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ABSTRACT

A study of Chinese logograph recognition investigated: (1) whether word-length effect is generalizable to Chinese readers in recognizing context-free logographic characters; (2) whether readers from mainland China would outperform readers from Taiwan when each group read its own familiar logograph version; (3) whether both groups would perform better in recognizing legal characters in comparison with illegal characters; and (4) the strength of the relationship between number of strokes, character frequency, and reaction time in the recognition task. Subjects were 166 native mainland Chinese and 159 native Taiwanese undergraduate and graduate students. Stimulus materials were 90 Chinese characters: 30 simplified legal, 30 complex legal, and 30 complex illegal characters. Subjects were asked to recognize and pronounce each character as quickly as possible. Results indicate that: the word-length effect can be generalized to context-free Chinese logograph recognition; familiarity of characters was more important than their simplicity; mainland Chinese outperformed Taiwanese Chinese subjects slightly in recognizing familiar characters, possibly due to presence of the complex illegal characters. Statistical summaries and data sheets are appended. (MSE)

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Effect of Different Versions of Chinese Logographs on Recognition of Chinese Characters

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Research on the perception of English words has shown that the amount of time readers spend in recognizing a word increases linearly with the increase of the number of letters the word contains. This phenomenon in reading is hypothesized as word-length effect by Just and Carpenter (1987). The Just, Carpenter and Wu study (cited in Just & Carpenter, 1987) demonstrated that the amount of time native Chinese readers spent on each logographic character increased linearly with the increase of the number of brush strokes that the Chinese character contains.

Research (McGinnies, Comer, & Lacey, 1952) has also shown that the amount of time in word recognition is related not only to word length but also to word frequency. The significant interaction between word frequency and word length revealed that frequency effect was more detectable with long words than short words. On the other hand, a word-length effect appeared to be more detectable with longer and low frequency words than with short and high frequency words.

From another perspective, some researchers (Cheng & Yang, 1989) have demonstrated that a reader's lexical knowledge is activated to threshold so that accurate recognition of a character can be completed. This is known as legal-character-advantage effect (Cheng & Yang, 1989).

Due to historical reasons, contemporary Chinese language has developed in two directions. In Mainland China, a simplified version of Chinese characters has been used since 1956 (Cheng, 1978) while in areas such as Taiwan and Hong Kong a traditional

complex version is more popular. Therefore, the Chinese in Mainland are more familiar with the simplified version of the characters whereas the Chinese in Taiwan are more familiar with the traditional complex version of the characters. The two versions have exactly the same pronunciation and the same meaning except that the characters of simplified version have fewer brush strokes than the same characters of complex version. The push of the use of simplified version of the characters in Mainland China is based on the hypothesis that simplified characters with fewer strokes would be easier for children and illiterates to learn how to read and write than the characters with more strokes. In the past few years, however, the belief about the superiority of the simplified version of the characters has been challenged by researchers and educators in China. There is, however, scarcity of empirical study to further explore the controversy.

The present study was intended to extend the findings reported by Just, Carpenter and Wu (cited in Just & Carpenter, 1987) and Cheng and Yang (1989). A condition of simplified, complex versions of characters was incorporated so as to investigate the character-stroke effect in Chinese, which corresponds to word-length effect in English, among Chinese students from Mainland and from Taiwan. In the experiment, we also incorporated a condition of legal characters versus illegal characters so as to assess legal-character-advantage effect in the recognition task.

The present study was designed to address four questions.

First, of special interest was whether word-length effect is generalizable to the Chinese readers when they are assigned to recognize context-free logographic characters in the situation where such extraneous effects as readers' background knowledge of the topic and context clues in text reading are controlled.

Second, of interest here was whether readers from Mainland China would outperform the readers from Taiwan when each group read their own familiar version of the characters, that is, the Chinese from Mainland recognized the simplified version of the characters with fewer brush strokes whereas the Chinese from Taiwan recognized the complex version of the characters with more strokes.

Third, it was of interest to investigate whether both groups would perform better in recognizing legal characters than illegal characters.

Finally, of interest here was to assess the strength of the relation between the number of strokes, the character frequency and the reaction time for the recognition task.

