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# Effects of Font Style and Font Color in News Text on User Cognitive Load in Intelligent User Interfaces

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**ABSTRACT** The advances on the Internet and news media technologies suggest intelligent and personalised media interfaces in order to improve reading efficiency of news readers and enhance news disseminations. Cognitive load is one of factors that affect the understanding ability of news readers and therefore news dissemination. It is expected that the display elements in an intelligent user interface of news media could be automatically adjusted to modulate the audience's perceived cognitive load level in order to improve the news reading efficiency. While the font style and font colour of news text are the main display elements in the user interface of news media, it is not clear how these elements affect perceived cognitive load of news readers. This paper investigates perceived cognitive load of news readers under different font style and font colour conditions. Experiments with the news text in Chinese as a case study found that the change of text font style of keywords resulted in the increase of the reader's perceived cognitive load during reading news text under the low introduced cognitive load and blue colour displayed keywords. While under the high introduced cognitive load, the italic font and red colour of keywords text resulted in the decrease of the reader's perceived cognitive load significantly during reading news text, which therefore improves the news reading efficiency. This paper is limited to the effects of two aspects of news text (font styles and colours) on user's perceived cognitive load. The future work will focus on the investigation of effects of other factors such as news pictures and their colours, numbers, and locations on user's perceived cognitive load.

**INDEX TERMS** Human-computer interaction, cognitive load, news media, text colour, text font

## I. INTRODUCTION

With the rapid development of the Internet and information technology, the way of information dissemination has been undergoing tremendous changes. Taking the news media as an example, the massive news information is emerging to the audience at every minute, which increases the difficulty and processing ability for the audience to understand news. Moreover, news topics extremely widely cover from everyday life, economics, politics to military and many others both

nationally and internationally. Since ordinary people have limited knowledge and interest, they need to consume some cognitive resources to reconstruct the information composition of news descriptions. For example, receiving, searching and reading news have become one of the frequent and main applications for smart mobile phone users on their phones [1]. All these suggest us to pay more attention to the efficiency of the interaction between the media and the audience. Cognitive Load (CL) refers to the load imposed on working memory when an individual is performing a cognitive task. A foundational finding in this respect was Miller's work [2] which suggested that people can only hold seven (plus or minus two)

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“chunks” of information in working memory at one time and human’s information processing ability is therefore restricted to these “chunks”. Cognitive load that is too high or too low will affect the effectiveness of the individual to perform the task to the fullest [3]. Lang [4] pointed out that cognitive load is an important variable in the news reading, and the cognitive load effect of a piece of news is a function of news content and description structure [5]. In the era of information explosion of news media, how to effectively deliver media content, especially news content, to the audience so that the audience can quickly obtain the disseminated information is a huge challenge. This is because: an important factor that affects the audience’s fast access to information is the audience’s perceived cognitive load, and the current media does not examine the audience’s awareness of the media content in real time; at the same time, it needs to be further investigated to understand what aspects of the media content affect the audience’s cognitive status. Automatic perception and adaptive adjustment of audience’s perceived cognitive load is an important aspect of the smart media, while the knowledge of the current user and the knowledge of the problems are important aspects for adaptive human-computer interfaces [6]. We can imagine that in an intelligent user interface of news media, the display elements of news media could be automatically adjusted based on the audience’s perceived cognitive load to keep the audience’s perceived cognitive load in an appropriate lower level aiming to improve the news reading efficiency. This paper aims to investigate how the display elements affect audience’s perceived cognitive load in order to build intelligent user interfaces of news media.

In the user interface of news media, the text font and text colour are the main display elements. Previous research work has studied different aspects regarding the display elements such as font size [7], brightness conditions [8], text clarity, static or dynamic text display [9]–[11] and other aspects that affect the cognitive load or learning effect of users. However, it is not clear how font style and font colour affect user’s perceived cognitive load. Cognitive load theory divides cognitive load into three types [8], [12], [13]: 1) intrinsic cognitive load, which refers to the inherent difficulty of the learning material itself, and may be affected by the prior knowledge of the subject; 2) extraneous cognitive load, which refers to the load generated by the way of learning materials through presentation; and 3) germane load, which refers to the mental resources devoted to acquiring and automating schemata in long-term memory. According to the cognitive load theory [8], [12], the cognitive load related to the presentation style of news text belongs to the extraneous cognitive load, and more specifically the perceived cognitive load by audiences which is the study object in this paper. However, there are few studies on the impact of colour and font style of text on cognitive load during reading news text.

On the other hand, “Uses and Gratifications Theory” (UGT) is a theory on the effects and use of mass media in the field of communication to study the relationship between

media and audiences [14]. From the viewpoint of the audience, this theory examines the psychological and behavioral effects of media communication to humans by analyzing the audience’s motivation to use the media and obtaining demand satisfaction. However, UGT theory and related research have not proposed specific methods for measuring audience status and methods to improve media effects based on UGT theory in the massive information environment of new media. The main technical challenges to solve these problems include: how to make the media to perceive the audience’s cognitive status on the media content, and how to improve the audience’s understanding of the media content according to the audience’s cognitive status.

