The Influence of Typeface and Case on Critical Care Systems Performance (Medical Ventilator)

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Abstract. Usability evaluation is a basic tool for investigating a system's performance in different environments. Many studies found a positive influence of different user interface aesthetics and their organization on usability ratings. These design aspects are one of the most important characteristics of systems usability, and few empirical studies have been examining the importance of typography specifically for safety-critical systems. This study aimed to investigate how different typographic factors, i.e., typeface and fontcase, influence a user's performance in health care safety-critical systems. Different study variables were considered, including task completion time, reflection time, and the total number of touches. To test the study objectives, the Hamilton-c6 ventilator prototype was developed. The experiments were conducted on 15 participants, including male and female physicians, in a controlled environment from different healthcare venues. A well-known technique, one-way ANOVA, was used to assess the data. The results suggest a significant difference between serif (times new roman) and sans serif (Calibri) groups for task completion time; in addition to that, the difference between font-case groups (sentence case, lowercase, and uppercase) was not statistically significant.Moreover, this study investigated the pairwise influence of different typeface and fontcase groups. The results show a significant difference in task completion time. The descriptive analysis of different groups shows that the times new roman with the upper case group has the lowest task completion time while the Calibri with the uppercase groups have the highest task completion time. This study may pave a good research direction to explore the impact of these and other aesthetic factors in multiple contexts.

Keywords: critical systems, usability study, typeface, Font-case.

1. Introduction

The medical industry has multiple healthcare machines that work in a critical environment and have a User Interface (UI) for interaction. Literature has described multiple usability issues in ventilator machines, including poor legibility, contrast, and poor feedback. Due to the extensive utilization of Computer-based medicinal devices in hospitals, monitoring has become a major and significant undertaking for clinicians during treatment. Visual display of physiological data impacts a clinician's reaction to changes in a patient's condition during the administration of anesthesia [1]. In the medical context, the data shows that sorting out and presenting information in an organization that matches the psychological translation made by the clinician should improve the speed and precision of decision-making [2]. Thus, the information display format becomes a significant factor in clinical monitoring and basic decision-making. In the Intensive Care Unit (ICU), there are multiple therapeutic devices: ventilation system, patient monitoring system, syringe pump, arterial blood gas machine, defibrillator, and electrocardiogram (ECG) machine. Most of these medicinal devices have UI alongside related controls and fastens for collaboration with therapeutic clients.

This study was employed on a medical ventilator machine that gives respiratory help to sick patients. Its UI encourages therapeutic clients to control different and enhanced framework parameters during patient care [3]. The UI display crucial information related to critically ill patients. This data incorporates numeric values, icons, options, menus, messages, graphs, tables, or alerts [4] and is hugely significant for correspondence with medical users.

There are different commonly watched ease of use issues with restorative UIs in ICU, for example, poor legibility or difference, absence of formats, right-hand configuration and intelligence, no help in nearby language, poorly distinguished alarms, and poor input about devices state and behavior [5–7]. Such issues may add to therapeutic mistakes. Many patients have been harmed or died only because somebody used the devices incorrectly, misread a number, lost a part, skirted a stage, or neglected a caution [7] when utilizing medicinal devices. The medicinal mistake is a main source of death alongside engine vehicle mishaps, breast cancer, and AIDS [8].

The following are the five sections that make up this paper: Section 2 presents a broad and multi-perspective assessment of the research, emphasizing the significance of typographic attributes. Section 3 covers study methodology, prototype design, data collecting, and dependent and independent variables information. Section 4 contains detailed results of performance-based measures, along with a broader discussion on the results of this study.

2. Literature review

Mechanical ventilation is a vital component of critical care management, and it is widely employed for patient safety. Especially during the COVID period, this use increased tremendously. In the critical care environment, the medical personnel deal with a high workload and instant response needed for multiple tasks, which is the main reason that leads to medical errors [9], and it is recorded that about 67% of medical incidents are because of human error [10]. In this respect, GUI design is a crucial process during software development, as the GUI is the part of the interface that will be in direct contact with the end-user.

