Enhancing Web Usability: Exploiting interactional properties of web interfaces with vocabulary and comprehension learning in non-native English speakers

Muhammad Adrees[1], Dr Nadeem Ahmad[2], Alessia Amelio[3], Khawaja Ali Qadeer[4]

[1]Assistant Professor, Department of CS & IT, The University of Lahore, Pakistan
[2]Assistant Professor, Head of CS & IT Dept, Superior University of Pakistan
[3]Ph.D. research fellow & contract professor University of Calabria, Italy
[4]Lecturer, Department of CS & IT, The University of Lahore, Pakistan

Abstract
The objectives of this study are to reduce the gulf between contextual meanings of words, split attention, cognitive load and improve the performance with immediate access to required information to users. An English article consisting of 810 words with 16 highlighted keywords (presumably difficult words) is presented to non-native English speakers to evaluate the usability of four differently designed interfaces in perspective of vocabulary and comprehension learning. The highlighted words in experimental interfaces have embodied with a pair of synonyms, a pair of antonyms and mix pair (synonym and an antonym) to achieve the study objectives.
160 subjects are randomly divided into four different groups to complete both tasks (vocabulary acquisition and comprehension learning) by using the proposed interfaces. Statistically, one of our experiments has improved more than 25 percent in vocabulary acquisition in 40 percent less time as compared to control group.
Statistical analysis of the System Usability Scale indicates that users average subjective usability score boosted from 56 to 70 using experimental interfaces. In our experiments, users of our proposed interfaces acquire significantly more information than users make in the control group. The results indicate that our techniques deliver better performance by enhancing user's vocabulary acquisition (low-level processing) in less time.

Key words:
User interfaces, Human-computer interaction, Usability, Partial attention, Cognitive load, Interaction techniques.

1. Introduction

Nowadays, users require immediate access to information at any place as digital reading is a natural development due to information on demand. Users consider as a challenge to understand the text provided on webpages, e-papers, e-documents, in particular bilingual /non-native English readers.
Several experiments have been done to achieve an effective reading while measuring many parameters such as performance, time, cognitive load and attention etc. One of the obstacles faced by a reader is to understand the contextual meaning of the word while reading [1].
In order to minimize the gulf between the context of composition and context of interpretation, we are providing immediate access to required contextual information in our designed interfaces. The user who cannot understand online information requires assistance to compensate his/her limitations [2].
It is also found in the previous study that the distraction is caused by lack of attention or continuous partial attention or split attention, which is one of the major obstacles in reading comprehension for the user [3]. So in order to compensate user's limitation, we wish to provide ancillary information to the user by reducing split attention and exploiting the intrinsic interactional properties of an electronic paper as compared to affordances offered by a tangible paper. We wish to pass on additional information through ancillary embedded words in various forms without intentionally distracting the user from his or her primary focus on the understanding of the text.
Sweller (1988), introduced cognitive load theory which distinguished between intrinsic and extraneous cognitive load [4]. Intrinsic load is directly related to the level of difficulty of content understudy while the extraneous cognitive load is any cognitive activity engaged in order to present any task in an organized an presentable way, which is not necessary to attain relevant goals [5]. For better learning, we can change the instructional materials by managing intrinsic and extraneous cognitive load for users particularly by decreasing extraneous cognitive load [6]. Since, the cognitive load has been identified as a major factor while designing instructional designs in different learning fields such as science [7], language [8] and technical training [9]. We also tried to reduce this factor in our experiments by different techniques in our interactional designs.
Norman introduced affordance in human-computer interaction [10][11], so in order to have an effective reading experience, we have to exploit affordances offered

Manuscript received October 5, 2018
Manuscript revised October 20, 2018

by e-documents in our study. In the previous research, it was found that the technology adopted for the users must adequate to the skills of users in order to exploit their potential [12]. As our users are non-native English speakers, we designed four different interaction designs to exploit their potential skills which have the almost same level of English reading skills. Reading is influenced by goals and motivation of reader, our techniques are created for learning and leisure purposes [10].

Scenario:
Consider a reader who reads a sentence in the text "Kate accepted the invitation with alacrity", if the reader does not know the exact meaning of word "alacrity", the reader may take "alacrity" as negative response from the subject (Kate) discussed here and may understand the sentence as Kate accepted the invitation with no interest. But once the reader knows the exact meaning of "alacrity" as eagerness then the reader actually understands the sentence as Kate accepted the invitation with interest.
The purpose of the study is to evaluate the usability of different user interfaces from the Bilingual/non-native English readers' perspective regarding English reading tasks.

