Reading preference and performance of K1 students for Chinese text presented on PDA interface

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Abstract: - This study investigates the reading preference and performance of young learners for Chinese text presented in either a horizontal format or a vertical format on PDA screens. In assessing the reading performance, the reading speed is taken as the performance evaluation criterion. The thirty participants in the current investigation are K1 students studying in the first grade of an elementary school.
The ANOVA results indicate that both the screen orientation and the document format exert a significant influence on the reading preference and reading performance of the young students. Specifically, it is found that a horizontal screen with a vertical text format is the preferred choice of the K1 students. This particular treatment of the screen and document factors results in the shortest reading time. The results of this study can be applied to develop PDA-based educational software which not only satisfies the reading preferences of young learners, but also enhances their reading performance.

Key-Words:- PDAs, Chinese, Children, Text, Reading, Interface

1 Introduction

Continuing technological advances have led to an increasing volume of information being generated, transmitted, and stored on computers [1]. e-learning represents the interaction between the teaching-learning process and the information and communication technology[2].However, for this information to be of any value, it must be regarded as important by its audience and therefore deserving of attention. When the information is targeted at young children, the screen interface and data presentation format play key roles in arousing and maintaining the users' attention. It has been suggested that children should not be treated as a single homogeneous user group, but should be differentiated based upon their level of development [3]. A central tenet for user-centered design practices is that there is no design which fits all. Rather, a design should be driven by a knowledge of the target user.

In recent years, an increasing number of schools and universities have started to use personal digital assistants (PDAs) as a means of presenting their teaching curricula in an attempt to enhance the students' learning experience and to reduce the instructors' workload[4]. PDAs avoid the need for children to carry large numbers of books and provide a more stimulating and less threatening learning interface than that provided by conventional textbooks. It is anticipated that the use of PDAs will emerge as a powerful teaching / learning strategy in the future and will be adopted in part with the intention of easing the students gently into the digital society to which they will belong in the future. PDA is a term for any small handheld device that provides information storage and retrieval capabilities [5]and mostly employed in business and education enviroments[6]. Dale & Hagen pointed that PDA method seems to perform better than pen and paper in most of the selected outcomes.[7] Öquist & Goldstein commented that a Pocket PC, i.e. a small PDA, is of approximately the same size and weight as a pocket book with approximately 250 pages[8]. However, the data card slots incorporated into most PDA devices enable considerably more information to be stored and retrieved. In practice, the contents of an entire collection of books can be stored and presented on a

single PDA device merely by inserting the appropriate data cards.

The importance of books in young people's lives cannot be under estimated[9]. The information provided in these books provides children with an abundance of information which both expands and enriches their lives.The potential exists for providing elementary school children with informative materials via computer screens[10]. It highlighted the growing popularity of PDAs in recent years and identified their increasing role in providing information management services in a broad range of fields[11].

K1 students in elementary schools in Taiwan typically use conventional textbooks to support the learning processes. It pointed that easily perceived graphical interface layouts would be more acceptable and popular for young children[12]. However, as the capabilities of PDAs continue to develop, it is likely that they will eventually replace textbooks as the main learning media and that books will be relegated to a supporting role. Since the learning interface provided by a PDA is flexible, both in terms of its content and its format, the interface can be tailored to meet the reading preferences of specific users, thereby stimulating their desire to learn and enhancing their learning performance as a result. A technological solution is described ,that provides educational tools using the new generation of PDAs[13].

The aim of this study is to evaluate the preferences of young students in Taiwan for the presentation of Chinese text on a PDA interface. Specifically, this study considers whether the text should be presented on a horizontal or a vertical screen, and whether it should be arranged in a vertical format (as in conventional text books) or in a horizontal format. Typically, students first receive formal instruction in the reading and writing of Chinese words when they enter elementary school. Therefore, elementary school students will most likely have a relatively limited vocabulary and will not have developed engrained reading preferences. Conversely, higher grade students will have a more extensive vocabulary and will probably have an established reading preference since the textbooks they use present text in a vertical format. Since one of the aims of the current study is to investigate reading preferences, Grade 1 elementary school students with a basic vocabulary ability are chosen as test subjects.

It studied the Chinese reading performance of adults with a typical basic vocabulary of 4808 words[14]. Clearly, one of the factors which differentiates the adult and children target groups for educational materials is the depth of their respective vocabulary knowledge. In assessing the reading performance of a particular target group, it is essential that the trials are conducted using vocabulary items appropriate for that group. Therefore, the current tests are carried out using simple Chinese vocabulary items with which the participants are already familiar. Since a typical Grade 1 student knows only a few words, the approach used in checking goal words or error words to evaluate the reading performance is not applicable in the present case. Therefore, this study assesses the reading performance of the students by recording the time they take to read a text passage comprising a random sequence of known Chinese words. The results of the present research provide an objective reference for the design of PDA-based text materials targeted at young children in a learning environment.

1.1. Interface orientation

It suggested that the text appearance and the presentation interface are important concerns in information retrieval applications[15]. This is particularly the case when the information is targeted at a young audience characterized by limited attention spans. Traditionally, Chinese text is presented in a vertical format, with the vertical columns read from top to bottom and right to left.