Method

Subjects and Design

Forty subjects (20 from Mainland China and 20 from Taiwan) were drawn from a pool of 166 Chinese from Mainland and 159 Chinese from Taiwan enrolled as graduate and undergraduate students at a large state-supported southeastern university. They were all native Chinese, who had completed high school and undergraduate study in their home country. Chinese language was

their first language although their duration in the United States varied from one to six years. They were majored in various subject areas.

The experiment was carried out by using 2 x 3 (Group X Type) factorial design with Type as repeated measures on simplified legal, complex legal, and complex illegal characters. The outcome measures were reaction time and correct responses.

Stimulus Materials and Apparatus

The stimulus materials consisted of 90 Chinese characters, of which 30 were simplified legal characters, 30 complex legal characters and 30 complex illegal characters. The 90 characters formed 30 sets; each character had its counterparts: simplified legal, complex legal, and complex illegal characters. In each set, the simplified legal and complex legal characters had identical meaning and pronunciation. The legal characters were selected from Cheng's vocabulary list (1982). Each character consisted of a combination of two radicals. All of the characters were with the frequency of 187 or more in one million occurrences of characters.

The 30 complex illegal characters were generated by exchanging the two constituent radicals of each of the 30 complex legal characters so that each final form was also nonsense and unpronounceable (see Figure 1).

Insert Figure 1 about here

Each stimulus was presented on a slide. All subjects participated in the recognition task were measured by reaction time and correct response. The character recognition task involved the subjects to decide whether the character presented was a legal or an illegal character. The task also required the subjects to pronounce the legal character after they completed the character recognition task. The reaction time and correct response to each character were recorded. Reaction time was recorded in milliseconds from stimulus onset to that point in time where the subject responded by pressing a button labelled with either "Yes" indicating a legal character or "No" indicating an illegal character.

The equipment utilized in this study was manufactured by Lafayette Instrument Company of Indiana. The visual reaction time apparatus (Model #63035) and a digital stop clock (Model #54030) were used in character recognition task. For the control of time, a Kodak Carousel Slide Projector with autofocus (Model #850H) adapted for a Lafayette tachistoscopic shutter and projection tachistoscope (Model #41010), three auxiliary relay boxes (Model #58026), and the digital stop clock were employed.

When each slide was advanced, the timing device automatically began. The clock automatically stopped as soon as the subject pressed a response button. Whenever a subject responded, the visual display was terminated and an automatic 8-second interstimulus interval (ISI) began. The next slide was then advanced at the end of the 8-second ISI.

Procedure

Subjects were told to respond as quickly as possible to the illumination by pressing a button with their index finger. The subjects were told that, because the presentation of the slides was random, the most efficient strategy for the task was to fixate on the center of the screen. Each subject was trained to operate on the apparatus with four or five trials.

The character was displayed for 2 seconds. As soon as the subject recognized what the character was, he or she was required to press one of the keys which were labeled as legal or illegal, then to pronounce the character if it was legal. The reaction time (milliseconds) for each character and the number of correct responses were recorded on the worksheet by the researchers.

Data Processing

Data processing consisted of four phases. In phase one, the subjects' reaction time to the different types of characters was recorded and their correct responses to the different types of characters were coded by the two researchers on a chart where the 90 characters were arranged according to the random order of the slides presented (see Appendix A). In phase two, the raw data were transformed to a chart, in which the characters were sorted into the categories of simplified legal, complex legal and complex illegal (see Appendix B). In phase three, the mean reaction time for each character was calculated based on the 20 observations for each group so that the relation can be assessed

between the outcome measure (reaction time) and the two independent measures (number of strokes and character frequency). In the final phase, the mean scores of reaction time for recognizing simplified legal, complex legal and complex illegal characters for each subject were calculated on the basis of 30 trials for each type. Then, the group means of reaction time for each type of characters were obtained based on the 20 observations for each group. The same procedure was used to obtain the mean scores of correct responses to each type of the characters for each group. The data obtained in this phase were analyzed by two separate 2x3 (Group X Type) analysis of variance.