2. Experimental Hypothesis

Null Hypothesis (H0)

Subjects of all groups have equal performance in vocabulary acquisition and comprehension learning regardless of interface style being used.

Hypothesis 1(H1)

Subjects are more likely to learn the vocabulary acquisition and comprehension learning when they are exposed to one of the experimental designed interfaces than the traditional interface.

Hypothesis 2 (H2)

If an interface style provides better vocabulary learning environment then subjects are more likely to learn the comprehension as well.

Hypothesis 3 (H3)

Subjects are more likely to enhance their vocabulary acquisition when they are exposed to the MixPair interface as this interface produces more retrieval cues.

3. Related work

In the previous study, the impact of fluid documents on reading was observed. The design of dynamic reading environments was required to use plugin or special browser to conduct the study. The fluid documents integrated ancillary annotated information into the electronic document by adjusting typography using different techniques [13]. Glosses were provided for link anchors to support hypertext browsing. The subjective questionnaires were asked which revealed the fact that the subjects required less time to use nearby glosses for link anchors provided in the text to see the effects. In general, hypertext can be used to provide more details than can fit typographically on a page but locating details elsewhere requires users to navigate while reading, which makes it more cognitively difficult to compare the information with the source document [14]. In this study, subjects were found to be sensitive to some glosses. It was observed that glosses must be processed quickly to perform typographic adjustment and should be close periphery to source anchors. If quick processing is not possible, typographic adjustment (Glosses) should put outside the primary text which can reduce negative reactions from users.
Eric Bahna and Robert J.K. Jacob performed an experiment whose result shows that their technique conveys additional information to users which help them to comprehend the text better while reading. This experiment required additional hardware like a projector and specially designed software. In this interactive display technique [15], users were provided peripheral vision to converse additional information to a user engaged in a reading task without distracting the users' primary focus. They wished to convey the additional information through peripheral images without distracting the user from his primary focus of reading the text. The techniques used to convey additional information in this study were based on lightweight, non-command, user interaction in the background [15]. In order to avoid distraction, small amount of contextual information in the background was provided, as required by the user, without using up screen space that was normally devoted to the main text.
Experimental group's subjects answered significantly more pictures (which are provided as peripheral vision) questions as compared to control group's subjects. Regarding subjective usability of the system, the subjects in the experimental group reported significantly less fatigue and greater enjoyment as compared to control group [15].
In another study [16], it was examined how multiple representations of information in second-language (German) learning helped and hindered the users. The English speaking subjects (152) received no annotation, verbal annotation, visual annotation or both to read a story of 762 German words with 35 keywords presented by a

multimedia computer program. It was observed that the recall of vocabulary words was the same for different types (low verbal, low spatial, high verbal, high spatial) of users when they received only verbal annotation. The recall of vocabulary words was better for high verbal and high spatial users when they received only visual annotation than low verbal and low spatial users. The text comprehension was worst for all users when they received visual annotation.

These results are consistent with the generative theory of multimedia learning with cognitive load theory which assumes that the processes are executed under the constraints of limited working memory. According to the generative theory of multimedia, the learner constructs text base and image base from relevant verbal information and visual information respectively.

In another study with 103 subjects [17], it was found that recall of individual vocabulary items was the best when users adopted both visual and verbal annotation, the result was moderate when users adopted only one type of annotation and worst when users adopted neither verbal nor visual annotation. The result of study [17] supports the Paivio's [18][6] dual coding theory which proved that users establish two types of retrieval cues for word in memory by a connection between the corresponding picture/video and word in the foreign language. Since the capacity of working memory is limited, the process of integrating the verbal and visual representation requires cognitive resources [19][20]. It is seen from experiments that ability to code a stimulus in two different ways increases the chances of remembering than the stimulus coded in one way but verbal annotations impose less cognitive load than visual annotations [16].

In another study [21], the cognitive load was explored with effects of split attention and redundancy in reading with explanatory notes on the different level of the readers. It was found that 5th-grade first language learners and 8th-grade low ability second language learners enhanced their comprehension and reduced their vocabulary learning when vocabulary definitions integrated within a passage(integrated format) compared to separate vocabulary list(separated format). The results were contrary when first language adult readers and 8th-grade high ability second language learners undergone through the same experimental scenario.

In similar experiments, McNamara presented biology instructional material [22] to high school subjects and found that additional material enhanced the learning for low-knowledge readers but high-knowledge readers performed better after reading original material. In this study [22], the cognitive load was not clearly defined and interpretation of results was also weak due to redundancy. The reduced text enabled more knowledgeable readers to process it more sharply which was a major factor behind the improved performance.