However, due to the increasing influence of Western language texts in today's global community, and the emergence of the Internet as an international communication medium, the format of a growing number of Chinese language texts is changing from the traditional style, i.e. vertical, to a more Western style, i.e. horizontal. In Taiwan, some official government documents are now written in a horizontal format. However, the format of the text in school textbooks has not changed, and continues to be presented in the traditional vertical style. In order to investigate the effect of the text format and display orientation on the reading preference and performance of young students, this study uses a PDA as the display interface and examines four specific screen / text orientation permutations, i.e. a vertical PDA screen with either vertical or horizontal text and a horizontal PDA screen with either vertical or horizontal text[16].

The weight and size of today's PDAs allow them to be easily held and used in the palm of the hand. It pointed out PDAs are available in both horizontal and vertical formats. Such devices are widely available in either a horizontal format or a vertical

format[11]. The choice of format typically depends on the user's subjective preference.

1.2. Screen layout for Chinese characters

It observed that Chinese characters are approximately square or rectangular in shape[14]. In a sense, therefore, they can be regarded as uniform "building blocks", which can be arranged in either a vertical or a horizontal format. Clearly, they are quite unlike English alphanumeric characters in this respect. It pointed that the complexity of Chinese documents lies in the high degree of freedom allowed in the layout structure [17].

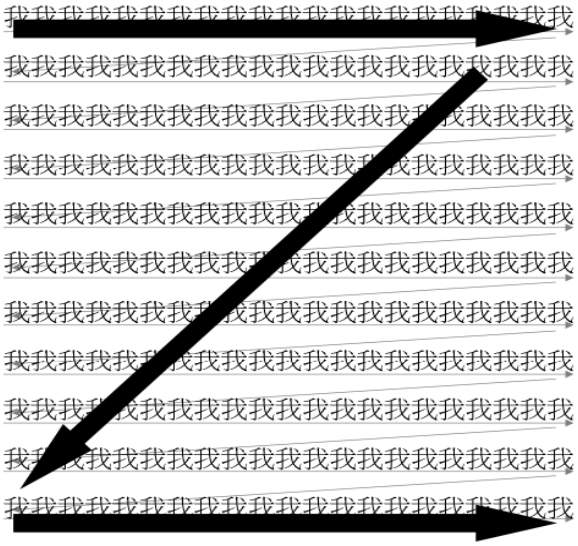

Fig. 1: "Z" type article

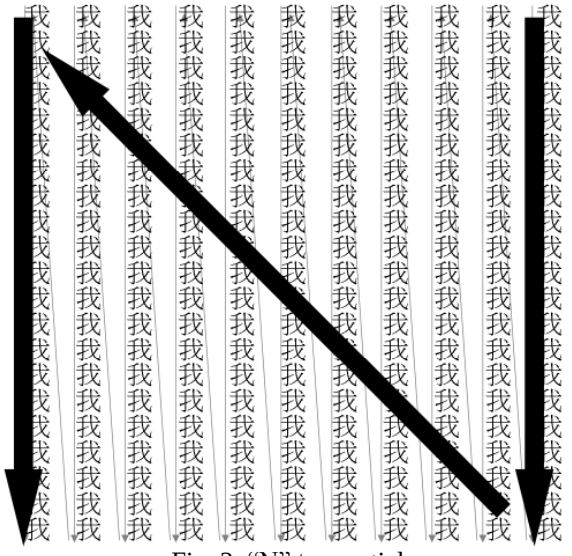

Fig. 2: "N" type article

Western documents have only a horizontal reading order, while Chinese documents have both horizontal and vertical orders. It observed that Western documents use only a horizontal format, whereas Chinese documents may use either a horizontal format or a vertical format [18]. It identified these text orientations as either "Z type" or "N type" [14].

Both format types are widely used in Chinese texts[19]. In Fig. 1, which shows the format of a "Z" type article in a newspaper, the text is read from the top-left corner to the bottom-right corner, with every line being read from left to right. In Fig. 2, which shows the format of an "N" type article, the text is read from the top-right corner to the bottom-left corner, with every line being read from top to bottom.

1.3. Related research

1.3.1. Chinese script style

It was investigated the effect of the style of Chinese characters, i.e. True type (Ming style) and Standard Kai type, on the users' reading comprehension of Chinese text presented on a small screen[20]. The results showed that the text style did not have a significant effect on the degree of comprehension. It was conducted a recognition test using common Chinese characters written in the Ming, Kai, and Li styles[21]. Each character was displayed in the three styles on a PC screen, and the minimum visible size of each character identified for each style. It was found that the characters written in the Ming style were the most legible. Hence, the Chinese characters used in the present study were all written in the Ming style.

1.3.2. Reading performance for Chinese texts

The readability of text passages presented on small screens could be increased by designing specific interfaces[8]. It was studied the effect of the contrast ratio on the reading speed[22]. In his tests, he deliberately chose Chinese words with a common usage, i.e. words which appeared on a list of the 600 most frequently used words. Using these words, he constructed random word sequences and presented the stimuli to the test participants using dark letters against a white background.

It was studied the relationship between letter recognition and reading speed. In his tests, the stimuli were presented sequentially in the same location of a screen [22]. The letters were rendered in Courier Bold and displayed as dark letters against

a white background. It was investigated the effect of the screen type, contrast ratio, and ambient illumination on the visual recognition and subjective preference aspects of visual display terminal (VDT) screens [23]. The results showed that both the subjective preference level and the visual recognition performance increased with an increasing contrast ratio.

