East Meets West

A Western Attempt to Explain Recognition of Chinese Characters

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INTRODUCTION

Object identification is the recognition of letters, faces, shapes, words and figures. The visual system process various images through a variety of low-level visual skills, including orientation and spatial frequency discrimination, element segregation using textual cues, depth perception and motion discrimination. (Westheimer, 1996) In object identification, we recognize an object by detecting and integrating the object's features. (Neisser, 1967; Campbell & Robson 1968, Watson, 1979, Robson & Graham, 1981, Pelli, Farell & Moore, 2003) It is still unknown how humans manage to integrate a series of features (Berger, 2001) but researchers believe that by analyzing the process of object recognition. Knowledge of how complex object recognition occurs can result in a better understanding of the reading process which is still a mystery today. Is object recognition for all objects the same? The Gestalt theory which attempts to explain objection recognition performed experiments with Roman letters, but is the concept universal? Does the recognition of Chinese characters the same as the recognition of Roman letters?

Currently, the most well known theory among psychophysicists is the Gestalt Theory, which states that humans recognize an object holistically; in other words, an object is recognizes as a whole. (Wertheimer, 1923) For example, the letter "A" is recognizes holistically because a normal reader can identify the letter "A" in their peripheral vision without a problem. The reader is able to see all three strokes of the letter "A", "/", "-" and "\" in his or her periphery, as one image and correctly state that it is the letter "A." An object that is recognizes holistically has only one part for recognition and the whole object falls within a fixed distance known as the critical spacing. (Martelli et al., 2005)

Contrary to the Gestalt Theory is the contemporary debate of objects that are recognize by parts. For example, readers recognize the word “School” by parts because a normal reader would not be able to identify the word in his or her peripheral vision. The word would appear ambiguous to the reader because other than the letters “S” and “L,” the letters seem jumbled up and nearly impossible to identify. This problem occurs because the letters that make up the word crowd each other in the periphery.

Crowding is the impairment of letters or objects recognition in the periphery by neighboring objects. (Pelli, D. G., 2004) The letters or objects appear to be scramble up and ambiguous because multiple parts of the letters, in this example, the letters “c“, “h“, “o“, “o” crowd each other. This problem occurs in the periphery because the area of where each of the letter “c”, “h”, “o” and “o” lie in, known as the critical spacing or isolation field interferes with another. For example, the letter “c” has an isolation field that crowds the letter “h.” (Bouma, 1970)

In attempt to resolve the problem between the Gestalt theory and the contemporary debate, researchers analyze crowding of letters and words in the periphery. For letter and word identification, spatial crowding is emphasizes because researchers are not sure which part of the letter or word is a feature or whether the entire word for experience readers is a feature. And attempts to empirically distinguish between the Gestalt theory and the contemporary debate had only limited success. (Rakover, 2002)

Modern psychophysicists and researchers focus on the problem of how we integrate features to recognize a word (Martelli et al., 2005) because very little is known but presumably images that appear to be identical share a large number of features. (Suchow, 2004) Experiments conducted by various psychology experts discovered that

the complexity of a letter may influence the identification of the letter in some alphabets. An example is the Roman alphabet, (letters “a” through “z”) which observers can easily identify. (Pelli, D. G, in press) However, although the identification of Roman letters is holistic, the recognition of words is not holistic. (Pelli, D. G, in press)

Researchers hope to understand something that would illuminate the general issue of object recognition in letter and word identification experiments and settle the disputes regarding the Gestalt Theory. The Roman letters, a practical and ideal tool for studying object identification because the identification of printed letters is the simplest case that preserves the processes of recognition. (Pelli, D. G., in press) Less complex Roman letters are believe to be easier to identify than Chinese characters which embodies a hierarchy of common written forms, and by extension features. (McNaughton & Ying, 1999) Because the Roman letters are less complex, there are fewer features in the letters that can crowd each other and affect the identification of the word. Chinese characters are believed to be inefficiently identified because their complexity exceeds the capacity of the visual memories that mediate letter identification. (e.g. Attncave, 1955, Fehrer, 1935, Weinsten, 1955, Pelli and Farell 1992, Pelli, D.G, in press)

My new prediction hypothesizes that Chinese characters are recognized holistically, independent complexity and the effects of crowding. This hypothesis disputes the Gestalt theory and adds to the contemporary debate of whether we recognize particular objects holistically or by parts. (Prinzmetal, 1995) Unlike the Gestalt theory, which states that the efficiency of letter identification is inversely proportional to the complexity, the Chinese characters introduces the idea of identifying and recognizing efficiency of a character independent of the amount of features it pertain. In addition,

internal crowding does not occur in holistic Chinese characters because the features of one character such as its number of strokes in a single isolation field at a fixed critical spacing does not crowd among itself.

