Abstract. 

Background, purpose. The purpose of the present study was to determine what text format, in the absence of space between words, is the easiest to read – “First-Letter-Capitalized” (e.g., SetTextStyle), “Uppercase-Word-Lowercase-Word-Alternation” (e.g., SETtextSTYLE), or “All-Lowercase” (e.g., settextstyle). 

Material and methods. Forty-five graduate students read nine statements (six true and three false) shown in those three text formats in a LATIN SQUARE design with repeated measures. 

Results, conclusions. The results indicated that the average reading time for the First-Letter-Capitalized condition was significantly less than that of the Uppercase-Word-Lowercase-Word-Alternation condition ($p < .01$). The average reading time for the Uppercase-Word-Lowercase-Word-Alternation condition, in turn, was significantly less than that of the All-Lowercase condition ($p < .01$).

Key words: legibility, text format, graduate students.

One difference among orthographies is space between words. Most written languages of the world such as English, French, Italian and German have space between words. Other written languages such as Japanese (when written in Hiragana), Sanskrit, Hebrew, Slavic, Greek, and Thai do not have space between words (Henderson, 1984; Just & Carpenter, 1987). The conventional Chinese text is also written without word spacing (Hsu & Huang, 2000). To compare written English text (space between words) with Thai text (no space between words), see, for example, the “preface” section of the Oxford River Books English-Thai Dictionary (Mallikamas, Chakrabongse, & Piammattawat, 2004). To compare written English text (space between words) with Chinese text (no space between

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1 Address for correspondence: Dept. of Counseling and School Psychology, College of Education, University of Nebraska at Kearney, Kearney, NE 68849; e-mail: archwametyt@unk.edu
words), see, for example, the “guide to the use of the dictionary” section of the *Oxford Chinese Dictionary* (Manser et al., 2003, pp. 1–4).

Does space between words facilitate reading speed? The answer seems to depend on which individual written language we are considering. In the Thai language which is normally written *without* space between words, Archwamety (1974, 1981) found Thai readers read Thai phrases or sentences with space between words *as fast as* those without space between words. However, in the Chinese language which also is normally written without space between words, Hsu and Huang (2000) found Chinese students spent significantly less time on Chinese text with half-character word spacing or with whole-character word spacing. On the other hand, in English which is normally written *with* space between words, Fisher (1975) found that when space between words is eliminated the reading speed could *slow down* from approximately 220 words/minute to about 110 words/minute. Try to read the following sentences:

1. “Thispaperwassubmittedforpublication.”
2. “This paper was submitted for publication.”

Although the normal written English language does have space between words, certain specialized written English languages do not. In a computer language called “C language,” space between words is not allowed in names of variables and functions. For example, Lafore (1991, p. 406) used a function name like “settextstyle” rather than “set text style” in his book on C language. This is certainly difficult to read as shown by Fisher’s work mentioned above. Despite its being difficult to read, this “All-Lowercase” (ALC) style is still being used in a large number of computer source codes today.

In the absence of spacing, one approach that makes the text easier to read is to use “First-Letter-Capitalized” (FLC) words, for example: “This-PaperWasSubmittedForPublication.”

Brady (1981) found that a sentence like the above was significantly easier to read than one in which all letters (except for the letter at the beginning of the sentence) were written in lowercase. The FLC approach has been employed popularly by computer programmers. For examples, Conger (1992, p. 34) uses a function name such as “GetWindowTextLength,” and Trudeau (1995, p. 358) uses a function name such as “GetDlgItemText” in their books on programming.
Still another approach that may make a *spaceless* text easier to read is the “*Uppercase-word-Lowercase-word Alternation*” (ULA) format, for example:

“THISpaperWASsubmittedFORpublication”

Here, each word is distinguished from its neighboring word by a difference in letter case, making each word a *perceptual whole* and therefore easy to recognize. Bock, Monk, and Hulme (1993) found that if this perceptual whole is disrupted by making some letters within a word taller than others, reading speed will be significantly reduced. However, this ULA approach is surprisingly absent from the literature of computer programming as well as research literature in the area of psychology of reading.