It was investigated elemental standard reading time estimates for traditional Chinese characters on computer displays [24]. He showed that Chinese characters rendered in the Ming style with a positive polarity led to a more rapid reading time and a higher preference than characters in the Li style with negative polarity. In a similar study, text effects on the reading performance of elementary school students using black text presented against a white computer screen[10].

1.3.3. Background and foreground effects for Chinese words

It was investigated the effects of the contrast ratio and the text color on the visual performance characteristics of thin transistor liquid crystal display screens[25]. The results showed that the text color did not significantly affect the visual performance provided that an acceptable contrast ratio was maintained. Therefore, it was concluded that the contrast ratio was more influential than the text color in determining the visual performance.

2. Methods

2.1. Participants

30 participants from elementary school in Tainan, a city in the south of Taiwan, volunteered to take part in the current experimental investigations. The participants ranged from 7 to 8 years of age (i.e. Grade 1 students) and were all capable of reading Chinese fluently as a first language. The participants received a small gift (an item of stationery) as a token of the researchers' appreciation for taking part in the trials. The experiments were conducted between 3 o'clock and 5:30 in the afternoon, after the regular school classes had finished.

2.2 Equipment

The experiments were performed using PDAs with screens measuring 7 cm x 5.5 cm. The 72 dpi RGB screens had a resolution of 320 * 240 pixels.

2.3. Experimental materials

It was investigated the presentation of reading texts on small display screens and specified that the chosen texts should include no extremely rare words[26]. Since the research targets in the current study are Grade 1 elementary school students with a limited vocabulary, the reading experiments were based on the Chinese language teaching materials used in their school. The Chinese words in these materials can be broadly classified as either "painting words" or "known words". In this study, a painting word was defined as a word which the student must learn how to read and write, while a known word was defined as a word which the student already knows how to write, but must learn how to read. Clearly, painting words are the fundamental words in the Chinese language learning process, and hence it was these words which were used to construct the current reading texts.

In the Chinese textbook designed for Grade 1 students in the target elementary school, the total number of words in each lesson varies. From inspection, it was found that for Lessons 1 to 4, the number of words per lesson varied between 26 and 35. Accordingly, the current experimental text passages were constructed using 35 words and presented on a single page of the PDA display. Having first checked that the teacher had fully covered Lessons 1 to 4 with the students, the following 35 words were chosen for testing purposes:一手左三上下大二我們在河玩白的三吹泡先個小向天跑四走你那來去直不到出口.

In the approaches studied text words randomly substituted throughout the passage. This study followed a similar approach in arranging the 35 chosen words in a random sequence so as to construct text passages with no obvious meaning[6].

3. Experiments

Two experiments were performed in the present study: (1) an evaluation of the students' reading preference, and (2) an evaluation of the students' reading performance.

3.1. Experiment 1: Reading preference

3.1.1. Treatment design

The PDA screen factor has two levels, namely vertical and horizontal. Similarly, the document factor also has two levels, namely "Z type" and "N type". The four treatments are presented in Fig. 3. The aim of the first experiment was to identify the students' reading preference, i.e. the preferred screen / document treatment. The actual text content is not important, and indeed should be designed in such a way as to focus the participants' attention on

the screen / document format rather than on the text itself. Accordingly, as described above, the 35 words were arranged at random to form a text passage with no obvious grammatical sense or semantic meaning. Importantly, the same text passage was presented to the participants in each of the four treatments. To avoid experimental influence, the treatments were presented to the participants in a random sequence.

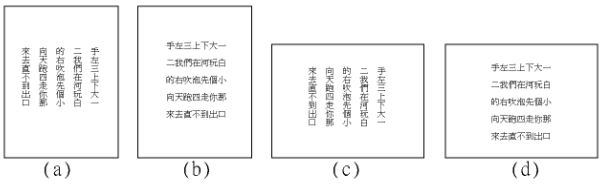

Fig 3 Experiment 1: (a) Screen type: vertical. Document type: N; (b) Screen type: vertical. Document type: Z; (c) Screen type: horizontal. Document type: N; and (d) Screen type: horizontal. Document type: Z.

3.1.2. Experimental procedure

Before commencing the reading experiments, the participants were shown the textbook and the researchers confirmed their ability to read the Chinese words within Lessons 1 to 4. The experimental procedure was then explained to the participants and the use of a questionnaire to record their evaluations of each treatment described. The researchers then confirmed that the participants had fully understood the experimental procedure.

Fig. 4: Participant taking part in reading preference experiment

Since the participants were young, no time limit was prescribed for the tests, and the children were permitted to view each treatment several times before completing the questionnaire. Fig. 4 shows a photograph of a participant holding the PDA in her hand as she takes part in the reading preference experiment.

3.1.3. Data collection and score evaluation

In the present study, the researchers observed and documented the reactions of the participants as they viewed each treatment. Having viewed the four treatments, the participants were asked to indicate on the questionnaire which treatment they preferred. They were then asked to rank the remaining treatments in order of diminishing preference. An appropriate score was then assigned to each treatment, ranging from 4 for the most highly preferred treatment to 1 for the least preferred treatment. The data provided by the participants was then analyzed using statistical methods.