The essence of this study was to explore the effect of some typographic attributes in critical care systems. Since the typographic is an exceptionally underlined attribute of the GUI design [11]. Hyunjoo Park investigated the legibility of font faces and line spacing used in actual commercial in-vehicle displays. In their experimentation, they employed the situation of selecting a location for the navigation system and distinguishing correct words among the visually similar words [12]. The study results concede that the secondary task arouses the cognitive workload that negatively affects primary task performance.

The relationship between font family and aesthetics plus readability was also observer [13, 14]. According to the study findings, some serif fonts were better for readability, while sans-serif fonts were better for aesthetics. It was also revealed that the readability is linked to the aesthetics of text elements[13, 14]. Murilo C. Camargo had designed a checklist including (typography, color, shapes, layout, and patterns) to meet the user acceptance and the usability recommendations [11]. Furthermore, considering the older population, Bernard, Michael. et al. explored the difference in legibility, general preference, and reading speed between sans serif and serif fonts at 12-point or 14-point sizes. The font size was reported to have a significant effect on legibility.

Moreover, the study reports that the participants read 12-point serif fonts significantly slower than 14-point serif or sans serif fonts, indicating a marginal interaction for reading time. Furthermore, participants preferred the 14-point font size over the 12-point font size [15]. According to S. Cho and S. Weiss, perceived trustworthiness is one of the most significant characteristics of web content. The study intended to determine if the shape of a typeface will impact how a message is interpreted [16]. The findings suggest that the look and feel of a typeface have no impact on a reader's assessment of a message's trustworthiness but that visual cues can affect subjective confidence in a reader's judgment. Another study investigates the relationship of gender with various typographic attributes while interacting with a gaming prototype. The results revealed major disparities between men and women [17]. More specifically, Jiang Shao et al. have investigated whether personal protective equipment (PPE) impacts legibility. The results of the study concede no significant difference. However, they concludes that a better legibility is possible with a ventilator interface that uses a 20pt Arial font with lowercase letters for information parameters [18].

Conceding the findings of different studies, it can be seen that typographic factors hold major importance in systems usability and along with other design aspects. By reviewing different studies, this study has formulated three hypotheses:

H1: Typeface will affect the users performance (task completion time, reflection time, and the total number of touches) on critical care systems.

H2: Font case will affect the users performance (task completion time, reflection time, and the total number of touches) on critical care systems.

H3: The pairwise groups of typeface and font case will affect the users performance (task completion time, reflection time, and the total number of touches) on critical care systems.

3. Materials and methods

This study is exploratory, as it aims to see how different design artifacts (typeface, font case) affect user performance. Various experiments are used to conduct the study. A prototype of a well-designed medical ventilator was developed to conduct these experiments. Data was collected using the purposive sampling technique. The participants in this study were given various tasks to complete on the developed experimental prototype to determine the differences between various design artifacts. One by one, the experiments were carried out in a controlled environment.

3.1. Experimental device and tool

The experiments were conducted on a 19-inch touchscreen-based all-in-one PC with an Atom processor, 4GB RAM, and an NVIDIA graphics card. We used a HostGator web hosting server to host the web-based application. We simulated the original screen size of the targeted prototype, 17 inches, with the same resolution by padding left and right with the ventilator's body color.

3.1.1. Instructions to Guide the User. Before the experiment, all participants signed a written informed consent form. Since a better understanding of the task would result in better results, instructions were given to the participant before each task on the screen. We measured task completion time, reflection time, and total number of touches in the current study. The task instructions were also presented to each participant in paper format and verbally to avoid the unnecessary memory load. The flow of the prototype is presented in Figure 1.

