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# Using MEL to present Chinese characters at brief display times

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Most studies that present Chinese characters at brief display intervals (10–100 msec) use tachistoscopic presentation. The present paper describes a way of using software packages NJSTAR (for generating Chinese characters) and MEL (for programming an experiment) to achieve computer CRT presentation. Techniques for (1) enlarging and smoothing characters, and (2) presenting characters at brief display times are featured. The techniques can be applied to brief CRT presentation of any graphics. A replication study is presented to demonstrate that the techniques produce reliable data.

A continuing controversy in the reading literature is the extent to which phonological processing is used or bypassed in fluent reading. A collection of studies supports the claim that phonological processing is not only present in fluent reading; it is also primary. That is, it dominates the word-identification process and actually precedes orthographic and semantic processing in the brief timeline of word identification (e.g., Van Orden, 1987). Whereas most of the early work on this topic was done with English readers, since then some researchers have examined the time course of phonological, orthographic, and semantic processing in readers of symbol-based orthographies, such as Chinese (Perfetti & Zhang, 1991) and Japanese Kanji (Wydell, Patterson, & Humphreys, 1993). At issue is whether the type of orthography (alphabet based or symbol based) determines the degree and timing of phonological processing in the word identification of fluent readers.

Two main methods have been used to study the timing of phonological processing in fluent readers' word identification. One is priming, in which a word or character that is similar phonetically, orthographically, or semantically to a target word is presented, followed by the target word. The exposure time of the prime or the target is varied in order to determine at what point in the processing a phonetic prime (or an orthographic or semantic prime) has its effect. The second method is masking. A target word or character is presented, followed by a masking word or character that is similar to the target phonetically, orthographically, or semantically. At a given stimulus onset asynchrony, the extent to which the mask effect is lessened by similarity to the target reflects the type of processing taking place. Thus, for much of this research, it is critical that words or characters can be presented at display intervals as brief as 20 msec.

In hundreds of studies, words have been presented on computer monitors at display times as fast as 20 msec. However, in our review of the literature, we could not find any studies in which Chinese or Japanese characters were presented on a computer for less than 100 msec. Typically, a tachistoscope has been used. Certainly, there are advantages to using a tachistoscope rather than a computer. However, there is also some advantage to using a computer rather than a tachistoscope. For example, a computer is often more available. It can control the parameters of the experiment and record subject responses at the same time. If programmed correctly, there is less room for human error in the ordering of trials.

The present paper describes our method of presenting Chinese characters using the Microcomputer Experimental Laboratory (MEL, Version 1.0; Schneider, 1990; Psychological Software Tools, Pittsburgh). The MEL program makes it very easy to present text at brief display intervals, but, to present graphics faster than 50 msec, the user must write additional code in the MEL programming language. Thus, the present paper should be useful not only to people doing research on reading Chinese characters, but also to researchers who want to use MEL to present graphics other than Chinese characters at fast display times. An experiment is described in which the techniques were used to replicate Perfetti and Zhang's (1991) Experiments 1 and 2, a backward-masking experiment which was done using a tachistoscope.

## COMPUTER CHARACTER DISPLAY TECHNIQUE

### Generating and Preparing Chinese Characters

Chinese characters were generated using the software NJSTAR 1.23 (Ni, 1991; Hongbo Datasystem, Epping, Australia). The program prompts for the pinyin spelling of a character, and the user types it in. Pinyin is the alphabetic equivalent for the pronunciation of a Chinese

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character. Then the program offers all the possible characters that match the pinyin spelling. There could be 1 to 10 or more. The user simply chooses the desired character, and it appears in the text portion of the screen. In this way, one can compose an entire text using Chinese characters, and proceed as with any other word-processing program. However, for our purposes, the characters to be used in the experiment were simply put into files, about 40 to a file.