3.1.4. Data collection and analysis

Table 1 shows the two factors involved in the reading preference experiments, namely the screen effect and the document effect, where each effect has two levels, i.e. horizontal or vertical and N type or Z type, respectively. The aim of the reading preference experiment was to establish which of these four treatments was most preferred by the participants. Accordingly, the analysis of variance (ANOVA) statistical technique was applied with a significance level of α=.05 to determine whether or not each factor was significant. The significant factors were then analyzed using Duncan's test (Probabilities for Post Hoc Tests) to identify any statistically significant differences between the individual factor levels.

Table 1 Factors and levels

Factor		Level
Screen	Vertical type	Horizontal type
Document	N type	Z type

a) Analysis of reading preference

The MANOVA results for Experiment 1 are presented in Table 2. For the first main factor effect, i.e. the screen effect, it is shown that $F1(1,116) = 22.3077$, $p = 6.56E\text{-}06 < .05$. Therefore, the screen effect is significant. Regarding the second main effect, i.e. the document effect, $F2(1,116) = 20.5588$, $p = 1.42E\text{-}05 < .05$, and hence the document effect is also significant. However, the interaction between the two main effects is not significant ($p = 0.1886 > 0.05$).

Table 2 Results of the analysis of variance in the experiment 1

Source of variable	df	F	p-level
(A)Screen type	1	22.3077	*6.56E-06
(B)Document type	1	20.5588	*1.42E-05
A×B	1	1.74892	0.1886

*p<.05

Fig. 5 shows that the K1 students favor the treatment shown in Fig. 3(c), namely a horizontal screen with N-type text (corresponding mean: 3.433). In order of diminishing preference, the students ranked the three remaining treatments as follows: horizontal screen with Z-type text (Fig. 3(d), corresponding mean: 2.4); vertical screen with N-type text (Fig. 3(a), corresponding mean: 2.3667); and, finally, vertical screen with Z-type text (Fig. 3(b), corresponding mean:1.8).

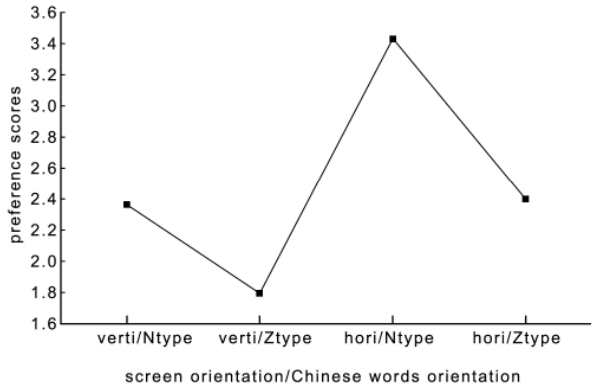

Fig. 5: Means of 4 treatments

Fig. 6 plots the screen factor effect. It is apparent that the students prefer a horizontal type screen (2.9167) to a vertical type screen (2.0833). Furthermore, in Fig. 7, which shows the document factor effect, it can be seen that the students prefer the N-type text format (2.9) to the Z-type format (2.1). Fig 8 illustrates the interaction between the two main effects. In general, the participants award the horizontal screen format a higher score than the vertical format and it is observed that the two lines are approximately parallel, which indicates that there is no interaction between the two factors.

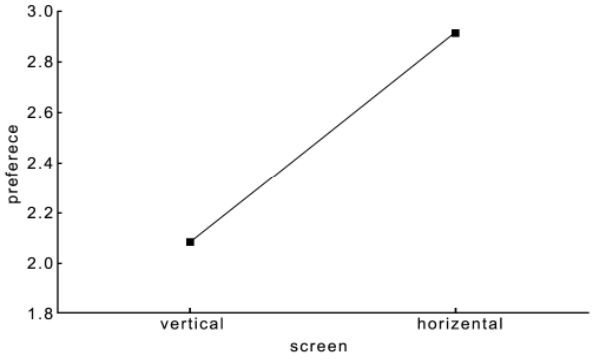

Fig. 6: Screen main effect

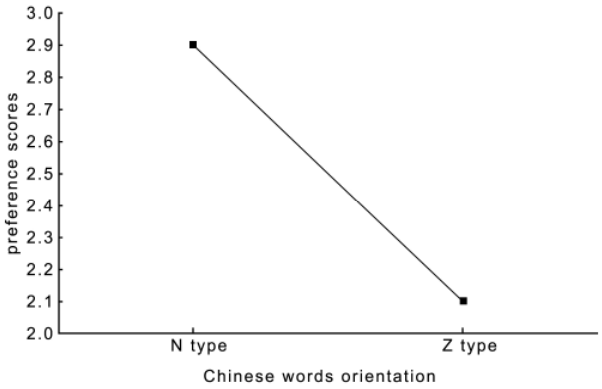

Fig. 7: Document main effect

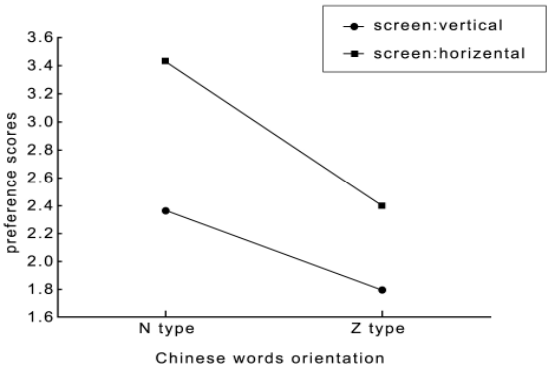

Fig. 8: 2-way interaction between main effects

Duncan's test (Probabilities for Post Hoc Tests) was conducted to determine whether the means of the four treatments' scores were significantly different. The corresponding results are presented in Table 3. For the treatments shown in Figs. 3(a) and 3(b), p=.0251<.05. Therefore, a significant difference exists between these two treatments. Specifically, the treatment in Fig. 3(a) is significantly better than that in Fig. 3(b). Similarly, for the treatments in Figs. 3(a) and 3(c), p=.00011<.05. Hence, the treatment in