Chinese characters are recognized holistic in the periphery compared to English words which are identified by parts. In general, words in the periphery are nearly impossible to identified, and if the words are recognized, the words' K-values are greater than one. K-values, the ratio of the area of the object to the area of the isolation field at the farthest distance the observer can identify the target in the periphery (Pelli, D. G., 2004) are used to represent whether an object is recognized holistically or by parts. If an object's K- value is less than or equal to one, the object is holistic and if its K-value is greater than one, the object is recognize by parts and crowding occurs.

Although Roman letters are combined to form words, a Roman letter by itself is recognized holistically thus its K-values are less than or equal to one. High K-values for words occur in the periphery because the letters crowd each other and the word becomes unrecognizable. (Bouma, 1973) However, word recognition can be possible in the periphery if the letters are spaced far enough apart so that each feature is isolated from the rest by critical spacing large enough to prevent crowding. Exploding the word or isolating the target, for example a letter in an experiment run in the periphery lowers the effects of crowding thus the similarities and differences between identification of Roman letters, English words and Chinese characters can be analyze. (Martelli, et al., 2005)

MATERIALS:

The experiments conducted to analyze whether Chinese Characters are holistic, tested 26 random Chinese characters obtained by using the Yung font were

26 random four letter words generated by the computer and 26 Roman letter alphabet (letters A-Z) in Times New Roman font on five observers. The random four-letter words were (dual, kill, kate, hubs, clip, hays, auto, soon, lint, sloe, damn, jars, raws, bass, jeep, fist, look, wave, polo, crew, rudy, rely, capo, chin, gaze and went.) The five observers performed the identification experiments on an Apple Power Macintosh computer which had a MATLAB software and Photoshop installed.

The MATLAB software analyzed the subject's responses for a single run, a run composed of 10 trials for each of the twenty-six variables, so in a single run there was a total of 260 flashes of variables on the screen. The MATLAB program produce the K-values, standard deviations, number of trials and the correct answers for each variable tested by converting the input of data performed by the observer into an output of data as K-values.

Photoshop was used to create the images of the Chinese characters, Roman alphabet and the random four letter words so the image of each variable was the same length and width; 2.5 by 2.5 pixels. Measuring tape was needed in order to measure the distance, 50 centimeters from the observers' eyes to the computer screen, a distance the

observer kept throughout the experiment. All five observers were from similar backgrounds, 17 years old American and fluent English readers, with the difference in their ability to read Chinese. Two of the subjects were not Chinese and could not read, speak or understand Chinese characters, while the other three subjects were Chinese and could speak, understand and read Chinese fluently.

METHODS:

Procedure I- Recognition of Chinese Characters for Fluent Chinese Readers

In procedure I, the three Chinese observers fluent in reading Chinese ran three different experiments in their periphery to demonstrate the differences in K-values due to the various effects of crowding with identification of 26 Chinese Characters, Roman letters and English words; a total of 78 variables. The Chinese characters, the random 4 letter words and the 26 letter Roman alphabet were flanked on all eight sides by random characters or letters (based on the variable being tested.)

Figure 1: Chinese character stimulus-

Fixating at the point on the right, subjects were asked to identify the center character, which in this example is the character .

The purpose of the flankers was to demonstrate the idea of holistic Chinese characters. If the Chinese characters are holistic, there would not be internal crowding among the flankers and the target so the observer would have no problem identifying the target (center) character. The flankers just like the target signal were in black in order to enforce the idea that the subjects had to identify the characters, words or letters using their peripheral vision and to prevent color as a confounding variable.

Before the three fluent Chinese observers could begin the experiments, they had to fixate on a fixation point, a small black circle on the right of the screen, and were asked to remain fixating on the black dot throughout the experiments. By fixating on the fixation point, the observers could only identify the target character using their peripheral vision. The three observers performed the experiment one at a time. Their first experiment was to identify the 26 random Chinese characters which were flashed one by one on the computer screen for 200 ms and followed by a blank screen. The observers were given as much time as they needed to say the character they saw in their periphery.