Because NJSTAR does not enlarge characters, the characters were enlarged using the graphics program Microsoft Windows Paintbrush 3.11. With enlargement, the characters lost their curved-line look, and so were "smoothed" manually, also by using Paintbrush. This was done by filling in and deleting pixels until the characters resembled standard written characters in the judgment of the first author, whose native language is Mandarin Chinese.

The NJSTAR program can write alphabet letters or Chinese characters to an ASCII or PCX output file format, but the particular versions of these formats are not necessarily compatible with other software. For example, the PCX format cannot be read by either MEL or Paintbrush (though both do read PCX-formatted files) but *can* be read by Harvard Graphics 3.0. In the present study, NJSTAR PCX files were read in by Harvard Graphics, converted to PCX files that were readable by Paintbrush and MEL, read in by Paintbrush, enlarged and smoothed, and finally prepared for reading in by MEL.

### Incorporating Chinese Characters Into a MEL Program

MEL allows two ways to program experiments. One is the fill-in-the-blank "form system," and the other is the MEL programming language code. The form system prompts the experimenter to fill in the information that will specify the details of the experiment (e.g., instructions, trial events, timing, trial presentation order, etc.). After the experimenter has filled in the forms, MEL program code is generated that will run the experiment. When no form exists to accomplish an aspect of an experiment, the experimenter can write MEL code him-/herself. Thus, the form system can be used to lay out most of the experiment, and MEL code can be added in wherever necessary. The form system includes a code form that calls the added MEL code programmed by the experimenter.

To present Chinese characters (or any graphics) for less than 50 msec, MEL code must be used. With the form system alone, MEL simply cannot find a graphics file on disk, clear the screen, and present the graphic any faster than about 50 msec. Too much time is needed to access the file on the disk. However, MEL code can be written to access several graphics at once if they are in the same file, hold them in video memory, and then display them when needed. The interface between the PCX file and MEL is made via the MEL code command READ_PAINT_FILE( ), which accesses the PCX file containing the prepared characters (see Part 3 of the MEL code in the Appendix).

For the present experiment, the enlarged, smoothed characters were copied, 40 to a file along with a fixation cross and a final pattern mask (a total of 42 items). The location of each item within its file was noted in pixel dimensions, obtained with the help of Paintbrush, after the characters had been enlarged and smoothed. The smaller the field of the graphic, the faster access and presentation can be. For this reason, the smallest pixel dimensions possible that still captured the entire character were used. For uniformity of screen presentation, the pixel dimensions for each character were the same, and the characters were centered within the field. A streamlined version of the MEL code that was used to present the characters is provided in the appendix.[1] It shows how to (1) locate each of 42 items in the PCX file by pixel dimensions, (2) turn on Graphics Mode and create a bitmap to store the PCX file, (3) read the PCX file into the bitmap, and (4) present a succession of four graphics on the screen at specified display times (a fixation cross, a target character, a character mask, and a final pattern mask). Comments—designated by "!"—precede the code.

## REPLICATION OF PERFETTI AND ZHANG (1991)

Perfetti and Zhang (1991) used both backward masking and priming to explore the role of phonological processing in Chinese character identification. The present study replicated their backward-masking results (their Experiments 1 and 2). They showed subjects a target Chinese character for 30–70 msec, followed by a mask for 30 msec and a final pattern mask, and asked the subjects to identify the target character. They compared five mask conditions: homophonic (sounding similar to the target character), graphic (looking similar to the target character), semantic (similar in meaning to the target character), control (unrelated to the target character), and baseline (no mask). Their results showed that if the mask was unrelated to the target character, target character identification was greatly reduced relative to that of the baseline condition. If the mask was graphically related to the target character, the detrimental effect of the mask was lessened. This indicated that graphic processing of the target character must have been taking place when the mask was presented. The aspects of the target character that were similar to the mask were, in a sense, not masked out. There was no attenuation of the basic masking effect when the mask was phonetically or semantically similar to the target character, suggesting that phonological and semantic processing were not taking place when the mask was presented. The implication was that phonological and semantic processing are not prelexical processes in the identification of Chinese characters.