Fig. 3(c) is significantly better than that in Fig. 3(a). Regarding the treatments in Figs. 3(b) and 4(c), p=4.55E-05<.05 and so the treatment in Fig. 3(c) is obviously better than that in Fig. 3(b). For the treatments in Figs. 3(b) and 3(d), p=.0235<.05. Consequently, the treatment in Fig. 3(d) is significantly better than that in Fig. 3(b). For the treatments in Figs. 3(c) and 3(d), p=.0002<.05 and so the treatment in Fig.3(c) is obviously better than that in Fig. 3(d). Finally, for the treatments in Figs. 3(a) and 3(d), p=.8941>.05. Hence, there is no significant difference between the two treatments.

From the results presented above, it can be concluded that the treatment shown in Fig. 3(c), i.e. a horizontal screen with N-type text, achieves the highest degree of reading preference for K1 elementary school students. Additionally, the degree of preference for the treatment in Fig. 3(a), i.e. a vertical screen with N-type text, is approximately the same as that for the treatment in Fig. 3(d), i.e. a horizontal screen with Z-type text. However, the treatment in Fig. 3(b), i.e. a vertical screen with Z-type text, finds obviously less favor with the young students.

3.1.5. Discussion

Following the reading preference experiments, the students were encouraged to provide some general feedback regarding their feelings and reactions towards the four treatments. Some students expressed the opinion that they preferred the horizontal screen format because it reminded them of the screens in their TVs and computer monitors, and was therefore familiar to them. Furthermore, they commented that most of the books they read were written using an N-type text format, and hence the Z-type format appeared rather "strange". From the students' comments, it is apparent that Grade 1 elementary school students have already developed a reading habit to a certain extent.

3.2. Experiment 2: Reading performance

The goal of the second experiment was to evaluate the reading performance of the participants for each of the four treatments. To avoid pressurizing the students by introducing new and possibly unfamiliar words, thereby adversely affecting their reading performance, the same 35 basic vocabulary items as those used in the reading preference experiments were used to construct a new set of text passages for the reading performance evaluation.

3.2.1. Treatment design

In the first experiment, the text passage used in each of the four treatments was the same. However, to ensure a fair evaluation of the effect of the screen / document treatment on the reading performance, in the second experiment, the 35 words were rearranged into four different random sequences to avoid the students becoming overly familiar with the passage as they read it repeatedly when assessing the four different treatments.

Having explained the experimental procedure to the participants, the researchers covered the PDA screen with gray paper and showed the participants how they were to hold the PDA during the reading test, i.e. vertically or horizontally. The participants were then told whether they were about to read N-type text or Z-type text. The gray paper was then removed from the screen and the time taken by the participant to read the text measured and recorded. Each participant read the four different text passages (i.e. a unique passage for each screen / document treatment) and the reading time was recorded in each case.

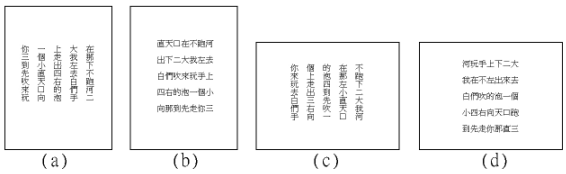

Fig. 9: Experiment 2:(a) Screen type: vertical. Document type: N; (b) Screen type: vertical. Document type: Z; (c) Screen type: horizontal. Document type: N; and (d) Screen type: horizontal. Document type: Z.

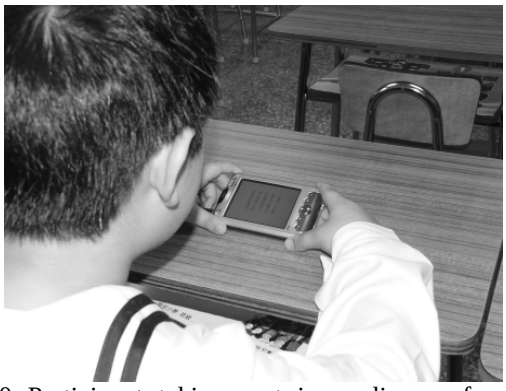

Fig.10 Participant taking part in reading performance experiment.

The second set of experimental treatments are shown in Fig. 9. Fig. 10 shows a student taking part in the reading performance experiment.