Results

Results from Multiple Regression Analyses

Two multiple regression analyses were employed to assess the strength of relation between the two independent variables (character frequency and number of strokes) and the outcome measure (reaction time in the recognition task) for the Chinese from Mainland and the Chinese from Taiwan. The data of the character frequency were obtained from a study by Cheng (1982) whereas the number of strokes for each character was counted according to the criteria in Contemporary Chinese Dictionary (1973).

The Chinese from Mainland. In recognizing simplified legal characters, there is a significant relation between the reaction time and the independent variables, $F(2, 26)=6.016$, $p=.0071$, $R2=.32$. The regression coefficients have revealed that both the

character frequency and the number of strokes are powerful predictors of the amount of time that students spend in recognizing the characters. The negative coefficient suggests that reaction time decreases with the rise of the character frequency.

Insert Table 1 about here

In recognizing complex illegal characters, there is also a significant relation between the reaction time and the number of strokes, F (2, 26)=5.12, p=.0133, R2=.28. The number of strokes is a powerful predictor of the reaction time but not the character frequency. In recognizing complex legal characters, there is no significant relation between the dependent measure and independent variables, F (2, 26)=1.020. p=.3745.

The Chinese from Taiwan. On simplified legal characters, there is a significant relation between the reaction time and the independent variables, F (2, 26)=3.771, p=.0365, R2=.22. The character frequency but not the number of strokes is a powerful predictor of the reaction time.

On complex legal characters, there is also a significant relation between the reaction time and the independent variables, F (2, 26)=3.686, p=.039, R2=.22. The number of strokes is a powerful predictor but not the character frequency.

On complex illegal characters, the univariate analysis indicates no significant relation between the reaction time and

the independent variables.

In summary, the results in the separate multiple regression analyses have suggested a general pattern that the amount of time in recognizing characters increases with the rise of number of strokes but decreases with the rise of the character frequency.

Results from Analysis of Variance

The data were also analyzed in two separate 2 (Group) x 3 (Type) analysis of variance with repeated measures on simplified legal, complex legal, and complex illegal characters. Reaction time and correct responses were the outcome measures.

Reaction Time. Table 2 shows the means and standard deviations for the reaction time by the Chinese from Mainland and the Chinese from Taiwan on each type of the character. Subjects spent less time recognizing their familiar version of the characters. This was expected because a familiar version of characters should speed up and expedite the readers' processing. Sphericity conditions were assumed to be tenable, with Greenhouse-Geisser Epsilon = .998 and Huynh-Feldt Epsilon = 1.0804.

Insert Table 2 about here

The results of the 2 x 3 ANOVA on the repeated measures are summarized in Table 3. There is a statistical significance of interaction effect between groups and types of characters, $F(2, 76)=62.59$, $P=.0001$, $\eta^2=.62$. The specific nature of the

interaction effect was explored by requesting seven pairwise contrasts. A Bonferroni approach was used for the adjusted alpha across 7 tests with overall alpha .10 (.10/7=.014). A pooled t-test has indicated that there was no significant difference between the Chinese from Mainland and the Chinese from Taiwan when each group was recognizing their own familiar version of characters, that is, the Mainland group recognized simplified legal characters with fewer strokes whereas the Taiwan group recognized complex legal characters with more strokes, t (38)=1.0637. p=.29.

Insert Table 3 about here

For the Chinese from Mainland, the nonsignificant t-test has shown that they did not spend significant less amount of time recognizing simplified legal than complex legal characters. The significant results have been found in the contrasts between simplified legal and complex illegal. t (58)=-5.23, p=.0001, and between complex legal and complex illegal, t (58)=-4.30, p=.0001, demonstrating that the readers spent significantly less time in recognizing simplified legal and complex legal characters than their counterpart complex illegal characters.

Insert Table 4 and Table 5 about here

For the Chinese from Taiwan, the significant results in the

contrast between recognizing simplified legal and complex legal, t (58)=5.92, p=.0001, and between recognizing complex legal and complex illegal, t (58)=-5.04, p=.0001 have exposed that the Chinese from Taiwan spent significantly less time recognizing complex legal characters than simplified legal and complex illegal characters. The nonsignificant result in the contrast between simplified legal and complex illegal indicates that they did not spend significantly more time recognizing simplified legal than complex illegal characters.