The three fluent Chinese observers were asked to identify the Chinese character they believed they saw in their periphery by verbally stating the character. I sat on the side listening for the correct answer. If subject's response was correct, I typed in the letter "r" for right and a beep was played to let the subjects know their response was correct. The letter "e" for error was pressed if the answer was incorrect and "c" for blank response, if something went wrong such as the subject was not fixating.

The orders of the Chinese characters flashed were randomized and the sizes of the characters changed depending on the observer's response. If the observer said the correct answer, the size of that character got smaller the next time it appeared, but if the response

was wrong, the character got larger. However, the fixation point did not change and the observers were not allowed to look away from the fixation point. The format of the screen from right to left was the fixation point, the eccentricity; the distance from fixation mark to the target, and the Chinese character flanked by 8 Chinese character flankers.

Each observer ran the experiments independently from each other and received breaks after each identification experiment but all three observers were asked to performed the identification for Chinese characters first, and after the identification of 26 Chinese characters, which was a total of 10 trials for each character, the observers ran 10 trials for the 26 Roman letters and 10 trials for computer generated four letter words using the same procedure.

Procedure II- Recognition of Chinese Characters by Non-Fluent Chinese Readers

In order to confirm the hypothesis that Chinese characters are holistic, even if the subjects were not fluent Chinese readers or speakers, the only difference between Procedure I and II was in the Chinese characters experiment. Procedure II's Chinese character experiment contained a training demo Procedure I did not contained because the two non-fluent Chinese readers were not able to verbally pronounce the character they saw in their periphery. Since they could not read the Chinese characters, the training demo represented, each Chinese character with a Roman letter from "a" to "z." The training demo was an introduction created in order to allow the non-fluent Chinese readers to be able to identify the characters flashed on the screen.

After all 26 characters were presented with representations in the training demo; the observers were tested for recognition of the characters. The demo flashed a certain

Chinese character for 200 ms and if the observer correctly identified it with its representation, the next character was flashed. If the observers incorrectly identified the character, the demo repeats the same image for 200 ms over and over again until the observer correctly identified it. Only after the subjects correctly identified all 26 Chinese characters were they allowed to proceed into the actual experiment.

The experiments that followed were exactly the same as Procedure I's with 10 trials for 26 Roman letters and 10 trials for the 26 computer generated 4 letter words and both observers were given breaks in between the experiments.

RESULTS/ANALYSIS:

Two of the three fluent Chinese readers performed four trials with the Chinese characters' experiment. The third Chinese reader performed three trials with the Chinese Characters. The non-fluent Chinese readers conducted the experiment twice, once with a training demo, once without it. Each trial composed of 10 runs and a complete set; a total of 26 Chinese characters on each run.

According to the graph (Figure 2) in general, the fluent-Chinese readers had lower K-values than the non-fluent Chinese readers. But for all five observers, most of their K-values were within the 0-1 range which meant that the observers identified the Chinese Characters holistically.