This paper takes the perceived cognitive load of the audience of news media in the new media era as the research object, and introduces cognitive load into the analysis process of news audiences for obtaining information from news media. The gaps of previous research in these areas include: it is not clear how colour and font style of text affect perceived cognitive load during reading news text, and there is a lack of method to effectively examine the perceived cognitive load levels of news audiences, and a lack of guideline to use the research outcomes on perceived cognitive load of news audiences for the design of personalised user interfaces of news media. This paper presents a method of examining the perceived cognitive load of media audiences, and studies factors that affect the perceived cognitive load of audiences of news media. The paper takes the perceived cognitive load of news audiences during reading news text in Chinese as a case study, and investigates the effect of text font style and text colour on the perceived cognitive load of audiences by manipulating display methods of keywords of news text. The results from this study allow the display method of news text to be adaptively adjusted in order to improve audiences’ reading efficiency and provide an efficient and personalised media display solution. The contributions of this paper include:

- Introducing perceived cognitive load of news audiences into the analysis process for the efficient information acquisition from news media;
- Setting up a mechanism for measuring perceived cognitive load of news audiences by manipulating display methods of news text;
- Finding relations between perceived cognitive load of news audience and display factors of news text;
- Proposing innovative and personalised interfaces of news media that adaptively adjust display factors of news text for the efficient news reading.

The remaining of this paper is organised as the following. Section II investigates the related work. Section III presents hypotheses of the paper. The method of the study is presented in Section IV. We report the experiment details in Section V. The collected experimental data is then analysed and the hypotheses are tested in Section VI. We give discussions on the study and results in Section VII before the conclusions and future work in Section VIII.

## II. RELATED WORK

Cognitive load is a multi-dimensional structure that represents the load imposed on an individual's cognitive system when processing a certain task. This structure is composed of the reasoning dimension reflecting the interaction between tasks and individual characteristics and the evaluation dimension reflecting the measurable concepts such as mental load, mental effort and performance [8], [15]. An and Wu [16] believed that in a given task environment, an important factor affecting the level of the cognitive load is the human cognitive processing system, which mainly refers to the working memory and the number of tasks that it can process. Researchers have proposed different methods to measure cognitive load including simple methods such as questionnaire surveys, and more complex methods such as analysis of functional brain imaging to assess cognitive load [17]. Cognitive load has been extensively studied in the field of human-computer interaction [8], [13]. In addition, the education field has also conducted research on the cognitive load of students in different environments. For example, Liang [18] analysed the cognitive load of learners in English news listening teaching, and proposed strategies to reduce the cognitive load in listening comprehension. Tewksbury and Rittenberg [5] believed that cognitive load is a complex concept that is difficult to distinguish from other characteristics of online news reading. In addition, cognitive load is one of the important factors that affect the efficiency of users' reading and review of software code in other fields such as software quality control [19]. Since cognitive load can be measured using different modal data [20], a closed loop of tasks can be established to allow adaptive adjustment of cognitive load [21].

Different research has been conducted to investigate the display of text from various aspects. For example, studies have found that the font size affects people's ability to remember learning materials. Compared with materials written in small fonts, people are more likely to remember materials written in large fonts [7]. Chen *et al.* [8] studied the impact of different brightness conditions on users' cognitive load and their method of measuring cognitive load based on pupil changes. Through a series of experimental studies, Manav [9] found that in an office environment, different colour saturations have different effects on users' comfort, space perception, and relaxation perception. Hitchcock [10] investigated the advantages and disadvantages of red and white lighting in the cockpit of a fighter aircraft and found that when performing different tasks, the pilots have different preferences for the colour of the lighting. If the pilot's mission requires strict observation of the cabin environment, the pilot prefers red light; if the pilot's task is mainly to read instrument displays in the cockpit, read maps and documents, etc., the pilot prefers white light. Fu and Peng [22] investigated the effects of font size and font colour on the human memory in Chinese vocabulary. According to the cognitive load theory, the design of learning materials should reduce unnecessary demands on working memory (WM) to

improve learning efficiency [21]. However, recent studies have shown that when using text-based learning materials, less clear text caused additional demand for WM, which led to better learning results [23]. The study found that the higher the working memory capacity, the better the performance of retention and understanding under such unsatisfactory conditions. However, the impact of this dissatisfaction on cognitive load needs further research [23]. Chen and Lin [11] evaluated the impact of two commonly used static and dynamic text display types (i.e., paging and automatic scrolling) on the reading performance of users on mobile devices, and found that mixed types of text display (i.e., using both paging and automatic scrolling display methods) caused the highest cognitive load, followed by dynamic text display methods, and static text display methods caused the least cognitive load. Furthermore, rules of technical requirements for special web pages have been released in order to meet specific accessibility [24], [25].

The above work can be used as a reference for the research in this paper, but it is difficult to directly apply to the analysis of the cognitive load of the audience in the news media. Based on the characteristics of the news media and the unique needs of the media audience, the study in this paper faces some new problems: 1) There is still a lack of theories and methods for measuring the perceived cognitive load of audiences of news media. Taking news text mediated by mobile terminals as an example, how to understand the audience's reading behavior from the perspective of cognitive load is a difficult problem that has not been studied in depth; 2) Factors affecting the perceived cognitive load of the audience. Taking news text as an example, including the vocabulary used in the text and the order of sentences in the text may affect the perceived cognitive load of the audience. This is also one of the main problems in measuring the perceived cognitive load of news media audiences. This paper studies the impact of text font information such as italics and bold text as well as text colour on the perceived cognitive load of news audiences.

## III. HYPOTHESES

This paper poses the following hypotheses during the news text reading:

- H1: Different font style will affect user's perceived cognitive load differently;
- H2: Different font colours will affect user's perceived cognitive load differently;
- H3: Under a given font style, the introduction of font colours will affect user's perceived cognitive load, and different font colours will affect user's perceived cognitive load differently;
- H4: Under a given font colour, the introduction of font styles will affect user's perceived cognitive load, and different font styles will affect user's perceived cognitive load differently;
- H5: These effects will be affected by the level of introduced cognitive load.