4. Reading Processes and Standards

In the interface design, perception and processing of text are very important which essentially required some textual display. There are several stages in a reading process, broadly, we can classify it into three stages.

In the first stage, the visual pattern of the word on the page is perceived. Decoding is the second process with reference to an internal representation of language studied while syntactic and semantic analysis is performed in the third stage by a user for further processing [23]. During the interface design, we mostly concerned with the first two stages.

Visual fixation is maintaining of visual gaze on single location which results in perception. During reading, the eyes make rapid jumping movements called saccades, three times in a second followed by fixations [24]. The eyes move back and forth over the text, known as regressions. The rate of regression is directly proportional to the complexity of the studied text [23].

Experiments have shown that words are recognized as quickly as a single character rather than scanned serially or character by character. It is seen that users recognized familiar words using their shape. It means that changing or removing the word shape is detrimental to reading speed and accuracy (for example, by capitalizing words) [25].

Similarly, the line length between 2.3 and 5.2 inches (58 and 132 mm) is equally legible. Standard font sizes ranging from 9 to 12 points are equally legible by providing proportional spacing between lines [23].

There is evidence that reading from a computer screen is slower than from a book [26]. There is a number of factors which are considered for slow reading from the screen: a longer line length, fewer words to a page, orientation and the familiarity of the medium of the page. By reducing these factors the design of textual interfaces can be improved [23].

Contrast plays a vital role in a visual display where higher luminesce is achieved through negative contrast (dark characters on a light screen), then positive contrast which increased the acuity (sharpness) which in turn increase the legibility. Experimental evidence suggests that negative contrast displays are preferred and result in more accurate performance [27].

5. Method

5.1 Subjects

For study purpose, 160 (136 males and 24 females) non-native English speakers but fluent in English reading voluntarily participated in our activity. All subjects were divided into four equal groups. Forty subjects were assigned to each group. All volunteers were undergraduate

students in computer science degree program having ages from 20 to 25 years. They have already acquired 12 years of education in which the medium of instruction was English.
Subjects were in a real learning environment in the class Lab setting. They were asked to learn from materials which are explained in section 5.3. They all were assigned temporary Id numbers so they did not need to disclose their names to keep their privacy.
The experimental studies were conducted in two parts. All volunteers took the same vocabulary and comprehension tests. First, they went through a vocabulary test, then a comprehension test, after a break of 30 minutes.

5.2 Experimental Design and Implementation

All the subjects were shown the same text to ensure the same basic complexity level and the experiment was conducted between-subjects. The additional respective embedded text was provided in all experimental interfaces. All interfaces designed for the experiment followed the reading text standards mentioned in Section 3and provided uniformity among all interfaces. For example, the standard font size was 12pt, text line length was 5.2 inches and negative contrast was used for a better reading experience.

5.3 Materials and Apparatus

For the experiments, an article titled "Life without Death" written by Duncan Turner from British magazine spectator's archive (Online) was presented to users containing 810 words.
The apparatus for presenting the reading text material to subjects consisted of a 40-station computer lab having Windows 10, equipped with 17-inches LCD screens. Figure 1, shows the interface provided to group B in which user is provided in-text help by showing a pair of synonyms in a tooltip.

5.4 Procedure

Each group was given a brief relevant demonstration of the experiment on a large screen through projector before starting the actual activity. The material shown in a demonstration to each group was different from the material presented to subjects in the experiment to avoid pre-learning factor. The demonstration text passage was short containing only 100 words with five highlighted words.
A pattern of vocabulary acquisition and comprehension questions was shown to all subjects based on demonstration material.
There were 40 subjects in each group and each group has been assigned a name in alphabetical order i.e. Group A, Group B, Group C and Group D. Group A is a control group while the rest of the groups are experimental in their nature. The maximum time given for comprehension learning and vocabulary acquisition was 20 and 30 minutes respectively but they were allowed to submit the test sheet whenever they finished the test. The pre-attempt reading time, the time taken to complete the comprehension and vocabulary acquisition was monitored and noted carefully against each participant for experimental analysis.
Regarding the subjective usability of the provided text, all groups were asked to fill the after-experiment questionnaire to measure the satisfaction level, cognitive load, and their experiences.
On the first day, only two groups were called for the experiments at different timings. Each participant was provided the material and apparatus as mentioned before.
On the second day, two more groups were called for the experiment at different timings following the same procedure.