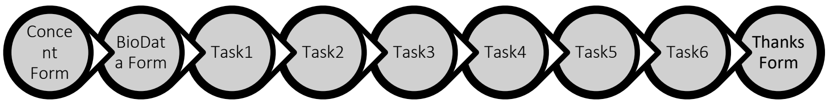

Figure 1. Experimental prototype flow.

3.1.2. Start Ventilation Task. In the first task, the participants were shown the first screen of the Hamilton c6 ventilator and instructed to change the patient's basic information to male and change the height up to five units. They were also required to change the ventilation mode to SIMV and increase the Tidal Volume and Oxygen values by five units. To complete the first task, they must first set up these specifics and press the start ventilation button.

3.1.3. Change ventilation settings task. In the second task, the participants were presented with a ventilator in running mode. They were instructed to update the values of various parameters such as Respiratory Rate, PEEP/CPAP, and Psupport for up to five units. Other than Psupport, the listed two parameters can be changed directly; however, participants must dig down to the hidden controls to handle Psupport.

3.1.4. Change ventilation mode task. The participants are shown a running ventilator in SIMV mode in this task. They must switch from (SIMV) to (PCV+) ventilation mode. Along with this, they must update the Pcontrol and Oxygen up to five units.

3.1.5. Start ventilation task with variation. This task was the variation of the first task where participants have presented with the first screen of the Hamilton c6 ventilator and told to change the patient's basic information to male and change the height up to five units. They were also instructed to change the ventilation mode to SIMV and increase the Respiratory Rate and PEEP/CPAP values to five units. They must first set up these specifics and then press the start ventilation button to complete this task.

3.1.6. Change ventilation settings task with variation. Similarly, this task was the variation of the second task where the participants were presented with a ventilator in running mode. They were instructed to update the values of various parameters such as Tidal Volume, oxygen, and Psupport up to five units. To control the value of the Psupport parameter, the participants have to explore the hidden controls.

3.1.7. Change ventilation mode task with variation. This task was the variation of the third task where participants presented a running ventilator in SIMV mode. They must have to switch from (SIMV) to (PCV+) ventilation mode and update the Respiratory Rate, PEEP/CPAP up to five units.

3.2. Design variations
The main objective of this study was to investigate the impact of typeface (Calibri and times new roman) and font case (Lower case, uppercase, and sentence case) on the performance of safety-critical systems. To achieve the stated study objective, all six possible combinations of typeface and font case were tested on each user with six different task scenarios mentioned above. To overcome the impact of memorizing the interface, different methods were incoprated, including shuffling and reversing of different design variations and incorporating results of different participants or different task activities.

3.3. Measure of study
The primary purpose of this study was to concede the performance measures. The study measures were carried out through the experimental environment using different task-related measures.To measure the performance, task completion time, reflection time, and the number of touches were considered as independent variables. The details are given in Table 1. However, different font case and some typefaces were conciderd as dependent variables are listed in Table 2 and Table 3.

3.4. Data collection and analysis
Fifteen physicians were targeted to perform experiments in a controlled environment for the data collection. The demographic distribution of the participants was as out of 15, five were females, and 10 were males, and their ages ranged from 24 to 32 years. Each participant has to perform all listed six tasks in a sequence. However, the sequence of pairwise design variants was changed after 2 to 3 participants. Eventually, to obtain precise results, the IBM SPSS Statistics 22 tool and its well-known technique One Way ANOVA (Analysis of Variance) and descriptive statistics were used.

Table 3. Independent variables of the study.

Variable	Description
Task Completion Time	Time to complete a task.
Reflection Time	Time to respond or proceed with a task after presenting the task screen and clear task details.
Number of Touches	Number of screen touches.

Table 2. Dependent variables of the study.

Variable	Label	Group
Font Case	1	Sentence Case
	2	Upper Case
	3	Lower Case
Typeface	1	Calibri
	2	Times New Roman

Table 1. Dependent variables of the study Pairwise.