#### IV. METHOD

This paper uses a controlled experiment method to study the impact of font information in news text in Chinese on users' perceived cognitive load. As shown in FIGURE 1, the study first selects different news texts from current popular Chinese news websites. The news texts from news websites also contain keyword information. This paper studies the effect of font styles and colours of news text on users' perceived cognitive load by controlling different font styles and colours of keywords. Furthermore, the paper uses the dual-task method [26], [27] to introduce cognitive load into the user's reading process. The dual-task method requires a user to engage in a secondary task that is generally dissimilar and requires less working memory resources in parallel to the primary task. The assumption of dual-task methodology is the limited capacity of working memory. Performance in the secondary task is hypothesized to deteriorate as cognitive load increases for the primary task. Therefore, the performance for the secondary task can then serve as indicators of changing load conditions. In a word, this paper studies the changes of user's perceived cognitive load by controlling the font style and colour information of keywords of news text in a dual-task environment. This section introduces the dual-task method, the control method for news font style and text colour, and user's perceived cognitive load measurement method in details.

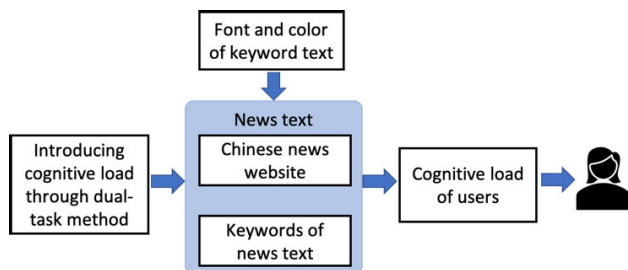


FIGURE 1. Research method used in this paper.

#### A. INTRODUCING COGNITIVE LOAD WITH THE DUAL-TASK METHOD

This paper uses the dual-task method [26]–[28] to introduce cognitive load into the user's reading task process through the following steps (see FIGURE 2):

- 1) Generate a random number with a given digit number, and the number of digits of the random number determines the level of the introduced cognitive load [29]–[31]. Through a series of experimental studies, the digit number of random numbers used for cognitive load from small to large (CL1, CL2, CL3) is 2, 5, and 8 digits to maximize differences between different cognitive load levels in this study;
- 2) Before displaying the news text, the random number is displayed to the participant for 5 seconds and then disappears;
- 3) Display the news text to the user, and the user reads the news text. The user is asked to memorise the random numbers during reading the news text;

- 4) The user is asked to recall and write down the random number after finishing reading the news text.
- 5) The user is asked to answer questions about the content of the news text.

#### B. FONT OF NEWS TEXT

This paper studies effects of text font style and text colour on users' perceived cognitive load by manipulating different font styles and colours of keywords in news text. In the dual-task method adopted in this paper, the cognitive load introduced by the random number memorisation task is called the introduced cognitive load, and the cognitive load caused by the news reading task is called the reading cognitive load or perceived cognitive load.

In this experiment, the keyword information of each news text comes from the relevant news website (the keyword information is stored in the meta information or other fields of the news html file). The display method of the keywords of the news text includes the following options:

- Font style: including Bold, Italic, and the same font as other text (Songti in Chinese, and it is represented as "Control");
- Colour: including cold colour (blue is used in this study), warm colour (red is used in this study), and the same colour as other text (black colour, and it is represented as "Control").

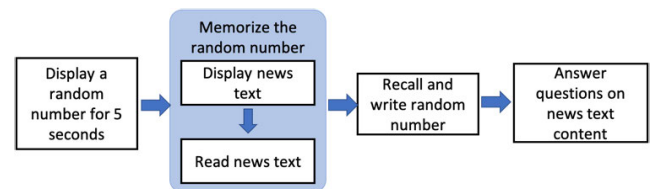


FIGURE 2. The process of introducing the dual-task method into the cognitive load.

#### C. METHODS OF COGNITIVE LOAD MEASUREMENT

Cognitive load measurement methods mainly include subjective method with questionnaires, performance measurement method, and analysis method based on physiological signals and behavioral signals [8]. This study uses a questionnaire method to collect users' cognitive load feedback after reading news texts. The subjective method with questionnaires is a widely used simple and effective method to obtain the cognitive load of users, and the subjective method is usually used as a benchmark to measure the effectiveness of other methods of cognitive load measurement [8].

#### V. EXPERIMENT

##### A. NEWS TEXT DATA

The method used in collecting news text data in this study is as follows: the news text was collected from the major Chinese news websites such as Sina (news.sina.com.cn) and Sohu (news.sohu.com) by considering different aspects: the length of news text, the topics of news text, and their



FIGURE 3. An example of news text used in the experiment.

regions (international news, participants may be familiar with Chinese domestic news and we do not include such news). This study collected 30 international news articles (including the keyword information of news text marked by news websites). The length of each news article is about 250 Chinese characters, and all experimental participants have not read these news text in advance to avoid potential bias. The contents of collected news text were all on disasters or events occurred globally to avoid any bias because of emotions from the contents of news text [32]. The font style and colour of key words of news text are only manipulated to investigate their effects on the perceived cognitive load. FIGURE 3 shows an example of news text used in the experiment.

## B. EXPERIMENT SETUP

This paper sets up a user experiment to investigate effects of text font style and text colour of news text on audience's perceived cognitive load. The experimental setup is shown in FIGURE 4. The experimental equipment includes a Lenovo laptop with a 14-inch display screen and a mouse for the system interaction. Each participant independently completed the given experimental tasks in a quiet classroom.

