent measures, achievement on the CBI geology tutorial, reading comprehension scores, and time spent to complete CBI lessons.

For time spent in completing the CBI lesson, it was expected that FI students would use less time than FD and FN students. However, the study found no significant differences between text density levels and among field dependence group levels. This result is consistent with previous research results on text density level use (Morrison et al., 1988, 1989a; Ross et al., 1988b) and is not consistent with time spent on the text density level. There were no significant differences between the LD and HD density lessons with respect to time spent to complete CBI lessons and achievement on the CBI tutorial. The results showed that students tended to prefer a high-density screen in both text density studies, in contrast to the recommendations in the literature suggesting the use of low-density screens with adequate white space and vertical typography. In addition, information display interface in multimedia design can be important in presentation. Text density research results are not the same with the text display of window-scroll and frame-based hypercards (Yang, 2000). Multimedia learning refers to a combination of verbal (text or narration) and non-verbal (diagrams, symbols, and images) representations that are designed to aid learning (Mayer 2005).

To develop text density levels in a CBI tutorial or on the Web, we need a clear definition of and international agreement on creating user-friendly interface design, based on social and international issues. Human factors in future software and Web design should be defined to create new information techniques presenting in content learning. For this reason, software designers and instructional designers should be aware of differences among learners based on cognitive and technological effects in order to avoid making more instructional or visual design mistakes in CBI programs and on Web screens. Additionally, the use of audio or text density as an instructional tool has recently increased due to the popularity of podcasts, which are digital mp3 files that can be in the form of audio, video, and/or audio and static images (Lucking, Purcell, & Christmann, 2006; Pastore, 2008). Redundant text and narration may be detrimental to learning, the learner may in fact prefer this style of presentation (Veronikas & Maushak, 2005).

As a result, this study may provide contributions with screen design and text design in multimedia instruction. It also offers new opportunities in traditional material development and web site design in our classrooms for instructional designers and system developers. Although there are no more studies in text density concept recently, software designers, educators and. instructional designers can apply these findings to improve in future research activities.. The outcomes of the study will be scattered to develop different type of text density levels which are necessary in computer screen design, web screen design and internet environments for the studies. Therefore, which level of screen density is best for learning remains to be examined further. Future research should focus on text density problems such as amount of text and its percentage with each window for developing multimedia materials, web design rules with amount of text for users and printed documents as well as developing effective lesson design for learners and users.

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