Insert Figure 2 about here

There is no statistically significant simple main effect in recognizing complex legal and complex illegal characters.

Correct Responses. Table 5 presents the means and standard deviations for correct responses by the Chinese from Mainland and the Chinese from Taiwan. Sphericity conditions are assumed to be met, with Greenhouse-Geisser Epsilon=.7194, and Huynh-Feldt Epsilon=.7598.

Insert Table 6 about here

Table 6 summarizes the results of the analysis of variance. There is a significant interaction effect between Group and Type, F (2, 76)=165.12, P=.0001, η^2=.81. Seven pairwise comparisons were requested to reveal the nature of the interaction with an

adjusted alpha at .014 probability level. The comparison between the Mainland group recognizing simplified legal characters and the Taiwan group recognizing complex legal characters was statistically significant, t (38)=2.6042, p=.0131, although the mean difference was only .55 between the two groups.

Insert Table 7 about here

For the Chinese from Mainland, the significant results have been found in the contrast between recognizing simple legal and complex legal, t (38)=4.66, p=.0001, between recognizing simplified legal and complex illegal, t (38)=5.50, p=.0001, and between complex legal and complex illegal, t (38)=3.21, p=.0001.

For the Chinese from Taiwan, the significant results have been demonstrated by the contrast between recognizing simplified legal and complex legal, t (38)=-15.71, p=.0001, and between simplified legal and complex illegal, t (38)=-12.84, p=.0001. The results have revealed that the Chinese from Taiwan were significantly more accurate in recognizing complex legal and complex illegal characters than simplified legal characters. There is no significant difference between recognizing complex legal and complex illegal characters.

Insert Figure 3 about here

The main effects on the complex legal and complex illegal are not

statistically significant.

Discussion

The results of the study have supported that the word-length effect in recognizing English words can be generalized to the recognition of Chinese logographic characters not only in text reading (Just & Carpenter, 1987) but also in context-free character recognition where the effects of readers' background knowledge of the topic and context clues are controlled. In recognizing less familiar version of the characters, however, the word-length effect seems to have disappeared for both groups in the present study. Interestingly enough, the subjects' reaction time in both groups was significantly related to the number of strokes in recognizing the complex illegal characters, demonstrating that word-length effect affected the recognition of the complex illegal characters.

The results of the study have also demonstrated that superiority of the simplified version of the characters over the complex version disappeared when the comparison was made between the two groups on the recognition of their own familiar version of the characters, that is, the Chinese from Mainland were recognizing simplified legal characters with fewer strokes whereas the Chinese from Taiwan were recognizing complex legal characters with more strokes. The finding suggests that the adult Chinese readers demonstrated no significant superiority recognizing the characters of simplified version over the same characters of complex version in terms of reaction time.

The Chinese from Mainland in recognizing simplified characters outperformed the Chinese from Taiwan in recognizing the complex characters by making more correct responses in character recognition. The difference appears to be small with mean difference .55 although it was statistically significant. This may be due to the fact that readers from Taiwan were disadvantaged because the illegal characters which were made out of the complex legal characters affected their accuracy in recognizing the complex legal characters more than the readers from Mainland China.

The frequency effect is found in both the Mainland and Taiwan groups recognizing simplified legal characters. This implies that frequency effect may be more detectable with characters of fewer strokes in Chinese. The result is inconsistent with the finding (McGinnies et al., 1952) that frequency-effect was more detectable with long words than short words in English.

The findings in the study have also been added to the support of Cheng and Yang's (1989) view that readers' lexical knowledge may be activated to threshold so that they can accurately recognize the words or characters. On both the reaction time and correct responses to the characters, both groups have demonstrated that they were more able to recognize meaningful characters than meaningless illegal characters. The explanation to the fact that the Chinese from Taiwan were the least successful in recognizing the simplified legal characters

is that simple legal characters were not only meaningless to them but also were less familiar to them than the complex illegal characters so that they could hardly resort to anything to help them recognize the characters.