In addition, this paper uses three levels of introduced cognitive load. Before performing the formal task sequence, each participant first performed three training tasks to get familiar with the tasks to be conducted. Therefore, each participant performed a total of 30 tasks, that is, read 30 news articles (3 font styles  $\times$  3 colours  $\times$  3 levels of cognitive load + 3 training tasks = 30). FIGURE 5 shows examples of news text with different font style and text colour settings for keywords.

## C. DATA COLLECTION

This study recruited 20 participants to conduct the experiment. The study was approved by the University Human Ethics Committee. The participants were from a university in China with different majors such as computer science, communication, vision, civil engineering, finance, accounting and

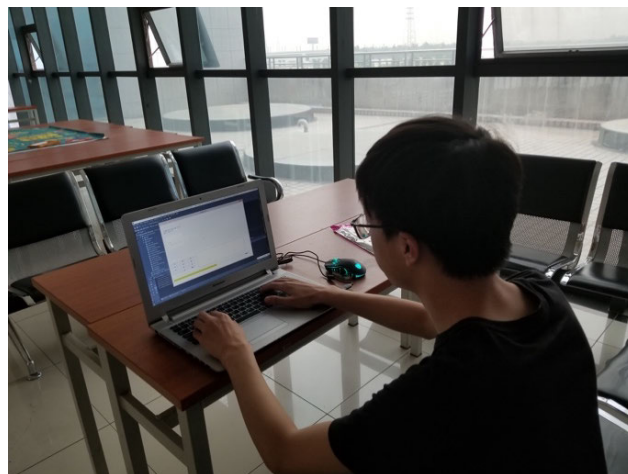
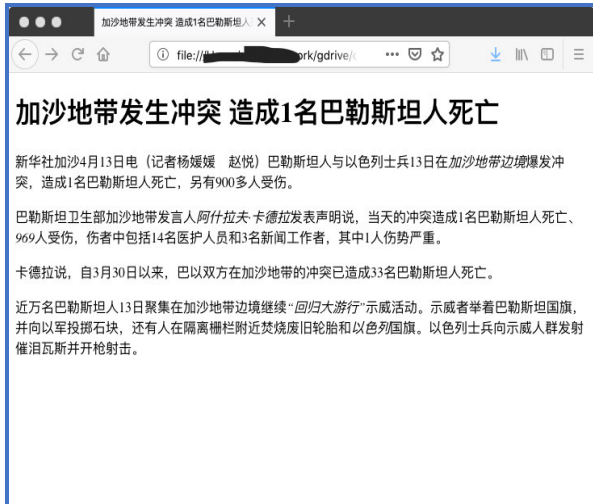


FIGURE 4. Setup of the experiment.

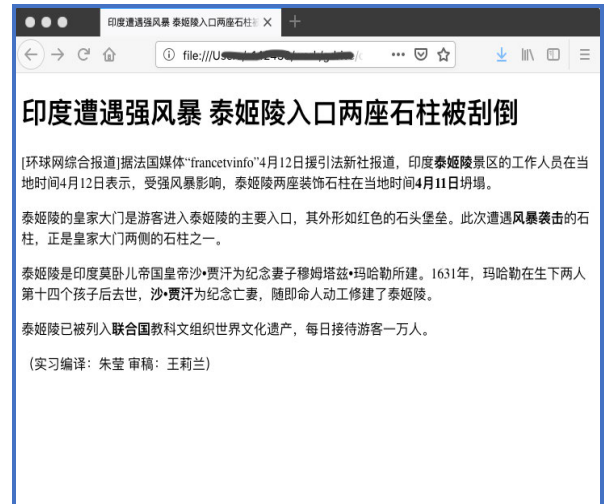
other majors. Among them, 12 were male and 8 were female. The age range was 21-25. The average age was 22.5 years. All participants did not have colour blindness which was surveyed before the experiment. Each participant was asked to firstly conduct 3 training tasks and 27 formal tasks. The order of formal tasks was randomised for each participant to avoid any potential bias. The task content included reading the news article and then answering questions about the news article. After each task was finished, the participant reported the random number memorised and the subjective rating of the perceived cognitive load on the task performed using the Likert scale from 1 to 9 (1: no cognitive load; 9: maximum cognitive load).

## VI. EXPERIMENTAL RESULT ANALYSIS

This section analyses the participants' subjective ratings of perceived cognitive load to find effects of text font styles and font colours on perceived cognitive load during reading the news text. In addition, this paper is only interested in extreme cognitive load conditions (i.e. minimum cognitive load CL1 as low introduced cognitive load and maximum cognitive load CL3 as high introduced cognitive load) that affect participants' reading process, because they are most relevant to the participants' perceived cognitive load of news reading. Therefore, this paper firstly fixes an extreme introduced cognitive load condition (CL1 or CL3) and two-way ANOVA tests are then conducted to examine the effect of font style and colour of news text on perceived cognitive load. Follow-up analyses using one-way ANOVA test and post-hoc test with t-test (with a Bonferroni correction [33] under a significance level set at  $p < .017$ ) are conducted to find pair-wise differences of the perceived cognitive load under different font conditions. The adjusted significance alpha level of .017 was calculated by dividing the original alpha of .05 by 3, based on the fact that we had three font style or colour conditions (font styles: control, italic, and bold; colour: control, blue, and red) to test. The one-way ANOVA test analyses whether there is a difference between the average perceived cognitive load of