6. Experimentation

6.1 Traditional Interface

Group “A” which is the control group was provided the traditional interface which had a text passage with 16 highlighted words in blue color. In order to know the meaning of highlighted words, subjects could look for the meaning of words from the Internet to understand the text. It was found that the users frequently searched the words to know the meanings of highlighted words. While looking for the information, the reader moved from age of information to age of interruption [3]. Reader navigated different pages and came back to comprehend the text again. By moving back and forth, the reader suffered the extraneous cognitive load, distraction due to split attention and presumably consumed more time. This method interrupted the reader's primary task and precisely overburdened the cognitive load of the user [9]. We observed that the traditional interface is an inherently multi-step approach to find the meaning of a particular word.
The Figure 1, shows the flow diagram taken by traditional-interface-subjects which is an inherently multi-step approach to find the meaning of the particular word [Right side flow]. Experimental-interface-subjects follow a one-step approach [Left side flow]. The subjects belonging to any group bypass the both multi-step and one step approaches while comprehending the text if they already have the meaning of a highlighted word in their long-term memory (LTM).

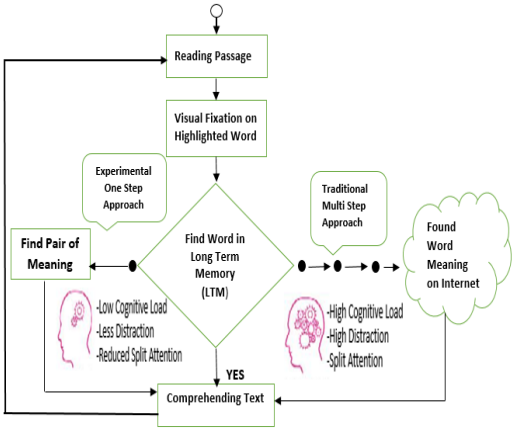

Fig. 1 Diagram illustrating the Multi-step (Right side flow) and Single-step (Left side flow) approaches followed by users of the control group and experimental groups respectively.

6.2 Designing Experimental Interfaces

The newly designed interfaces such as interface 2 (Synonyms Pair), interface 3 (Anonyms Pair), Interface 4 (Mix Pair) having 16 highlighted words were provided to subjects of experimental Groups B, C, and D respectively. The subjects of these groups can move their mouse over highlighted words and get the relevant pair of synonyms/antonyms/Mix Pair as a tooltip. The provided pair of words may help users in better understanding of the text.
The Figure 2 shows the single-step approach followed by the users of experimental groups.

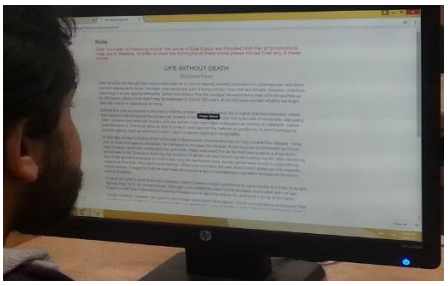

Fig. 2 A user from Group B is moving his mouse over the highlighted word and gets a pair of synonyms as a tooltip to better understand the text.

The users of these groups were not allowed to use the Internet to get the meanings of words. Truly, in order to reduce the gulf between the context of composition and context of interpretation these experimental interactional designs can be used to reduce the cognitive load in the learning process. Instead of suffering from distraction by moving back and forth in the search of information, a pair of words is provided inline within the text merely using extra space for a short period of time.

7. Results

There is one independent variable which is an interface style for each group and three dependent variables are measured by using ANOVA tests such as vocabulary acquisition (shallow learning), comprehension learning (deep learning) and time is taken by each group for tasks completion.
Subjects of each group were given two written memory tests, the first test for vocabulary acquisition, contains a total of 40 questions. Ten questions, each was related to recalling synonyms and antonyms of the word (a word highlighted in blue color provided with blank space to write the meaning of the word) while other ten questions were related to cross-matching of synonyms and antonyms respectively.
The second test for comprehension learning contained 15 questions, in which subjects had to comprehend the questions and answer in agree/disagree format.
Evaluation of Research Questions:

7.1 Evaluation of H_0 and H_1

In order to evaluate the H_1, first, we tested the Null Hypothesis (H_0) that says that the all groups have equal performance in vocabulary acquisition and comprehension learning regardless of interface style being used. The results of ANOVA test are discussed below in detail.