The failure to find difference between the Mainland Chinese's recognizing simplified legal and complex legal characters seems to mirror the fact they were efficient in recognizing both versions of the characters simply because they had an access to them although they were less accurate in recognizing the complex legal characters.

In conclusion, the word-length effect is generalizable to the recognition of the Chinese characters but theory needs to be developed to explain the nonexistence of the effect in the recognition of less familiar version of the characters. The finding of the legal-character-advantage effect has revealed that the recognition of the Chinese characters is multifaceted, which is affected by word length (character strokes in Chinese), as well as by the activation of meaning and sound of the character.

Finally, some limitations in the study need to be addressed. One limitation is that we recruited some of the subjects to participate in the research because of the unavailability of some students and schedule problems although most of the subjects were randomly selected from the pool. Also, the investigation was limited to the isolated presentation of single characters. The results found here may or may not extend to the study which involves reading two- or more-character words. Another

limitation is that a set of simplified illegal characters was not included, which could have affected some of the results we have found on the Chinese from Mainland.

Table 1

Summary Table of Beta Weights (and p-values) Obtained from Regression Analyses

	Mainland		Taiwan	
	Frequency	# of Strokes	Frequency	# of Strokes
Simplified	-.0754 *	37.2403 *	-01557 *	17.2101
	(.0261)	(.0121)	(.0121)	(.4963)
Complex	-.0192	10.7590	-.0017	26.5977 *
	(.5768)	(.2221)	(.9654)	(.0121)
Illegal		38.0841 *		24.0023 *
		(.004)		(.0387)

Note: The asterisk (*) indicates that the coefficient is statically significant.

Table 2

Means (and Standard Deviations) for Reaction Time by the Chinese from Mainland and the Taiwan

	Types of Characters		
Group	Simplified Legal	Complex Legal	Complex Illegal
Mainland	822.8	897.8	1299.2
	(210.9)	(229.7)	(348.1)
Taiwan	1390.1	896.1	1276.8
	(297.6)	(224.7)	(251.5)

Note: The mean reaction time is in milliseconds. n=20 for each cell.

Table 3

Summary Table for Repeated Measures ANOVA on Reaction Time

SV	DF	SS	MS	F	p	η^2
Group	1	983011.0	983011.0	5.63	.0228	
Error	38	6633828.6	174547.4			
Types	2	3063610.1	1531805.0	85.61	.0001	
Group*Type	2	2239785.3	1119892.6	62.59	.0001	.62
Error	76	1359818.7	17892.4			

Table 4

Summary Table for Pairwise Contrasts on Reaction Time

	Variable	Mean diff.	DF	T-value	P-value	R2
Mainland	SR-CR	-75.00	38	-1.08	.2889	-
	SR-IR	-476.00	31	-5.23*	.0001	.47
	CR-IR	-401.40	38	-4.30	.0001	.08
Taiwan	SR-CR	494.30	38	5.92	.0001	.48
	SR-IR	113.30	38	1.30	.2015	-
	CR-IR	-380.70	38	-5.04	.0001	.40
(MC) SR-(TW) CR		-73.25	38	-1.06	.2944	-

Note: SR=reaction time for simplified characters, CR=reaction time for complex characters, IR=reaction time for complex illegal characters, SF=correct responses for simplified characters, CF=correct responses for complex characters, IF=correct responses for complex illegal characters, MC=the Chinese from Mainland TW=the Chinese from Taiwan. The asterisk (*) indicates separate t-test was used because the assumption equal variance was not tenable. Point biserial r-square was used as an indicator of effect size.

Table 5

Summary Table for Pairwise Contrasts on Correct Responses

	Variable	Mean diff.	DF	T-value	P-value	R2
Mainland	SF-CF	.80	38	4.66	.0001	.36
	SF-IF	1.95	24	5.50*	.0001	.56
	CF-IF	1.15	24	3.21*	.0037	.30
Taiwan	SF-CF	-12.60	21	-15.71*	.0001	.92
	SF-IF	-11.65	31	-12.84*	.0001	.84
	CF-IF	.95	25	1.93*	.0651	-
(MC) SF-(TW) CF		.55	38	2.60	.0131	.15

Note: The asterisk (*) indicates separate t-test was used because the assumption equal variance was not tenable. Point biserial r-square was used as an indicator of effect size.