(a) Keywords with italic font



(b) Keywords with bold font



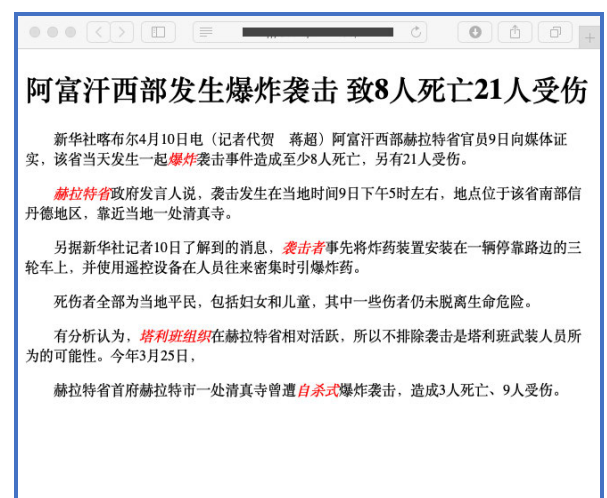
(c) Keywords with blue colour



(d) Keywords with red colour



(e) Keywords with blue colour and bold font



(f) Keywords with red colour and italic font

FIGURE 5. Examples of news text with different font and text colour settings for keywords.

two or more groups, while the t-test analyses the difference between the average perceived cognitive load of two groups.

In order to perform the analyses, we first normalised the collected perceived cognitive load data to minimise

individual differences in rating behaviour. The perceived cognitive load values were normalised with respect to each subject to minimise individual differences in rating behavior using the equation given below:

$$C_i^N = \frac{C_i - C_i^{min}}{C_i^{max} - C_i^{min}}, \quad (1)$$

where  $C_i$  and  $C_i^N$  are the original cognitive load rating and the normalised cognitive load rating respectively from the participant  $i$ ,  $C_i^{min}$  and  $C_i^{max}$  are the minimum and maximum of the ratings respectively from the participant  $i$  in all of his/her tasks.

**A. LOW INTRODUCED COGNITIVE LOAD CONDITION (CL1)**

Under the low introduced cognitive load condition, a two-way ANOVA was conducted that examined the effect of font style and colour of news text on perceived cognitive load. There was a statistically significant interaction between the font style and colour of news text on perceived cognitive load ( $F(4, 57) = 3.3, p = .012$ ). Follow-up analyses were conducted to find effects of font style and colours of news text on perceived cognitive load. TABLE 1 and TABLE 2 show detailed statistically significant differences found among them.

**1) BLUE COLOUR AND DIFFERENT FONT STYLES**

As shown in TABLE 1, under the condition that the introduced cognitive load is low and the colour of given keywords is blue, a one-way ANOVA analysis found that participants showed significant differences in perceived cognitive load when reading news text with different font styles ( $F(2,57) = 4.410, p = .017$ ) (see FIGURE 6). Further post-hoc t-tests found that participants showed a significantly higher perceived cognitive load when reading news text with keywords displayed using bold font style than that Control font was used (that is, the keyword font style is the same as the font style of main body text (Songti)) ( $t = 3.005, p = .005$ ) (see FIGURE 6). This result shows that under the condition of low introduced cognitive load and blue-toned keyword display, the change of keyword font style significantly increased the perceived cognitive load of participants during reading news text in this study as we expected in H1 and H4.

**2) RED COLOUR AND DIFFERENT FONT STYLES**

Under the low introduced cognitive load and red colour of given keywords, a one-way ANOVA analysis found that participants had significant differences in perceived cognitive load when reading news text with different font styles ( $F(2,57) = 3.848, p = .027$ ) (see FIGURE 7). The post-hoc t-tests found that participants showed a significantly lower perceived cognitive load when reading news text with keywords displayed using bold font style than that using Control font ( $t = 2.501, p = .017$ ) (see FIGURE 7). The result shows that under the condition of low introduced cognitive load and red-toned keyword display, the change of keyword font style significantly decreased the perceived cognitive load of

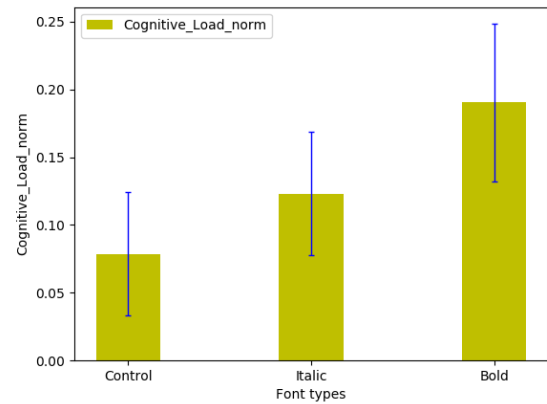


FIGURE 6. Perceived cognitive load analysis (CL1, colour = blue).

participants during reading news text in this study as we expected (H1 and H4).

**3) BOLD FONT AND DIFFERENT COLOURS**

As shown in TABLE 2, under the low introduced cognitive load and bold font style, a one-way ANOVA analysis found that participants had significant differences in per-

TABLE 1. Statistical analysis results of effects of font style given colour of news text on perceived cognitive load under the low introduced cognitive load condition.

Colour	One-way ANOVA		Post-hoc tests			
	F-value	p-value	Font style 1	Font style 2	t-value	p-value
Blue	4.410	.017	Control	Italic	1.265	.214
			Italic	Bold	1.638	.110
			Bold	Control	3.005	.005
Red	3.848	.027	Control	Italic	0.571	.5713
			Italic	Bold	2.226	.032
			Bold	Control	2.501	.017

TABLE 2. Statistical analysis results of effects of colour given font style of news text on perceived cognitive load under the low introduced cognitive load condition.