Variable	Label
Calibri*Sentence Case	1
Calibri*Upper Case	2
Calibri*Lower Case	3
Times new Roman* Sentence Case	4
Times new Roman* Upper Case	5
Times new Roman* Lower Case	6

4. Results and discussion

4.1. Analysis of difference between different pairwise groups

The result of ANOVA on data of task completion time, reflection time, and the total number of touches between pairwise groups (font case and typeface) revealed that the significance value of task completion time is 0.042, which is below 0.05; therefore, there is a statistically significant difference in task completion time. However, the significance value of reaction time and the total number of touches is above 0.05, so there is no significant difference in reaction time and the total number of touches within pairwise groups. However, the detailed analysis of descriptive statistics within pairwise groups reveals that the task completion time of (times new roman & upper case) group is slightly lower than the average. In contrast, the (Calibri & upper case) group completion time is slightly higher. In addition to that, the reflection time was recorded as slightly higher in (Calibri & lower case) group.

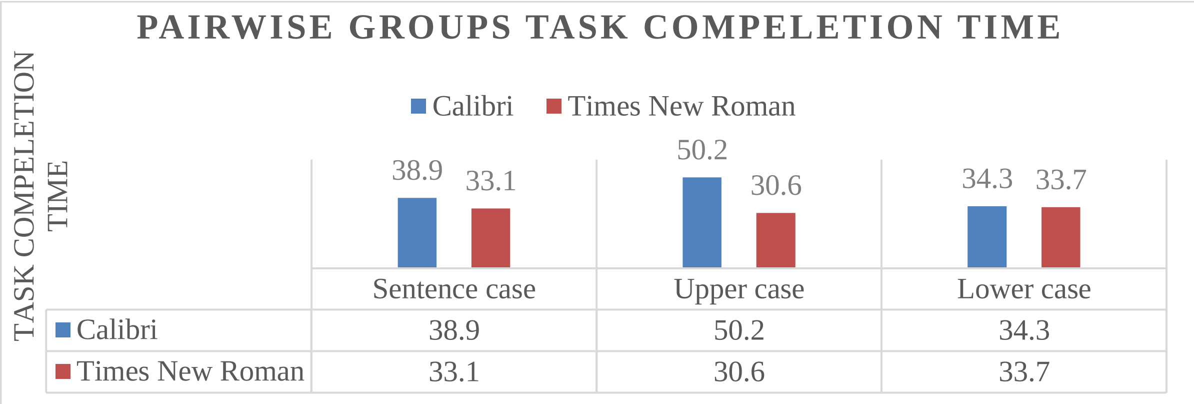

Figure 2. Task completion time of pairwise groups.

In contrast, the reflection time is slightly lower in (times new roman & lower case) group. Group results were slightly better in terms of accuracy or the total number of touches (Calibri & times new roman with lowercase). The detailed results of task completion time within pairwise groups are presented in Figure 2.

Table 4. Results of ANOVA on pairwise groups.

		Mean Square	F	Sig.
Task completion time	Between Groups	753306589.804	2.419	.042
	Within Groups	311365340.938		
Task response time	Between Groups	4324145.724	.643	.667
	Within Groups	6724366.889		
Total task touches	Between Groups	18.011	.741	.595
	Within Groups	24.302		

4.2. Analysis of difference between different font case groups

Similarly, the result of ANOVA on data of task completion time, reflection time, and the total number of touches between font case groups (sentence case, upper case, and lower case) revealed that the significance value of task completion time, reflection time, and total no. of touches is above 0.05, so there is no significant difference in task completion time, reflection time, and total no. of touches within font case groups. However, the detailed analysis of descriptive statistics reveals that the task completion time of the lowercase group is slightly lower than average. In contrast, it is recorded slightly higher for the uppercase group. Regarding reflection time, the results of the uppercase group are slightly better, and conversely, in terms of accuracy, lowercase group results are slightly better.

Table 5. Results of ANOVA on font case groups.