3.2.2. Data collection and analysis

Clearly, in the reading performance experiment, a shorter reading time represents a better result. The reading time data were analyzed using the ANOVA statistical analysis technique using α=.05 as a

significance indicator to determine whether or not a particular factor (or interaction) was significant. The significant factors were then analyzed using Duncan's test to identify significant differences between the factors and their levels.

a) Analysis of reading performance

The MANOVA results for the second experiment are presented in Table 4. For the screen factor main effect, $F(1,116) = 4.0575$, $p = .0463 < .05$, and hence the screen factor has a significant influence on the reading performance. Similarly, the document factor main effect is $F(1,116) = 7.9736$, $p = .0056 < .05$, and hence the document factor main effect is also significant. However, the interaction between the two main effects is not significant, i.e. $p = 0.9389 > 0.05$.

Table 4
Results of the analysis of variance in the experiment 2

Source of variable	F	p-level
(A)Screen type	4.0575	0.0463
(B)Document type	7.9736	0.0056
A×B	0.0059	0.9389

*p<.05

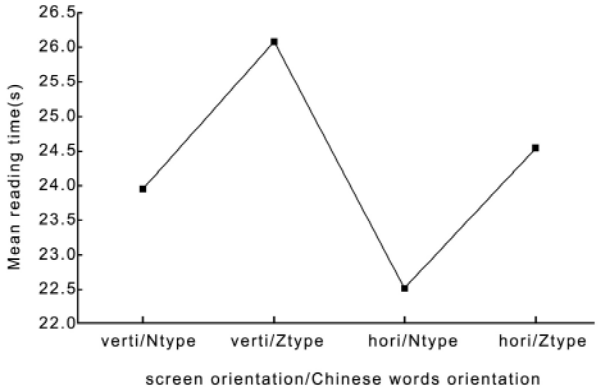

Fig. 11: Mean of four treatments

In Fig. 11, it can be seen that the treatment shown in Fig. 9(c), i.e. a horizontal screen with N-type text, results in the shortest mean reading time of the four experimental treatments, i.e. 22.5140 seconds. The treatment shown in Fig. 9(a), i.e. a vertical screen with N-type text, results in a mean reading time of 23.94300 seconds. Similarly, the treatment shown in Fig. 9(d), i.e. a horizontal screen with Z-type text, results in a mean reading time of 24.5400 seconds. Finally, the treatment shown in Fig. 9(b), i.e. a vertical screen with Z-type text, results in a mean reading time of 26.0833 seconds.

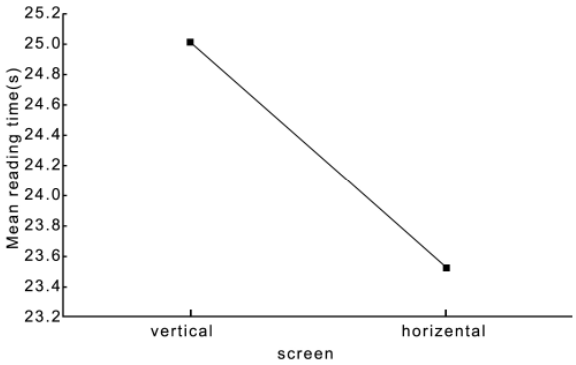

Fig. 12: Screen factor main effect

Fig. 12 shows that the horizontal screen factor has a more beneficial effect on the reading performance than the vertical screen format, i.e. $F(1,116) = 4.06$, $p = .0463 < .05$. In other words, the K1 students are able to read the text passage more rapidly when it is presented on a horizontal screen than when it is displayed on a vertical screen, i.e. an average reading time of 23.5270 seconds (horizontal screen) compared to 25.0127 seconds (vertical screen). Fig 13 illustrates the document factor main effect. It is clear that the N-type text results in a better reading performance than the Z-type text, i.e. $F(1,116) = 7.97$, $p = .0056 < .05$. In other words, the K1 students are able to read N-type text faster than Z-type text, i.e. 23.2285 seconds (N-type text) compared to 25.3112 seconds (Z-type text). Fig. 14 shows the interactions between the two main factors. Since the two lines are approximately parallel, it can be inferred that there is no significant interaction effect between them.

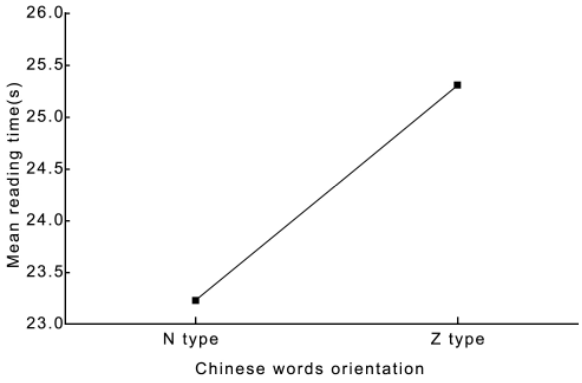

Fig. 13: Document factor main effect

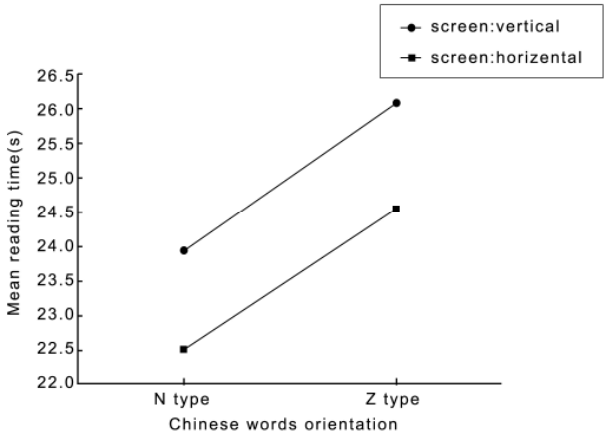

Fig. 14: 2-way interaction between main factor effects

Table 5 Duncan test; probabilities for post hoc tests, main effect: document

	Fig9(b)	Fig9(c)	Fig9(d)
1. Fig9(a) 23.9430	0.0539	0.1734	0.5683
2. Fig9(b) 26.0823		*0.0016	0.1420
3. Fig9(c) 22.5140			0.0681
4. Fig9(d) 24.5400			