Font style	One-way ANOVA		Post-hoc tests			
	F-value	p-value	Colour 1	Colour 2	t-value	p-value
Bold	5.145	.009	Control	Blue	0.500	.620
			Blue	Red	3.294	.002
			Red	Control	2.583	.014

ceived cognitive load when reading news text with different colours ( $F(2,57) = 5.145, p = .009$ ) (see FIGURE 8). The further post-hoc t-tests were conducted, and it was found that participants showed a significantly lower perceived cognitive load when reading news text with keywords displayed using red than that using Control colour ( $t = 2.583, p = .014$ ) and that using blue colour ( $t = 3.294, p = .002$ ) respectively (see FIGURE 8). The result shows that under the condition of low introduced cognitive load and bold font keyword display, the change of keyword colour display significantly decreased the perceived cognitive load of participants during reading news text in this study as we expected in H2 and H3.

**B. HIGH INTRODUCED COGNITIVE LOAD CONDITION(CL3)**

Under the high introduced cognitive load condition, a two-way ANOVA was conducted that examined the effect of font style and colour of news text on perceived cognitive load. There was a statistically significant interaction between the font style and colour of news text on perceived cognitive load ( $F(4,57) = 7.007, p < .000$ ). Follow-up analyses were conducted to find effects of font style and colours of news text on perceived cognitive load respectively. TABLE 3 and TABLE 4 show detailed statistically significant differences found among them.

**1) CONTROL COLOUR AND DIFFERENT FONT STYLES**

Under the condition that the introduced cognitive load is high and the colour of the given keywords is Control (that is, the colour of the keywords is the same as the colour of the main body of news texts (black in this study)), a one-way ANOVA analysis found that participants showed significant differences in the perceived cognitive load during reading news text with different font styles ( $F(2,57) = 4.967, p = .010$ ) (see FIGURE 9). Further post-hoc t-tests found that participants had significantly higher perceived cognitive load when the keyword font style was bold than that when the keyword font is Control (Songti in Chinese in this study) ( $t = -3.264, p = .002$ ) (see FIGURE 9). The result shows

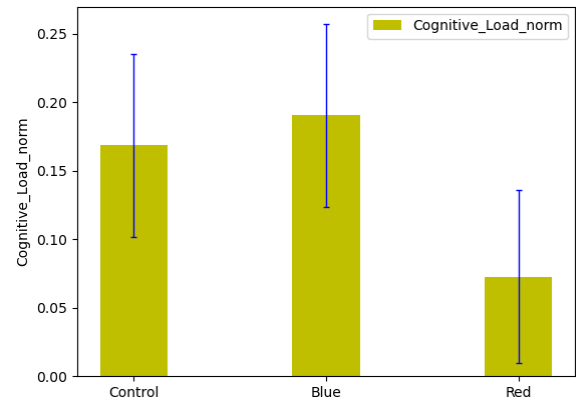


FIGURE 8. Perceived cognitive load analysis(CL1, font = bold).

TABLE 3. Statistical analysis results of effects of font style given colour of news text on perceived cognitive load under the high introduced cognitive load condition.

Colour	One-way ANOVA		Post-hoc tests			
	F-value	p-value	Font style 1	Font style 2	t-value	p-value
Control	4.967	.010	Control	Italic	1.447	.156
			Italic	Bold	1.655	.106
			Bold	Control	3.264	.002
Blue	10.306	.000	Control	Italic	4.453	.000
			Italic	Bold	1.214	.232
			Bold	Control	3.055	.004
Red	4.955	.010	Control	Italic	2.752	.009
			Italic	Bold	2.827	.007
			Bold	Control	0.091	.928

that under the condition of high introduced cognitive load, the change of keyword font style resulted in the significant increase of the perceived cognitive load of participants during reading news text in this study as we expected in H1.

**2) BLUE COLOUR AND DIFFERENT FONT STYLES**

Given that the keyword colour is blue and the introduced cognitive load is high, a one-way ANOVA analysis found that there were significant differences in the perceived cognitive load of participants during reading news text with different font styles ( $F(2,57) = 10.306, p = .000$ ) (see FIGURE 10). Further post-hoc t-tests found that participants showed significant lower perceived cognitive load during reading news text when the keyword font was Control (Songti in Chinese in this study) than that when the keyword font was italic ( $t = 4.453, p = .000$ ) and bold ( $t = 3.055, p = .004$ ) respectively

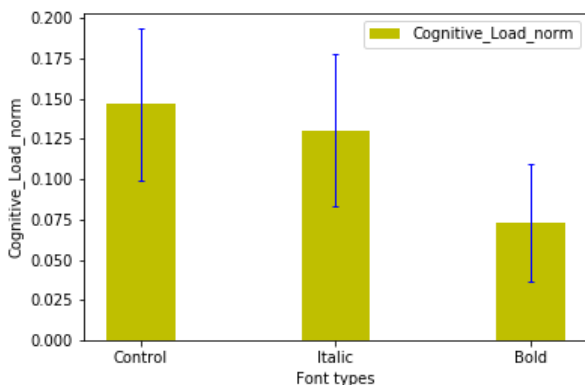


FIGURE 7. Perceived cognitive load analysis(CL1, colour = red).



**TABLE 4.** Statistical analysis results of effects of colour given font style of news text on perceived cognitive load under the high introduced cognitive load condition.