7.1.1 Vocabulary Acquisition (Shallow Learning)

In the usability evaluation experiments, we measured the performance as the number of correctly answered questions by each group for vocabulary acquisition. We calculated the mean (M) and standard deviation (SD) of Group A(M= 27.95, SD=6.41), Group B(M= 35.02, SD=4.31), Group C(M=31.20,SD=7.94) and Group D(M=38.6,SD=4.53). We got p-value(0.00) < p-value(0.05) which shows that performance is significant among groups due to change of interface styles.
Figure 3, shows the average marks of vocabulary understanding in all four groups. From the Figure 3, it is evident that overall Group D on average is better compared to all other three groups and got 38 marks out of 40 (96.5%). The average score of Group C is 8% improved than control group A. The average score of Group B (87%) is better than Group C (78%) which indicated that end users were able to understand synonym pairs better than antonym pairs.

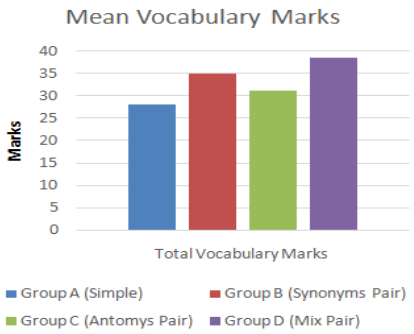

Fig. 3 Comparison among all Groups in average marks obtained during vocabulary acquisition

We can conclude that MixPair Interface style is most helpful to users in vocabulary acquisition than any other experimental group and control group.

Figure 4, shows the mean time taken by all groups in vocabulary acquisition. The subjects of Group B, C, and D took 26 %, 32 % and 42 % less time than Group A respectively. Figure 4, exhibits that Group A took the maximum time using Traditional Interface while Group D using MixPair Interface took the minimum time.

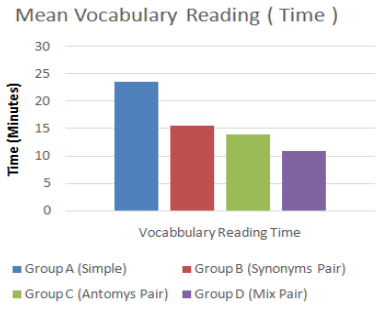

Fig. 4 Comparison among all Groups in average time consumed during vocabulary acquisition

We got a p-value (0.001) < p-value (0.05) which shows the significance of interface styles on vocabulary acquisition. The groups results of A, B, C and D are A(M=23.55, SD=6.93), B(M=15.6, SD=3.14), C(M=14.0, SD=2.65) and D(M= 10.95, SD=2.25) respectively.

We can conclude from vocabulary acquisition test that the Mix Pair Interface provided far better results in vocabulary acquisition in minimum time.

Comprehension Learning (Deep Learning):

We measured the performance (Number of correctly answered questions) of all groups for comprehension learning. We found interface styles do not make a significant difference in comprehension learning as p-value=0.985 is greater than the significance level (0.05).

The trivial mean difference is found as the results of Group A (M=9, SD=2.36), Group B (M=8.75, SD=1.91), Group C (M=8.85, SD=2.71) and Group D (M=8.75, SD=2.4).

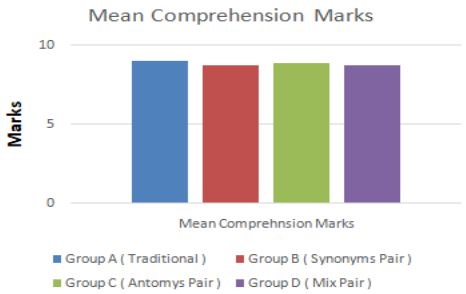

Fig. 5 Comparison among all Groups in average correct answers during comprehension learning

Figure 5, shows that the interface style do not have a significant effect on comprehension learning experimental groups or control group.

During comprehension learning, the p-value= 0.001 of the meantime taken by Group A (M=8.25, SD=2.75), Group B (M=10.1, SD=3.69), Group C (M=8.3, SD=3.11) and Group D (M=12.4, SD= 4.28) is less than the significance value (0.05) which shows that interface style also makes a significant effect over time consumed by all groups.

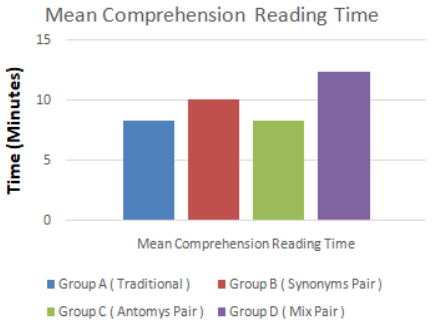

Fig. 6 Comparison among all Groups in average time consumed during comprehension learning

Figure 6, shows that the mean time taken to attempt the comprehension test by subjects of Group A(Traditional Interface) and Group C(Antonyms Pair) is almost same. The subjects of group D (MixPair Interface) and group B (Synonym Pair) took 20 % and 9 % more time than Group A respectively.