*p<.05

Table 5 shows that the treatments in Figs. 9(b) and 9(c) are significantly different, i.e. p=0.0016<0.05. Specifically, the treatment in Fig9(c), i.e. a horizontal screen with N-type text results in a better reading performance than that in Fig. 9(b), i.e. a vertical screen with Z-type text. For the treatments in Figs. 9(a) and 13(b), p=.0539>.05, and so there is no significant difference between the reading performance obtained for the treatment with a vertical screen and N-type text and that obtained from the treatment with a vertical screen and Z-type text. Similarly, for the treatments in Figs. 9(a) and 13(c), p=.1734>.05. Therefore, the reading performances obtained for the treatments with a vertical screen and N-type text and a horizontal screen with N-type text, respectively, are approximately the same. For the treatments in Figs. 9(a) and 9(d), p=.5683>.05, and hence the reading performance obtained for a vertical screen with N-type text is not significantly different from that obtained for a horizontal screen with Z-type text. For the treatments shown in Figs. 9(b) and 9(d), p=.142033>.05, and so there is no significant difference between the reading performance obtained for a vertical screen with Z-type text and that obtained for a horizontal screen with Z-type text. Finally, for the treatments shown in Figs. 9(c) and 9(d), p=.0681>.05. Therefore, the reading performance for the horizontal screen with N-type text is approximately the same as that for the horizontal screen with Z-type text.

The results above indicate that the best reading performance by K1 students is achieved when the Chinese text is presented on a horizontal screen with an N-type format.

3.2.3. Discussion

Due to the limited vocabulary of the present K1 students, the text passages used in the reading experiments are not long (35 words), and hence the reading time, is quite short. Therefore, it is difficult to draw definitive conclusions regarding the different effects of the experimental treatments on the reading performance. However, some basic conclusions can nevertheless be drawn. For example, the reading performance results indicate that the K1 students read quicker when the text is presented on a horizontal screen rather than on a vertical screen. Furthermore, the students are able to read N-type text more rapidly than Z-type text.

Comparing the findings of the two sets of experiments, some differences are observed between the effects of the experimental treatments on the reading preference and the reading performance, respectively. Specifically, regarding the reading preference, the preferred treatment order is Fig.3(c), 3(d), 3(a), and 3(b), while for the reading performance, the preferred treatment order is Fig.9(c), 9(a), 9(d), and 9(b).

4. Conclusions

The present experimental results have shown that the screen and document factors exert a significant influence on the reading preference and performance of K1 students when reading Chinese text presented on a PDA interface. Specifically, the students prefer the text to be presented in a horizontal format with the text arranged in an N-type format. This particular treatment not only finds the greatest favor with the K1 students, but also provides the best reading performance.

A smaller head contribution for individual vertical gaze saccades suggests a differential coupling between eye and head movements, the nature of which depends on the reading direction. Reading N-type text requires less head motion than Z-type text [27]. This may explain the higher reading preference and performance observed in the current study for N-type text. It was investigated the effect of the text orientation, i.e. horizontal or

vertical formats, on the search time for full screen menus,the results suggested that a vertical orientation was easier to use[28]. It also reported that vertical alphabetic menus resulted in an improved performance. The present results are consistent with these findings [29].

Some of the participants in the current tests commented that the horizontal PDA felt more physically comfortable in their hands than the vertical PDA. This observation may help explain the present findings for the reading preference and performance results, which both show that the students favored the horizontal format. Furthermore, some of the K1 students mentioned that they preferred the horizontal format since they were familiar with this format in their TVs and computer monitors.

Considering the format of the text passages, many of the students pointed out that their textbooks are always written using an N-type text format. Therefore, whenever called on by the teacher to read aloud, they always read N-type text. For this reason, they were less familiar with the Z-type format, resulting in a slightly poorer reading performance. From these results, it seems apparent that even Grade 1 elementary school students already possess a reading preference for N-type text.

A growing amount of attention has been paid to children as a special user group over the past 10 years or so[30]. The results of the present study have suggested that when developing PDA-based reading materials for this particular user group, the optimum treatment is a horizontal screen with vertical text.

References:

[1] J.H. Wu, Y. Yuan, Improving searching and reading performance: the effect of highlighting and text color coding. *Information & Management*, 40,2003, 617-637.

[2] S. Enache, A.Campeanu, M.A.Enache,S.Ivanov, E-learning tools for education in asynchronous machines,*WSEAS transactions on advances in engineering education*,4,2007,238-241.

[3] P. Markopoulos, M. Bekker, Interaction design and children. *Interacting with Computers*, 15, 2003,141-149.