		Mean Square	F	Sig.
Task completion time	Between Groups	322460693.911	.958	.388
	Within Groups	336509197.701		
Task response time	Between Groups	2008546.944	.300	.742
	Within Groups	6694832.798		
Total task touches	Between Groups	41.644	1.769	.177
	Within Groups	23.541		

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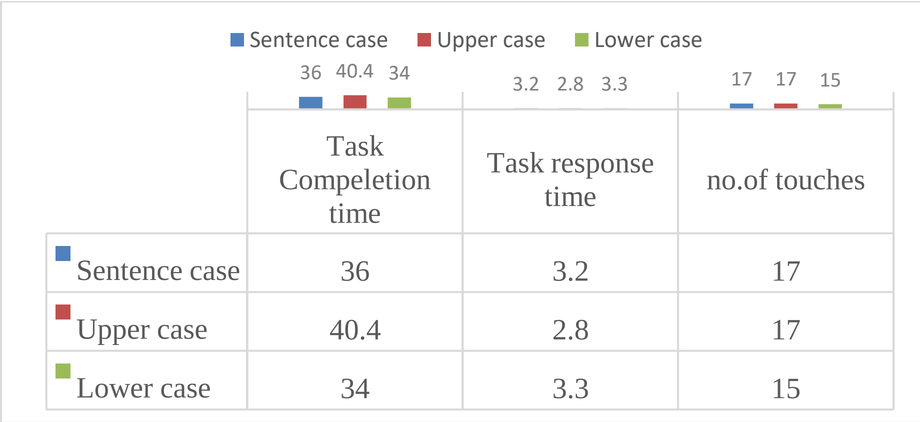

Figure 3. Results of different font-case groups.

4.3. Analysis of difference between different typeface groups

The result of ANOVA on data of task completion time, reflection time, and the total number of touches between typeface groups (Calibri and Times new roman) revealed that the significance value of task completion time is 0.025, which is below 0.05; therefore, there is a statistically significant difference in task completion time. However, the significance value of reflection time and the total number of touches is above 0.05, so there is no significant difference in reflection time and total no. of touches within typeface groups. However, the detailed analysis of descriptive statistics reveals that the task completion time of the san serif (Calibri) group is significantly higher than the serif (times new roman) group. Moreover, the reflection time of the serif (times new roman) group was recorded as slightly lower than the san-serif (Calibri) group. The detailed results are given blow.

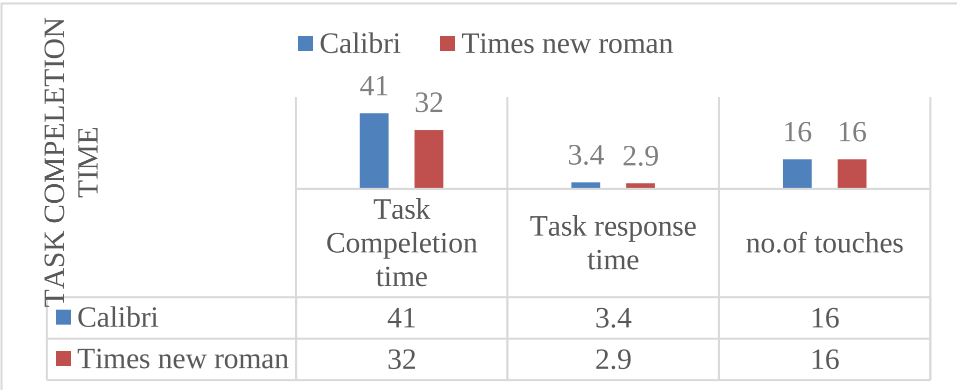

Figure 4. Results of different typeface groups.

Table 6. Results of ANOVA on typeface groups.