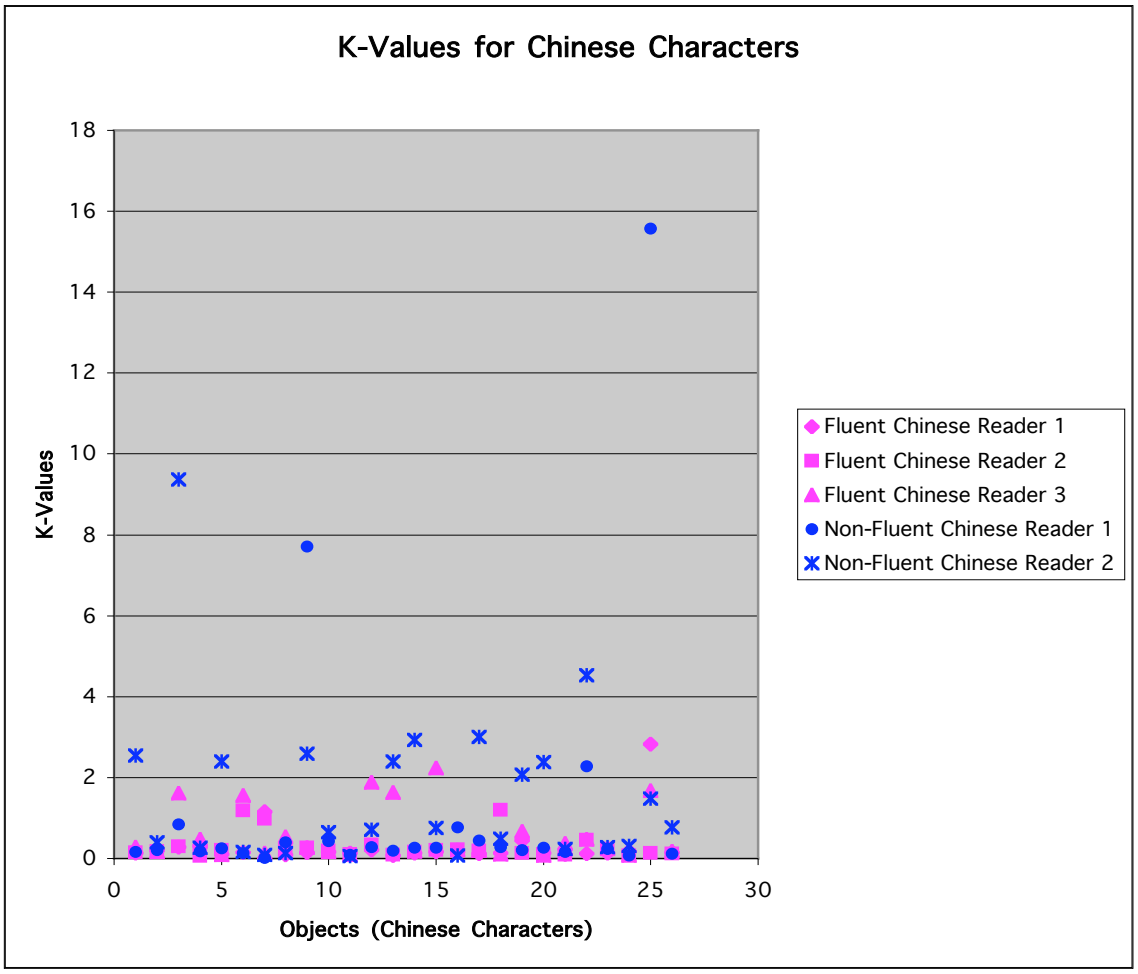

Figure 2- K-values for Chinese Characters

Similar to the Chinese character's K-values, most of the Roman letters fall within the 0-1 range indicating that the observers identified the Roman letters holistically. (See Figure 3) Although the K-values for Roman letters were lower than the K-values for Chinese characters, since most of the points were below a K-value of 0.5, the K-values which were greater than 1 were non-fluent observers whose K-values decreased as they proceed into the experiment. In addition the observer whose K-values was greater than 1 for Chinese characters tend to have higher K-values for Roman letters as well. Thus with further practice, the K-values for non-fluent Chinese readers would be lower than 1 and similar to the Roman Letters'.