In short, regarding the vocabulary acquisition, we reject the null hypothesis (H0) as we observe that all groups (A, B, C, D) have different results, it means that the interface style, indeed has a considerable effect on vocabulary acquisition. In average, Group D (MixPair Interface) got more than 25% marks (38) in 40 % less time by Group A (23 min).

But, regarding the comprehension learning, we accept the null hypothesis as we observe that all groups have the almost same result, it means the style of interface does not have any considerable effect on comprehension learning of all groups. But the time taken by Group D is slightly higher (which was given as Mix Pair interface style) than other Groups in our study.

Conclusion H_0, H_1
Subjects are more likely to learn the vocabulary when they are exposed to one of the experimental designed interfaces than the control group. But no improvement was seen in comprehension learning when they exposed to one of the experimental designed interfaces.

7.2 Evaluation of H_2

As we know, The Group A(Traditional), B(Synonym Pair), C(Antonym Pair) and D(Mix Pair) have 69.87 %, 85.62 %,78 %,96.5 % marks respectively in vocabulary acquisition with p-value (0.00) which is less than the significance p-value (0.05). It shows that there is indeed statistical difference among the Groups in vocabulary learning performance when users adopt a particular interface style.
The Group A(Traditional), B(Synonym Pair), C(Antonym Pair) and D(Mix Pair) have 9.0,8.75,8.85 and 8.75 mean marks respectively in comprehension learning with a p-value(0.985) which is greater than the significance p-value(0.05). It shows that statistically there is no difference among Groups performance when users either adopt traditional or experimental group interface.
According to H2, the subjects of Group D should have the best comprehension results as Group D provides 96.5 % marks in vocabulary acquisition but we observed that p-value of comprehension is 0.985. Figure 7, shows that if an interface style provides better vocabulary acquisition it does not affect comprehension learning in our experimental scenarios.

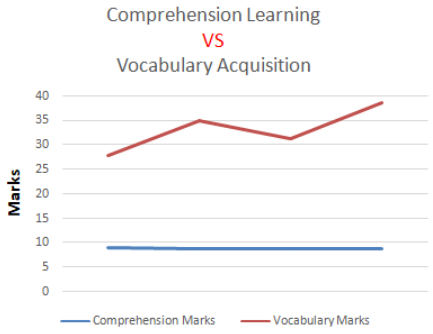

Fig. 7 Comparison b/w comprehension learning and vocabulary acquisition among all Groups.

It is obvious that if an interface style provides different (better) vocabulary acquisition, it does not affect the comprehension learning skill of non-native English readers. Hence, we can conclude that H_2 is false.

Conclusion H_2:
If an interface style provides better vocabulary learning environment it does not affect the comprehension learning of non-native English readers.

7.3 Evaluation of H_3

While evaluating H_3, during the vocabulary acquisition test, the users of Group D (Mix Pair interface) got 26.3 %, 11 % and 19 % more marks on average than Group A, B, and C respectively. Group D performed better in vocabulary acquisition due to divergent retrieval through Mix Pair interface as compared to other Groups (See Figure 3).
We found that H_3 hypothesis is true and it also satisfies the dual code theory, which states that the ability to code a stimulus in two different ways increases the chances of remembering than stimulus coded in one way.
In our experiment in Group D(Mix Pair), our stimulus(Highlighted word) is coded in two types/ways which increases the vocabulary learning as compared to other experimental designed interfaces in which stimulus(highlighted word) is coded in one way by synonyms pair or by antonyms pair.

8. Subjective Usability

Subjective usability of all interfaces is measured through System Usability Scale (SUS) which is a reliable and low-cost tool for global assessments of system usability [28]. SUS is a questionnaire tool for assessment of the usability of interfaces of a wide variety of software such as application software interfaces, web applications and user interfaces [29].
The SUS provides a single score for valuation of system usability. It contains tens questions each with 5-points on Likert scale, wherein in Likert scale we used 1 for strongly agree to 5 for Strongly Disagree. For the purpose of our experiments, we modified the questions according to the context of our experiments.
After completing the vocabulary acquisition and comprehension tests, subjects of each group were asked questions about their experience. The same questionnaire was asked to users of all groups.
Figure 8 shows the average SUS score of all groups.