		Mean Square	F	Sig.
Task completion time	Between Groups	1677284010.000	5.226	.025
	Within Groups	320953836.112		
Task response time	Between Groups	5883912.711	.892	.348
	Within Groups	6597541.302		
Total task touches	Between Groups	.100	.004	.949
	Within Groups	24.219		

4.4. Discussion

Concerning systems usability, aesthetics play a vital role in GUI design. Text elements are one of the key components in any graphical interface. The different typographic features of text elements such as (font size, font case, line height, line spacing, letter spacing, and word spacing) are important to determine aesthetics and legibility. The primary purpose of this study was to explore the influence of legibility or different typographic attributes (typeface, font-case) on the performance (task completion time, reflection time, and the total number of touches) of safety-critical systems. Explicitly legibility means how the characters are easily read in terms of typography features [19]. The typographic factors highly influence legibility. The current study's findings explored the significant difference in task completion time on safety-critical machines between serif (times new roman) and san serif (Calibri) groups. The participant's performance was significantly better on the interface with serif (times new roman) typography.

Additionally, this difference was also recorded as significant in font-case and typeface pairwise groups. Furthermore, the detailed analysis of descriptive statistics within pairwise groups reveals that the task completion time of (times new roman & upper case) group is slightly lower than average. In contrast, the (Calibri & upper case) group completion time is slightly higher. In addition to that, the reflection time was recorded as slightly higher in (Calibri & lower case) group. In contrast, the reflection time is slightly lower in (times new roman & lower case) group.

Regarding the accuracy of the total number of touches, the results of (Calibri & times new roman with lowercase) groups were slightly better. Likewise, the task completion time of the san serif (Calibri) group is significantly higher than the serif (times new roman) group, and the reflection time of the serif (times new roman) group was recorded as slightly lower than san-serif (Calibri) group. In addition to that, the task completion time of the lowercase group is slightly lower than average, in contrast, and it is recorded as slightly higher for an uppercase group. Regarding reflection time, the results of the uppercase group are slightly better, and conversely, in terms of accuracy, lowercase group results are slightly better.

Over time researchers agreed and countered one another's findings, although most prior research has demonstrated that font choice and features affect the participants' preferences [20–22]. Conversely, the authors of this study [23] contradict. Font choice has been observed to affect the reading speed in some studies [20, 21], though some have not [22, 24–26]. Prior research on the relationship between font size and reading speed is also divided, where's, some studies indicate that font size does affect reading speed [20, 24], while others do not [23, 25]. When comparing diverse typographic parameters, even Boyarski et al. influential work revealed mixed findings [26]. Several other studies [27, 28] also highlighted the role of typography in online context. These differences might be cited for several reasons, including constantly changing font selection libraries, device variants, demography, and modern digitization. We feel that these disparities do not falsify any research findings; instead, they emphasize the challenges of understanding digital readability. These findings highlights that reading experiences should be customized to assist diverse readers.

5. Conclusion

This study inspected the influence of different typographic factors, including typeface and font case, on safety-critical systems usage. The study's focus was to check whether there is a statistical difference between task completion time, reflection time, and no. of touches w.r.t. typeface, font case, or their pairwise groups specifically in a critical care systems context. The results revealed significant differences between serif (times new roman) and sans serif (Calibri) groups for task completion time; in addition to that, the difference between font-case groups (sentence case, lowercase, and uppercase) was not statistically significant. Although the results of the lowercase group were slightly better in terms of task completion time and accuracy, in terms of reflection time, the upper case group results were recorded slightly better. This study also investigated the pairwise influence of different typeface and font case groups. The results show a significant difference in task completion time. The descriptive statistics of different groups show that the times new roman with upper case typography have the lowest task completion time while the Calibri and uppercase groups have the highest task completion time. In addition to that, the reflection time was recorded slightly higher in (Calibri & lower case) group. In contrast, the reflection time is slightly lower in (times new roman & lower case) group. Group results were slightly better in terms of accuracy or the total number of touches (Calibri & times new roman with lowercase). The findings of this study highlight the importance and complexity of typography in critical machines interface design.

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