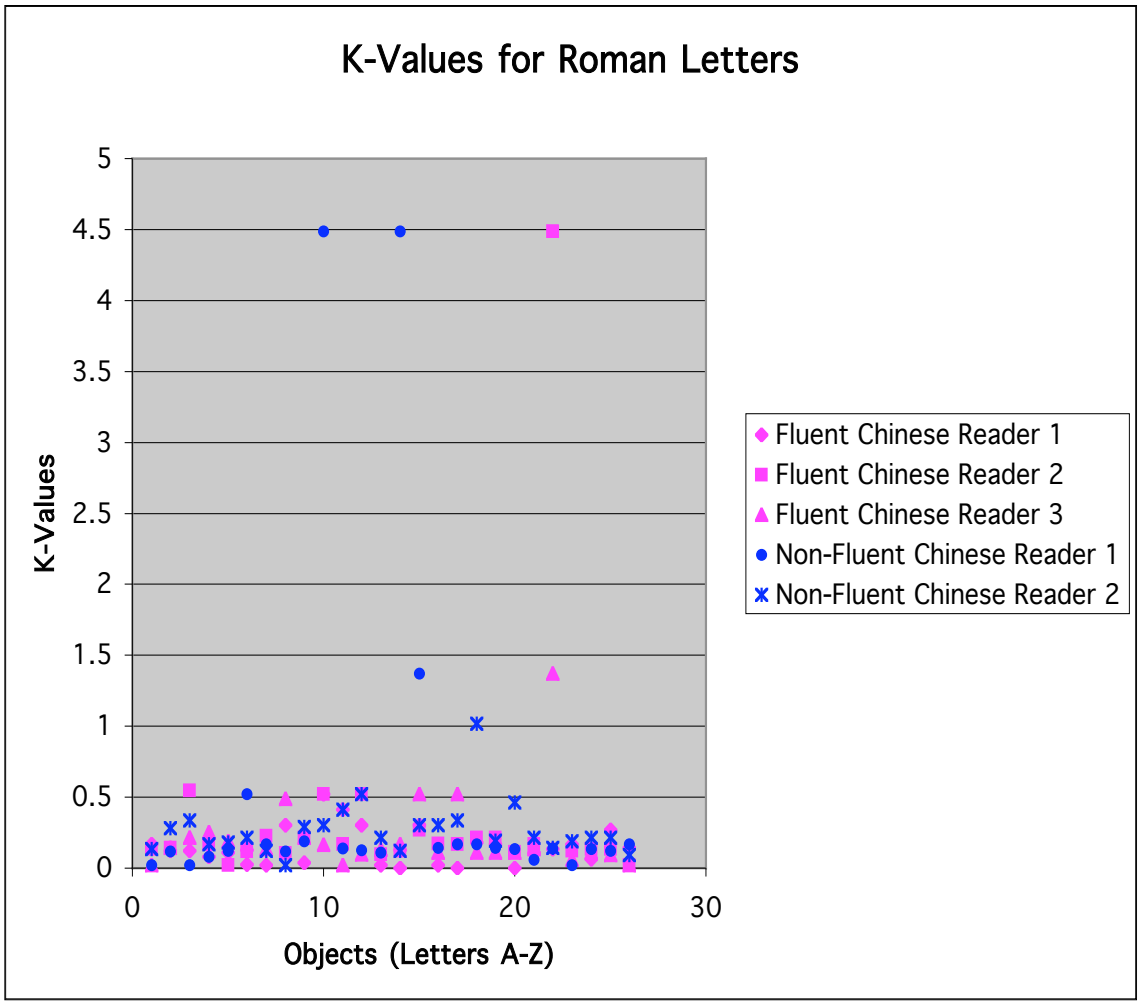

Figure 3- K-values for Roman Letters

The graph for random four letter words (Figure 4) showed that words are recognized by parts because for all five observers, their K-values were greater than one but within the 0-50 range. The one exception was an observer with a K-value of 571 because she could not recognized the word bass. What she recognized was the word bats.