Font style	One-way ANOVA		Post-hoc tests			
	F-value	p-value	Colour 1	Colour 2	t-value	p-value
<b>Italic</b>	16.383	.000	Control	Blue	1.174	.248
			Blue	Red	5.499	.000
			Red	Control	4.088	.000
<b>Bold</b>	3.483	.037	Control	Blue	1.693	.099
			Blue	Red	0.981	.333
			Red	Control	2.622	.013

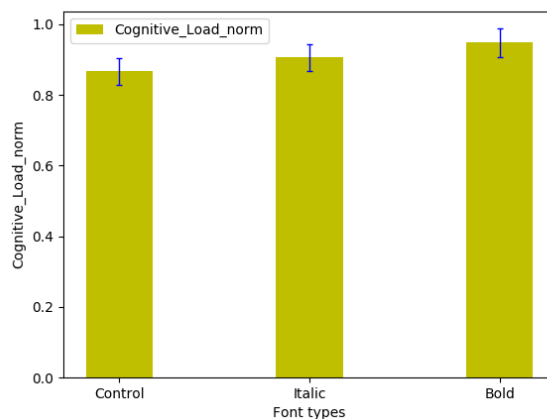
(see FIGURE 10). This result shows that under the conditions of high introduced cognitive load and blue-tone keyword display, the change of keyword font style significantly increased the perceived cognitive load of participants during reading news text in this study as we hypothesized in H1 and H4.

3) RED COLOUR AND DIFFERENT FONT STYLES

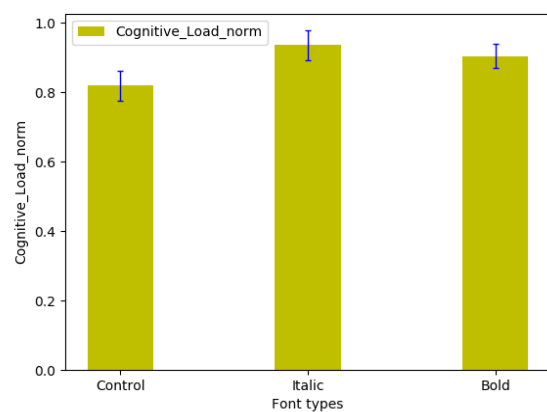
Under the condition that the keyword colour is red and the introduced cognitive load is high, a one-way ANOVA analysis found that there were significant differences in the perceived cognitive load of participants when reading news text with different font styles ( $F(2,57) = 4.955, p = .010$ ) (see FIGURE 11). Further post-hoc t-tests found that participants showed significantly lower perceived cognitive load when the keyword font was italic than both the condition of the keyword font with Control ( $t = 2.752, p = .009$ ) and the keyword with bold ( $t = 2.827, p = .007$ ) respectively (see FIGURE 11). This result shows that under the condition of high introduced cognitive load and red-tone keyword display, the keywords in italic font helped reduce participants' perceived cognitive load during reading news text in this study as expected in H1 and H4.

4) ITALIC FONT AND DIFFERENT COLOURS

As shown in TABLE 4, under the high introduced cognitive load and italic font style, a one-way ANOVA analysis was conducted and it was found that participants had significant differences in perceived cognitive load when reading news text with different colours ( $F(2,57) = 16.383, p = .000$ ) (also see FIGURE 12). The post-hoc analysis with t-tests found that participants showed a significantly lower perceived cognitive load when reading news text with keywords displayed using red than that using Control colour ( $t = 4.088, p = .000$ ) and that using blue colour ( $t = 5.499, p = .000$ ) respectively (see FIGURE 12). The result shows that under the condition of high introduced cognitive load and italic



**FIGURE 9.** Perceived cognitive load analysis (CL3, colour = control).



**FIGURE 10.** Perceived cognitive load analysis (CL3, colour = blue).

font keyword display, the change of keyword colour display significantly decreased the perceived cognitive load of participants during reading news text in this study as expected in H2 and H3.

5) BOLD FONT AND DIFFERENT COLOURS

As shown in TABLE 4, under the high introduced cognitive load and bold font style, a one-way ANOVA analysis found that participants showed significant differences in cognitive load when reading news text with different colours ( $F(2,57) = 3.483, p = .037$ ) (see FIGURE 13). The further post-hoc analysis with t-tests found that participants showed a significantly lower perceived cognitive load when reading news text with keywords displayed using red than that using Control colour ( $t = 2.622, p = .013$ ) (see FIGURE 13). The result shows that under the condition of high introduced cognitive load and bold font keyword display, the change of keyword colour display significantly decreased the perceived cognitive load of participants during reading news text in this study as we hypothesized in H2 and H3.

From the results with different font style and font colour conditions as presented above, it was found that participants had different perceived cognitive load responses under low and high level of introduced cognitive load. This confirms our hypothesis of H5.

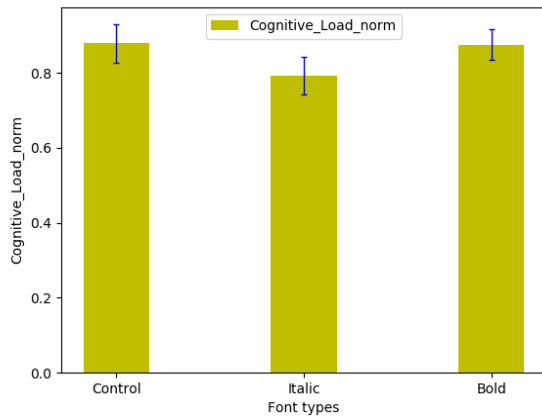


FIGURE 11. Perceived cognitive load analysis (CL3, colour = red).