The purpose of the present study was to determine which format is easier to read-ALC, ULA or FLC. It was hypothesized in the present study that the “All Lowercase” (ALC) format would be most difficult to read because the word boundary indicator (space between words) is eliminated. The “*Uppercase-word-Lowercase-word-Alternation*” (ULA) would be easier to read because the case change provides a substitute word boundary. However, the “First-Letter-Capitalized” (FLC) format would be the easiest to read because not only does each capitalized letter indicates a word boundary but also words beginning with capital letters are already familiar to readers as in, for example, *titles* of books, articles, and tables.

**METHOD**

**Participants**

Forty-five graduate students in two research classes participated in the present study. They were randomly divided into three groups of 15 each through the use of the Table of Random Numbers.

**Materials**

Each student in each of the three randomly assigned groups was to read nine statements (six true and three false) shown randomly one at a time on the computer screen. The nine statements were selected by the author from a pool of statements collected from another class.
of graduate students who were told to generate a number of “obviously true” and “obviously false” statements.

**Group 1.** Each participant in Group 1 read the following nine statements: (FLC = “First-Letter-Capitalized” format; ULA = “Uppercase-word-Lowercase-word Alterna-
tion” format; ALC = All Lowercase” format)
1. theballcomesbackdownifitisthrownup [true, ALC]
2. thewaterstopswenthefaucetisturnedoff [true, ALC]
3. PeopleWearHeavyClothesInWinterToStayWarm [true, FLC]
4. TheBalloonPopsIfYouStickItWithAPin [true, FLC]
5. FORyouTObeABLEtoSEEyOUMustHaveLIGHT [true, ULA]
6. BRICKSareHEAVIERtoCARRYthancOTTON [true, ULA]
7. mostbirdscanswimfasterthanmostfish [false, ALC]
8. TheSunRisesInTheWestAndSetsInTheEast [false, FLC]
9. CHRISTMASfallsONtheLASTthursdayINjune [false, ULA]

**Group 2.** Each participant in Group 2 read the following statements:
1. TheBallComesBackDownIfItIsThrownUp [true, FLC]
2. TheWaterStopsWhenTheFaucetIsTurnedOff [true, FLC]
3. PEOPLEwearHEAVyClothesINwinterTOstayWARM [true, ULA]
4. THEballoonPOPSifYOUstickITwithAPin [true, ULA]
5. foryoutobeabletoseeyoumusthavelight [true, ALC]
6. bricksareheaviertocarrythancotton [true, ALC]
7. MostBirdsCanSwimFasterThanMostFish [false, FLC]
8. THEsunRISESinTHEwestANDsetsINtheEAST [false, ULA]
9. christmasfallsonthelastthursdayINjune [false, ALC]

**Group 3.** Each participant in Group 3 read the following statements:
1. THEballCOMESbackDOWNifITisTHROWNup [true, ULA]
2. THEwaterSTOPSwhenTHEfaucetISturnedOFF [true, ULA]
3. peoplewearheavyclothesinwintertostaywarm [true, ALC]
4. theballoonpopsifyoustickitwithapin [true, ALC]
5. ForYouToBeAbleToSeeYouMustHaveLight [true, FLC]
6. BricksAreHeavierToCarryThanCotton [true, FLC]
7. MOSTbirdsCANswimFASTERthanMOSTfish \[false, ULA\]
8. thesunrisesinthewestandsetsintheeast \[false, ALC\]
9. ChristmasFallsOnTheLastThursdayInJune \[false, FLC\]

**Procedures and Design**

Each student read the nine statements described above (six true and three false as described above) shown randomly one at a time on the computer screen (IBM PC) for five seconds. The student hit the “Enter” key if the statement was “true” but did not hit any key if it was “false.” The computer was programmed to record the “reading time” accurate to milliseconds. The “reading time” of a true statement was defined as the time it took a student to determine that the statement was true plus the time it took the student to press the “Enter” key on the computer. The false statements were included to ensure that the participants *really* read statements rather than just hit the “Enter” key.

The six true statements were grouped into three pairs typed in three different formats (FLC, ULA, ALC) and assigned to the three groups of students in a LATIN SQUARE design with repeated measures as shown in Table 1.

**Table 1. Assignment of Participants and Statement Formats in a Latin Square Design with Repeated Measures**

<table>
<thead>
<tr>
<th>Participants</th>
<th>n</th>
<th>Statement format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pair #1</td>
</tr>
<tr>
<td>Group 1</td>
<td>15</td>
<td>ALC</td>
</tr>
<tr>
<td>Group 2</td>
<td>15</td>
<td>FLC</td>
</tr>
<tr>
<td>Group 3</td>
<td>15</td>
<td>ULA</td>
</tr>
</tbody>
</table>

Thus, each group of students was exposed to all three formats and each pair of statements was written in all three formats. At the end of the reading task, the computer calculated the average reading time of each pair of sentences for each student.
RESULTS

The reading time averages, standard deviations, and number of participants were as shown in Table 2.