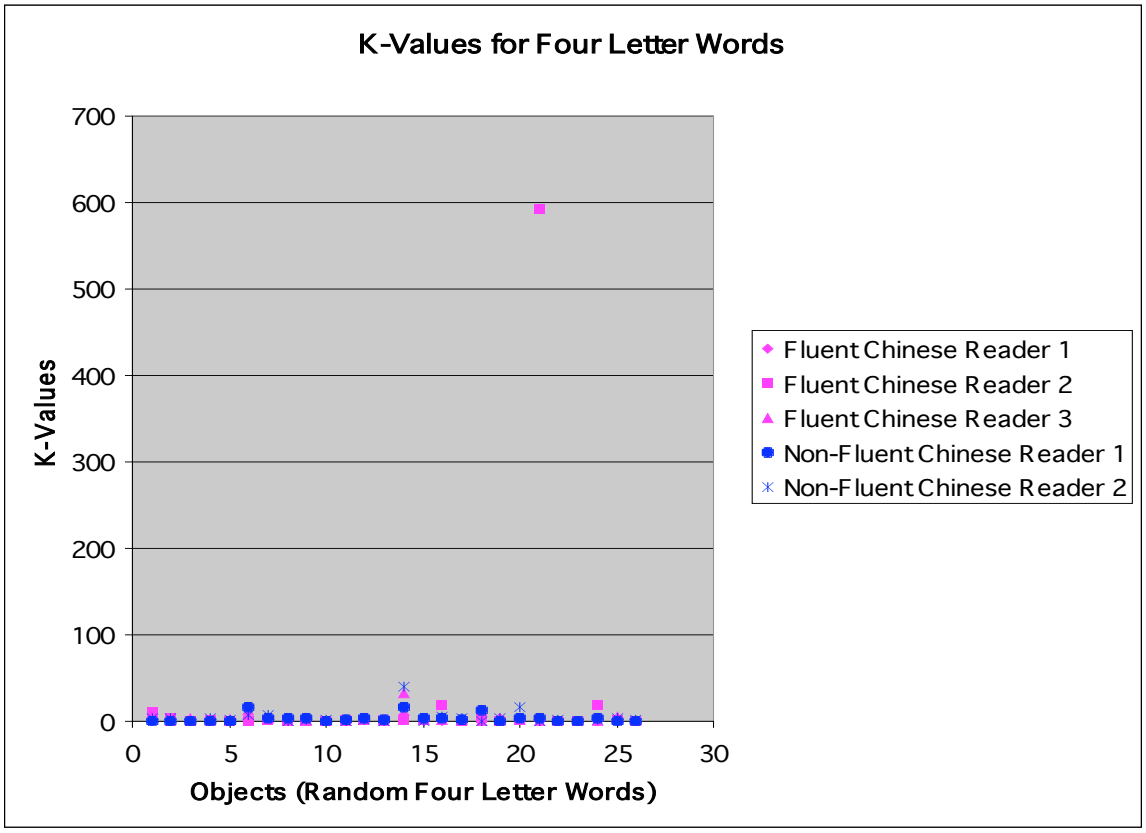

Figure 4 – K-values for four letter words

DICUSSION:

Based on the three experiments conducted with 26 Chinese characters, 26 Roman letters and 26 random four letter words , results suggested that recognition of Chinese characters is similar to the recognition of Roman letters. Unlike the recognition of four letter words, Chinese characters and Roman letters were recognized holistically by all three fluent Chinese readers. The non fluent Chinese readers identified most of the Chinese characters holistically, and their data were similar to fluent Chinese readers because the K-values, for Chinese characters and for Roman letters were analogous.

Surprisingly, although non-fluent Chinese readers were only trained by a demo to recognize the Chinese characters, in general, the subjects were able to use their peripheral

vision and recognize the characters flanked by random Chinese characters holistically. The non-fluent observers' at first performed relatively poorly compared to the fluent readers, but a tremendous improvement occurred after the first half of the experiment. Comparing the data for the first trial with the second trial for both non-fluent subjects reveal a significant change in K-values. Two possible reasons for the K-values to be much lower on the second trial than the first were familiarity with the task and familiarity with the Chinese characters.

After analyzing both possibilities, the influence of familiarity with the Chinese characters was probably the essential reason because familiarity with a task would not be able to over come the effects of crowding, which in this case the subjects, both fluent and non-fluent readers were able to overcome. Holistic recognition is possible when there is no internal crowding among the features of the letters, words, and characters which cause the observer to perceive the letter, word and character ambiguously. The results from the non-fluent observers confirmed the idea that Chinese characters are recognized holistically regardless of whether the subject was a fluent reader or speaker.

The results also showed several low K-values for the 4-letter words, for both, the fluent Chinese readers and the non fluent Chinese readers (see Figures 5 and 6) however, the visible trend was holistic Chinese Characters and letters. The reason behind the low K-values was not due to holistic recognition but sample size. The sample size was only 26 four letter words because there was only 26 letters in the English alphabet. Observers were able to use the process of elimination when they perceived one or two letters to correctly identify the word.

A single run was performed for the 26 Roman letters experiment and the 26 four letter words experiment because all observers were able to correctly guess answers after the third trial. By the second run, the non fluent Chinese observers were also familiar enough with the Chinese characters that they were able to guess the character flashed thus the two non-fluent Chinese readers only performed two trials of the experiment. Although the fluent Chinese readers were familiar with the Chinese characters, they performed four trials for Chinese character experiment because their range of vocabulary hindered their use of the process of elimination. Often times, the three fluent Chinese readers said a Chinese character that was not in the experiment because they forgot the 26 characters in the set due to their large range of vocabulary.

CONCLUSION:

Contrary to the belief that Chinese characters are recognized by parts due to the amount of brushstrokes and its complexity, the Chinese Character is recognized holistically. The character is recognizes holistically like a Roman letter, and not like four letter word. Because Chinese characters are recognized holistically, the observers were able to recognize the character in one isolation field. The background of the observers, whether they were fluent Chinese readers did not affect the holistic recognition of Chinese characters. The holistic recognition of Chinese characters confirmed the Gestalt theory that objects are recognized holistically but disputed the idea that complexity influences the recognition of holistic objects.

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