[4] N. Segall, T.L. Doolen, J.D. Porter, A usability comparison of PDA-based quizzes and paper-and-pencil quizzes, *Computers & Education*, 45, 2005,417-432.

[5] R. Kitchiner, The role of the personal digital assistant in chiropractic practice. *Clinical chiropractic*, 9, 2006,119-128.

[6] M.Berglund,C.Nilsson,P.Révay,G.Petersson,G. Nilsson,Nurses' and nurse students'demands of functions and usability in a PDA. *International journal of medical informatics*, 76,2007,530-537.

[7] O. Dale, K.B. Hagen, Despite technical problems personal digital assistants outperform pen and paper when collecting patient diary data. Journal of clinical epidemiology, 60,2007,8-17.

[8] G. Öquist, M. Goldstein, Towards an improved readability on mobile devices: evaluating adaptive rapid serial visual presentation, *Interacting with Computers*, 15, 2003,539-558.

[9] J.P. Hourcade, B.B. Bederson , A. Druin, A. Rose, A. Farber, Y. Takayama, The International Children's Digital Library: Viewing digital books online. *Interacting with Computers*, 15, 2003,151-167.

[10] M. L. Bernard, B. S. Chaparro, M. M. Mills, C.G. Halcomb, Examining children's reading performance and preference for different computer-displayed text. *Behaviour & Information Technology*, 21, 87-96.

[11] A. H.Wang , Y.Y.Lai, , & C. T. Sun , Effect of PDA scrolling- and hierarchy-menu design on users' operating performance. *Displays*, 25, 2004,109–114.

[12] C. H.Chen, F. G.Wu, , P. L. P.Rau, , & Y. H.Hung, Preference of young children regarding interface layouts in child community web sites. *Interacting with computers*, 16, 2004, 311-330.

[13] B.M.Garrett,C.Jackson,A mobile clinical e-portfolio for nursing and medical students, using wireless personal digital assistants (PDAs), *Nurse education today*, 26, 2006, 647-654.

[14] R. S.Goonetilleke, W. C. Lau, , & H. M.Shih, Visual search strategies and eye movements when searching Chinese character screens, *Human-Computer Studies*, 57, 2002,447–468.

[15] B.Wang, X. F. Li, F.Liu,, & F. Q.Hu, Color text image binarization based on binary texture analysis. *Pattern Recognition letters*, 26,2005, 1650-1657.

[16] Y. M.Chang, C. Y.Lin, , Y. K.Lee, & H. H.Lai, Optimized PDA orientation and screen layout for Chinese vocabulary learning by young children, *Displays*, 2006,27, 73-79.

[17] F.Chang, S. Y.Chu, & C. Y.Chen, Chinese document layout analysis using an adaptive

regrouping strategy, *Pattern Recognition*, 38, 2005, 261-271.

[18] Y.M.Chang, C.Y.Lin,& Y.K.Lee, The preferences of young children for images used in dynamic graphical interfaces in computer-assisted English vocabulary learning. *Displays*, 26, 2005,147-152.

[19] K.C.Fan , L.S.Wang , & Y.T.Tu , Classification of machine-printed and handwritten texts using character block layout variance. *Pattern Recognition*, 31, 1998, 1275-1284.

[20] C.H.Chen, & Y. H.Chien, Reading Chinese text on a small screen with RSVP. *Displays*, 26, 2005,103-108.

[21] D. C.Cai , C. F.Chi, & M.You, The legibility threshold of Chinese characters in three-type styles. *International Journal of Industrial Ergonomics*, 27, 2001,9-17.

[22] B.A. O'Brien, J.S. Mansfield , & G.E. Legge, The effect of constrast on reading speed in dyslexia. *Vision Research*, 40,2000,1921-1935.

[23] M.T.Chen , & C.C.Lin, Comparison of TFT-LCD and CRT on visual recognition and subjective preference. *International Journal of Industrial Ergonomics*, 34, 2004,167-174.

[24] A.Chan ,& P.Lee , Effect of display factors on Chinese reading times, comprehension scores and preferences. *Behaviour & Information Technology*, 24, 2005, 81-91.

[25] C.C .Lin, Effects of contrast ratio and text color on visual performance with TFT-LCD. *International Journal of Industrial Ergonomics*, 31, 2003,65-72.

[26] J. F.Juola , A.Tiritoglu, & J. Pleunis , Reading text presented on a small display. *Applied Ergonomics*, 26, 1995, 227-229.

[27] H.Seo,&C.Lee,Head-free reading of horizontally and vertically arranged texts. *Vision research* , 42,2002,1325-1337.

[28] R. W.Backs, L.C. Walrath, & G. A. Hancock, Comparison of horizontal and vertical menu formats. In Proceedings of the Human Factors Society 31st Annual Meeting, 1987,715-717.Santa Monica, CA: Human and Ergonomics Society.

[29] S. R.Parkinson, N.Sisson, & K.Snowberry, Organization of board computer menu displays. *International Journal of Man-Machine studies*, 23, 1985, 689-697.

[30] A. Bruckman, & A. Bandlow, HCI For Kids .In: Jacko, J., Sears, A.(Eds.),*Human-Computer Interaction Headbook, Lawrence Erlbaum*, Hillsdale,NJ, 2003,428-440.