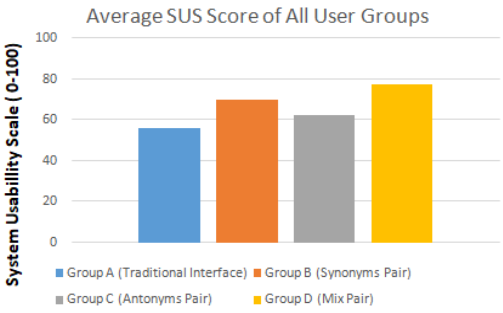

Fig. 8 Comparison among all groups in average subjective usability scores (SUS).

The average subjective usability of Mix Pair Interface (SUS Score=77) is 21 % more than Traditional Interface (SUS Score=56). The Synonyms Pair Interface (SUS Score=70) and Antonyms Pair Interface (SUS Score=62) have 15 % and 7 % more usability than Traditional Interface.

A single factor analysis of variance test conducted on system usability scale ($F= 9.19 > F_{crit}=2.60$, $p<0.05$) shows that the average subjective usability score of each group is different in all four types of interfaces.

The independent (Unpaired) samples t-tests (one-tailed) were conducted to compare the experimental designed interfaces with traditional interface. The average SUS score of Group B(M=70.10, SD=8.51) was significantly greater than Group A(M=55.9,SD=12.67) conditions, $t_{static}(78)=5.88>T_{crit}$(one-tailed)=1.66, where p-value <0.05.

Similarly, the average SUS score of Group C(M=62.4,SD=15.48) conditions, $t_{static}(78)=2.05>T_{crit}$(one-tailed)=1.66, where p-value<0.05 and Group D(M=77.3,SD=8.83) conditions, $t_{static}(78)=8.76>T_{crit}$(one-tailed)=1.66,p-value=0.05, was significantly greater than control Group A. These results suggest that the newly designed interfaces have effect on the average subjective usability of interfaces.

Effect sizes express the magnitude of an effect. We calculated Glass's Δ(Delta) of each experimental group with the control group as each group has different standard deviation. Effect Sizes measured between group A and group B are (1.136), between group A and group C are (0.52) and between group A and group D are (1.72), and effect sizes measured between group A and group D show that Mix Pair Interface has the highest subjective usability.

Subjects in the all three experimental groups reported significantly less weirdness and significantly greater satisfaction of the system as compared to the control group. The subjects of experimental groups felt less distraction as compared to control group. Few subjects in experimental groups felt weirdness regarding the interface styles.

9. Implications

We chose random samples for our experiments. Accordingly, the subjects had to go through the vocabulary acquisition and comprehension learning situations. Individual differences cannot be measured as long-term memory is huge with unknown limits [30], which may help to contribute vocabulary acquisition and comprehension learning.

Same text has been provided to all the subjects and their personal preferences have not been considered regarding the selection of text since for the purpose of experiment the text should be unseen.

10. Conclusion and Future Work

Our interaction techniques conveyed how extra information can be used by exploiting interaction properties of website/e-paper to enhance user's vocabulary acquisition while lowering their time without using any special browser. Quick response is achieved without encountering any spatial (distant) problems. No adverse effect is found on comprehension learning by using the techniques we employed in our experiments. Our interaction techniques enhanced the usability by keeping the users focus on the primary text while lowering their time, cognitive load and partial attention.

More benefits can be achieved for users by applying several changes, e.g. images; audio can be provided by simple action of users which may enhance the learning according to dual coding theory. The meaning of difficult words can be provided in user's native language, may help them to increase their comprehension particularly. We could also incorporate eye tracking to calculate the time spent by the user to get the help from the system which may help to design more sophisticated interfaces. The switching is difficult in small screen, so such kind of techniques may be more helpful for mobile phone users.

References

[1] E. Chin, "Redefining "Context" In Research On Writing," Written Communication, vol. 11, pp. 445-481, 1994.
[2] N. A. K. S. Muhammad Waseem Iqbal, "Usability evaluation of adaptive features in smartphones," Procedia Computer Science, vol. 112, pp. 2185-2194, 2017.
[3] E. Rose, "Continuous partial attention: Reconstructing the role of online learning in the age of interruption," Educational Technolgy, vol. 50, no. 4, pp. 41-46, 2010.
[4] P. A. S. K. John Sweller, Cognitive Load Theory, New York: Springer, 2011.
[5] P. C. P. T. M. C. John Sweller, "Cognitive Load as a Factor in the Structuring of Technical Material," Journal of Experimental Psychology, vol. 119, no. 2, pp. 176-192, 1990.
[6] A. Paivio, Mental Representation: A Dual Coding Approach, Oxford: Oxford University Press, 1990.