Perfetti and Zhang (1991) used a tachistoscope to present Chinese characters at fast display times. In the present replication, the same five masking conditions were compared, but a different set of characters was used and the experiment was run on a computer rather than a tachistoscope. The only other differences were that in the present experiment Perfetti and Zhang's Experiments 1 and 2 were combined, allowing the same subjects to perform both the baseline condition and the masking condition, and a noncharacter mask ("#") was added to the baseline condition so that the time between target character and final pattern mask would be the same as in the character-mask conditions.

## Method

**Subjects**. Thirty native speakers/readers of Mandarin Chinese participated. All subjects were students from overseas or their relatives. Their mean age was 28.77 years (*SD* = 4.11).

**Apparatus and Materials**. A DTK computer (IBM/PC AT compatible) equipped with an EGA graphics card and a Samsung SC-431 13-in. monitor was used. Stimulus materials consisted of 40 target Chinese characters each matched with five masks—homophonic, graphic, semantic, and control character masks and a noncharacter mask ("#") that was used in the baseline condition. In addition, there was a final pattern mask, consisting of a circle with a cross in it, that was used to end all trials.

The approximately 1.3 × 1.3 cm fixation cross, characters, and pattern mask appeared in white against an approximately 2.5 × 2.5 cm black square, outlined in white. The screen background was black. Viewing distance was about 30 cm.

The character masks were matched to their target character and to each other in terms of number of strokes and frequency, using the reference *Frequency of Modern Chinese Characters* (Committee of National Linguistic Study & National Standard Institute, 1992). Mean number of strokes were 8, 9, 9, 9, and 8 for target, homophonic, graphic, semantic, and control characters, respectively. Mean frequencies for those characters were 487, 348, 231, 375, and 395, respectively.

**Procedure**. Each subject completed a threshold session and an experimental session. The threshold session determined the target character display time needed for 40%–60% identification accuracy when followed by an unrelated character mask. This display time was considered the threshold identification time and was calculated for each subject separately.

The threshold session consisted of up to nine blocks of 20 trials. In each trial, a fixation cross was shown in the center of the screen for 1 sec, followed by a target character for 20–100 msec, followed by a control character mask for 30 msec, followed by the final pattern mask, which stayed on the screen until the response was made. The subjects were to try to identify the target character, write it down, and press a key to continue. In the first block of trials, the target was presented for 20 msec; this duration increased by 10 msec in each successive block, until the subject met a criterion of between 40% and 60% correct within one trial block, at which time the threshold session ended.

In the experimental session, there were 200 trials (40 target characters in each of five different masking conditions). On each trial, a fixation cross was shown in the center of the screen for 1 sec, followed by a target character for a time interval determined in the threshold session, followed by a mask for 30 msec, and then by the final pattern mask, which stayed on the screen until a response was made. As in the threshold session, subjects were to identify the target character, write it down, and press a key to continue.

For each target character, each mask condition appeared first of the five for an equal number of subjects (6). The remaining four mask conditions were ordered randomly for each target character. Given these constraints, the order of trials was randomized and was different for each subject.

## Results and Discussion

The mean percent correct and standard deviation for each mask condition were 40.3 (*SD* = 16.0), 48.6 (*SD* = 15.6), 41.4 (*SD* = 15.8), 40.3 (*SD* = 14.1), and 55.2 (*SD* = 15.0) for homophonic, graphic, semantic, control, and baseline mask conditions, respectively. A one-way repeated measures analysis of variance showed a significant effect of mask condition [$F(4,116) = 23.7$, $p < .001$]. The baseline condition was significantly easier than the control mask condition [$t(29) = 7.9$, $p < .001$], suggesting that the character masking was effective. Also, the graphic mask condition was significantly easier than the control mask condition [$t(29) = 4.2$, $p < .001$], suggesting that subjects were processing the characters graphically at the time the mask was presented. There were no significant differences between the control mask condition and the homophonic or semantic mask conditions.