Table 2. Means and Standard Deviations of Reading Times for Three Statement Formats

<table>
<thead>
<tr>
<th>Statement format</th>
<th>Reading time (in seconds)</th>
<th>M</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLC</td>
<td>2.671</td>
<td>0.502</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>ULA</td>
<td>2.933</td>
<td>0.491</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>ALC</td>
<td>3.252</td>
<td>0.694</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

An Analysis of Variance of the 3 x 3 Latin Square with repeated measures indicated that the difference among the three averages in Table 1 was significant, $F(2, 84) = 17.654$, $p < .001$. Since the three averages (FLC, ULA, ALC) differed significantly, post-hoc comparisons were performed using the Newman-Keuls test. The test indicated that the average reading time for FLC was significantly less than ULA, $q(2, 84) = 3.782$, $p < .01$. ULA was significantly less than ALC, $q(2, 84) = 4.604$, $p < .01$. FLC was significantly less than ALC, $q(3, 84) = 8.386$, $p < .01$.

DISCUSSION

The hypotheses of the present study were supported by the analysis of the data presented above. The “All Lowercase” (ALC) text format was most difficult to read. The “Uppercase-word-Lowercase-word-Alternation” (ULA) format was significantly easier to read than the ALC. The “First-Letter-Capitalized” (FLC) format, in turn, was significantly easier to read than the ULA. The findings have practical implications for the present computer source code writing and the teaching of writing computer source codes. First, the popular practice of writing variable names and function names in First-Letter-Capitalized (FLC) format is to be commended. Second, the still prevalent practice of writing variable na-
mes and function names in All-Lowercase (ALC) format is unwarranted. Third, the still ignored practice of writing variable names and function names in Uppercase-word-Lowercase-word-Alternation (ULA) format should be tried by computer programmers as well as students and instructors of computer science. Reading computer source codes is usually hard work; the reader must decipher the code text as well as understand the algorithm. Using the results of the present study, future source code writers could write codes that are easier to read, thus freeing the readers to concentrate more on the algorithm.

The findings in the present study also have practical implications for teaching beginning readers of languages that do not have space between words such as Japanese (when written in Hiragana), Sanskrit, Hebrew, Slavic, Greek, and Thai. To help these beginning readers, the first character of each word could be printed in larger size than the rest, or the words could be printed in alternating large and small sizes.

In addition to the practical implications described above, the present study also paves the way to possible future related studies. The study has pointed to and emphasized the fact that in the absence of space between words, other indicators of word boundary such as FLC and ULA do facilitate reading. It has also indicated that not all forms of word boundary are equally facilitative. The First-Letter-Capitalized (FLC) boundary format is more facilitative than the Uppercase-word-Lowercase-word-Alternation (ULA) boundary format. Future research may need to experiment with further variation of word boundary indicators (such as underlining orboldfacing the first letter of every word in a spaceless phrase or sentence) and their relative facilitative effects on reading. How could these relative facilitations be explained? A theoretical formulation may provide an answer to this question in the future.

Finally, the present study points to a need for more research on the effect of letter case alternation at higher than the individual letters level. Although many past studies (e.g., Besner, 1989; Fisher, 1975; Smith, Lott, & Cronnell, 1969) have investigated the effect of case alternation letter by letter (e.g., ThEbALLcOmEsBaCkDoWnIfItIsThRoWn Up) on reading, little has been done on the effect of case alternation word by word as tried in the present study (e.g., THEballCOMESbackDOWNIfITisTHROWNup). Future studies could further investigate the effect of case alternation word
by word or even phrase by phrase (e.g., THEBALLcomesbackdownIFitisT-HROWNUP). Comparing the effects of case alternation at the letter level, word level, and phrase level could shed further light on the issue of unit of processing in reading. While we are reading, do we process letter by letter, word by word, or phrase by phrase?

References
TEKSTO, KURIAME NĖRA TARPŲ TARP ŽODŽIŲ, ĮSKAITOMUMO GERINIMAS

Teara Archwamety


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