[7] J. S. Paul Chandler, "Cognitive Load Theory and the Format of Instruction," Cognition and Instruction, vol. 8, no. 4, pp. 293-332, 1991.
[8] C. P. Just MA, "A capacity theory of comprehension: individual differences in working memory.," Psychological Review, vol. 10, no. 1, pp. 151-170, 1996.
[9] J. S. Paul Chandler, "Cognitive Load While Learning to Use a Computer Program," Appllied Cognitive Psychology, vol. 10, no. 1, pp. 151-170, 1996.
[10] K. O'Hara, "Towards a Typology of Reading Goals," Rank Xerox Ltd, Cambridge, 1996.
[11] D. A. Norman, The Psychology of Everyday Things, New York: Basic Books, 1988.
[12] A. S. K. T. Indrani Medhi, "Text-Free User Interfaces for Illiterate and Semi-Literate Users," Information Technologies And International Development, vol. 4, no. 1, pp. 37-50, 2007.
[13] S. H. R. ,. J. D. M. B.-W. C. Polle T. Zellweger, "The Impact of Fluid Documents on Reading and Browsing: An Observational Study," in Proceedings of the CHI 2000 Conference on Human factors in computing systems, The Hague, 2000.
[14] J. Conklin, "Hypertext: An Introduction and Survey," Computer,IEEE, vol. 20, no. 9, pp. 17-41, 1987.
[15] R. J. K. J. Eric Bahna, "Augmented Reading-Presenting Additional Information Without Penalty," in CHI EA '05 CHI '05 Extended Abstracts on Human Factors in Computing Systems, Portland, 2005.
[16] D. M. R. E. D. L. Jan L.Plass, "Congnitive Load In Reading A Foreign Language Text With Multimedia Aids And The Influence Of Verbal And Spatial Abilities," Computers in Human Behavior, vol. 19, no. 1, pp. 221-243, 2003.
[17] D. M. R. E. D. L. Jan L.Plass, "Supporting Visual And Verbal Learning Preferences In A Second-Language Multimedia Learning Environment," Journal of Educational Psychology, vol. 90, no. 1, pp. 25-36, 1998.
[18] A. Paivio, Imagery And Verbal Processes, Holt: Rinehart and Winston, 1971.
[19] J. Sweller, "Cognitive Load Theory, Learning Difficulty, And Instructional Design," Journal Of Educational Psychology, vol. 4, no. 4, pp. 295-312, 1994.
[20] J. Sweller, Instructional Design In Technical Areas, Camberwell: ACER Press, 1999.
[21] P. J. J. S. Alexander Seeshing Yeung, "Cognitive Load and Learner Expertise: Split-Attention and Redundancy Effects in Reading with Explanatory Notes," Contemporary Educational Psychology, vol. 23, no. 1, pp. 1-21, 1997.
[22] E. K. N. B. S. W. K. Danielle S. McNamara, "Are Good Texts Always Better? Interactions of Text Coherence, Background Knowledge, and Levels of Understanding in Learning from Text," Institute of Cognitive Science, Boulder, 1996.
[23] J. F. G. D. A. R. B. Alan Dix, Human-Computer Interaction, Harlow: Prentice Hall, 2003.
[24] D. E.Irwin, "Integrating Information Across Saccadic Eye Movements," Current Directions In Psychological Science, vol. 5, no. 3, pp. 94-100, 1996.
[25] D. F. Fisher, "Reading And Visual Search," Memory and Cognition, vol. 3, no. 2, pp. 188-196, 1975.
[26] B. R. W. K. B. Anne Mangen, "Reading Linear Texts On Paper Versus Computer Screen: Effects On Reading Comprehension," International Journal of Educational Research, vol. 58, pp. 61-68, 2013.
[27] S. Kelkar, Usability and Human-Computer Interaction: A Concise Study, Delhi: Prentice-Hall of India, 2016.
[28] J. Brooke, "SUS: A quick and dirty usability scale," Usability evaluation in industry, vol. 189, no. 194, pp. 4-7, 1995.
[29] P. T. K. J. T. Aaron Bangor, "An empirical evaluation of the System Usability Scale," International Journal of Human-Computer Interaction, vol. 24, no. 6, pp. 574-594, 2008.
[30] M. W. Eysenck, Simply Psychology, Hove: Psychology Press, 2002.