The results replicate the exact pattern of results in Perfetti and Zhang (1991), suggesting that graphic processing, but not phonological processing or semantic processing, is present prelexically in the identification of Chinese characters. It should be noted that the results (of both studies) pertain only to identification of characters in isolation—not of those in text—and only when a written response was required. Results could be different if subjects were required to read connected text or to say the name of the character.

## CONCLUSION

The present study showed that, using MEL, Chinese characters can be presented on a computer screen for display times less than 50 msec. The replication of Perfetti and Zhang (1991) showed that there is little, if any, sacrifice in the clarity of the data as compared with tachistoscopic presentation. The techniques we used to present characters are of immediate value to researchers studying reading in Chinese. However, they can also be used with any other type of graphic, and therefore should be beneficial to researchers studying other areas of perception and cognition as well.

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## NOTE

1. The source code files and the executable file are archived in COMPsych, which can be accessed via anonymous ftp to gluon.hawk.plattsburgh.edu in the directory pub/compsych/bmric. For more information about COMPsych, send e-mail to compsych@snyplava.bitnet or compsych@splava.cc.plattsburgh.edu.

## APPENDIX
## Streamlined Version of MEL Code Used to Present Characters

(1) locate each of 42 items in the PCX file by pixel dimensions specify constants determining the position of the characters and variables (in this example, the target character is shown for 40 ms, since time_target=40).

```
  constant (ncells=48, nchars=40, column=8, xwidth=70,
     ywidth=70, x_offset=5, y_offset=20, time_target=40)
  integer (i,i1)
  string (response(1))
  array_of_integer(shapex(ncells),shapey(ncells),rect_array(4))
!set coordinates for upper left corner of each character in the
  !PCX file
     for i=1 to ncells do begin
     shapex[i]=remainder(i−1,column)*xwidth+x_offset
     shapey[i]=(i−1)/column*ywidth+y_offset
  end
```

(2) turn on Graphics Mode and create a bitmap to store the PCX file

```
  graphics_on ('')
  create_bmap(1)
```

(3) read the PCX file into the bitmap ('filepath\filename.pcx' is a variable representing the name of the PCX file in which the characters are stored)

```
  set_bmap(0)
  clear
  read_paint_file('filepath\filename.pcx',1,true,0,0)
```

(4) present a trial—a succession of 4 graphics presented at specified display times (a fixation point, a target character, a mask, and a final pattern mask). Trial order is specified in the form system. A loop (i1) is established to accomplish the presentation of all trials (20 in this example).

```
    i1=1
    while (i1 <= 20) do begin
!match upper left corner of character to appropriate screen
!position
    rect_array[3]=(maximum_x−xwidth)/2
    rect_array[4]=(maximum_y−ywidth)/2
!display fixation cross for 1 second
    rect_array[1]=shapex[47]
    rect_array[2]=shapey[47]
    copy_bmap_rect(1,rect_array,xwidth,ywidth)
    wait(1000)
!display target character for specified duration (time_target)
    rect_array[1]=shapex[2*(i1−1)+1]
    rect_array[2]=shapey[2*(i1−1)+1]
    copy_bmap_rect(1,rect_array,xwidth,ywidth)
    wait(time_target)
!display mask for 30 ms
    rect_array[1]=shapex[2*i1]
    rect_array[2]=shapey[2*i1]
    copy_bmap_rect(1,rect_array,xwidth,ywidth)
    wait(30)
!display final pattern mask and wait for keypress to start the
!next trial
    rect_array[1]=shapex[48]
    rect_array[2]=shapey[48]
    copy_bmap_rect(1,rect_array,xwidth,ywidth)
    key_in(response,' ','w',0,0)
    wait(-1)
    execute
!increment i1 to go on to the next trial
    i1=i1+1
  end
```

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