## VII. DISCUSSION

The findings from this study showed that blue colour and red colour affected participant's perceived cognitive load differently under the low introduced cognitive load condition: blue colour increased participant's perceived cognitive load significantly, while red colour decreased participant's perceived cognitive load significantly when keywords were displayed with the bold font. Under the condition of high introduced cognitive load, when keywords were displayed in blue colour, the change of keyword font style increased the perceived cognitive load of participants during reading news text; and when keywords were displayed in red colour, the italic displayed keywords can significantly reduce the perceived cognitive load of participants when reading news text. Furthermore, under the condition of high introduced cognitive load and italic font keyword display, the change of keyword colour significantly decreased the perceived cognitive load of participants; while under the bold font keyword display, only red colour significantly reduced the perceived cognitive load during reading news text in this study. These findings confirm our hypotheses on how font styles and font colours as well as introduced cognitive load affect user's perceived cognitive load during reading news text. Different from previous studies which focus on the aspects of font size, brightness conditions, text clarity, static or dynamic text display and others that affect the cognitive load or learning effect of users [7]–[10], [22], this study investigated font styles and font colours that are more meaningful for news reading tasks. Such information is also easy to control in the user interface of news text, and therefore can be easily applied in practice.

The proposed experimental design on the cognitive load measurement at least has the following contributions:

- In the news reading research, since the reading performance of audiences is complex to examine directly, this experimental design provides an easy access approach to examine audiences' perceived cognitive load during reading news text.
- In the cognitive load research, this experimental design examines the effects of font style and colour of text on

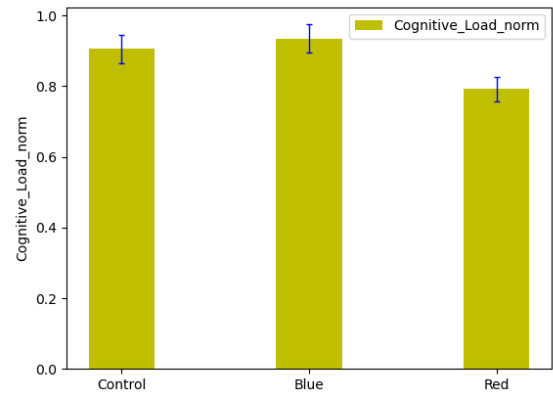


FIGURE 12. Perceived cognitive load analysis (CL3, font = italic).

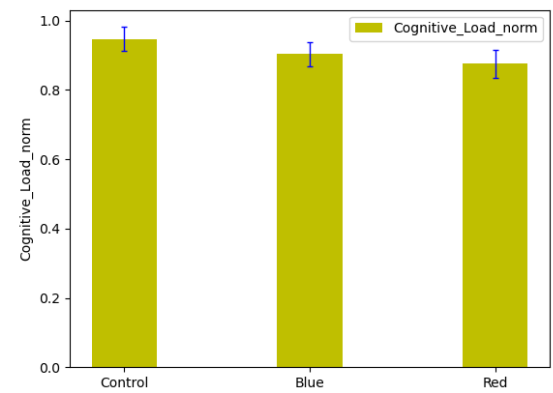


FIGURE 13. Perceived cognitive load analysis (CL3, font = bold).

perceived cognitive load which was not fully investigated in the previous research.

The research of this paper provides effective means and methods for implementing personalised intelligent media interface under the new media era. Based on the findings from this paper, a mechanism can be established to adaptively adjust display methods of keywords to keep low perceived cognitive load of users. For example, under the high introduced cognitive load, if the user shows high perceived cognitive load, the keywords of news text can be displayed with the red colour and italic style to reduce the perceived cognitive load of the user. Such mechanism is integrated into the interface of news media for smart interfaces.

The limitation of this study is that it focused on the investigation of the effects of font style and colour of news text on perceived cognitive load. However, other factors may also affect perceived cognitive load such as ages or even cultural background [8]. This study did not consider these factors and limited the participants from the same cultural background with a small range of ages to avoid any bias, which affects the generalisation of the outcomes from this study. Another limitation is that this study only considered the font style and colour of keywords of news text and did not apply these conditions to full news text, which could be one of our future research on this study. This study only investigated the news text in Chinese. It is also important to study the effects of font

style and colour of news text in other languages on perceived cognitive load, and investigate how the outcomes from this study can be generalised to news text in other languages.

## VIII. CONCLUSION AND FUTURE WORK

Cognitive load is one of the important factors that affect the news audience's reading efficiency and thus influence the news dissemination ability in the era of information explosion. This paper took the perceived cognitive load of news audiences as the research object, and studied the perceived cognitive load of news audiences in different font styles and text colours when reading news text. The experimental results found significant relations between font display methods and perceived cognitive load of users. For example, under the condition of high introduced cognitive load, the use of italics and red colour font of keywords can significantly reduce the perceived cognitive load of users when reading news text and improve news reading efficiency. The research results can be used in the smart media interfaces to realize the automatic adjustment of the news text display mode according to the user's current perceived cognitive load, thereby improving the user's reading efficiency and enhancing the dissemination performance of news.

The future work of this paper will focus on the investigation of effects of factors of news pictures in the news article on perceived cognitive load, such as colour pictures and black-white pictures, the number of pictures, and the location of pictures. We are also interested in how these different text and picture settings affect reading behaviours of news audiences. Furthermore, we are interested in applying the font style and colour conditions to full news text instead of keywords to understand how those conditions affect user's perceived cognitive load, and investigating how to generalise outcomes to news text in other languages. Other font colours will also be investigated to consider special conditions such as colour-blind people in news text reading.

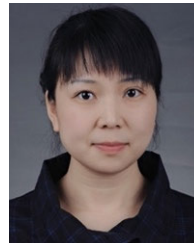
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