Table 6

Means (and Standard Deviations) for Correct Responses by the Chinese from Mainland and Taiwan

		Types of Characters		
Group	N	Simplified Legal	Complex Legal	Complex Illegal
Mainland	20	29.8 (.523148)	29.0 (.561951)	27.9 (1.49649)
Taiwan	20	16.7 (3.4985)	29.3 (.786398)	28.3 (2.05452)

Note: Maximum score for each type = 30.

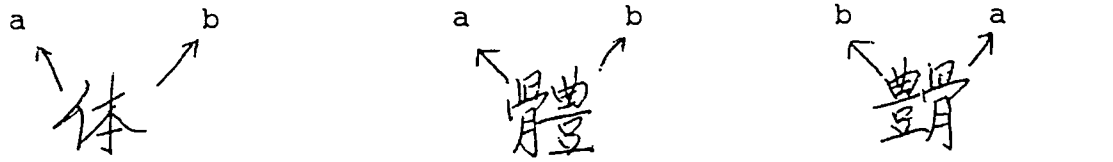
Table 7

Summary Table for Repeated Measures ANOVA on Correct Responses

SV	DF	SS	MS	F	p	n2
Group	1	516.7	516.7	199.16	.0001	
Error	38	98.6	2.6			
Type	2	792.5	396.2	107.68	.0001	
Group*Type	2	1215.2	607.6	165.12	.0001	.81
Error	76	279.7	3.679			

Figure 1

Three Types of the Character "Body"



Simplified Legal | Complex Legal | Complex Illegal

Figure 2

Mean Reaction Time (in msec) for Three Types of Characters (SL=Simplified Legal, CL=Complex Legal, and C~L=Complex Illegal Characters)

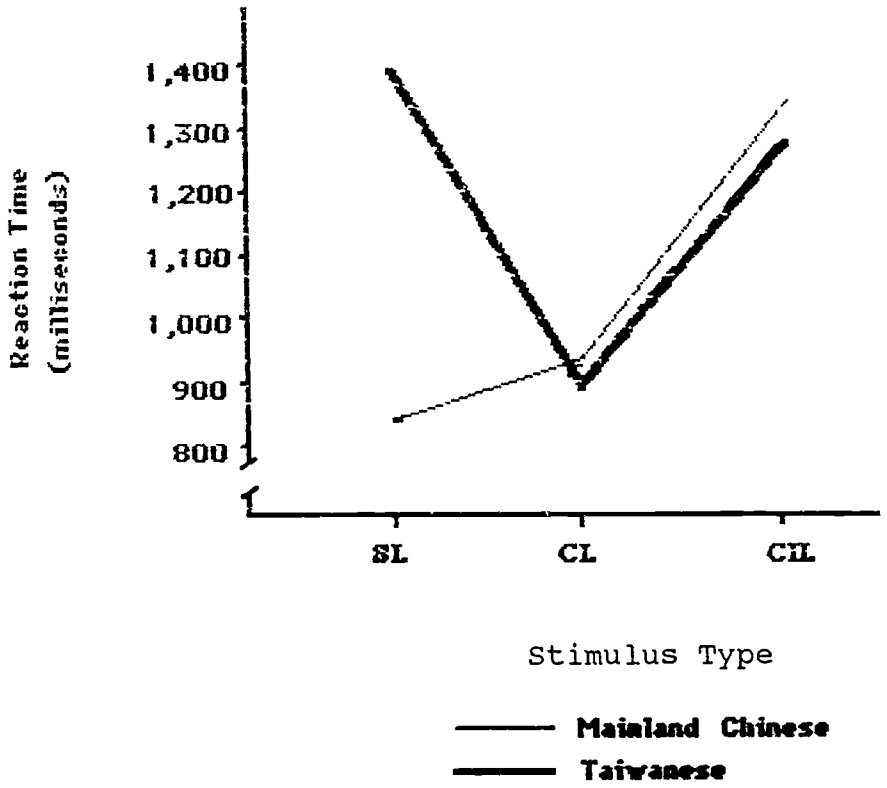
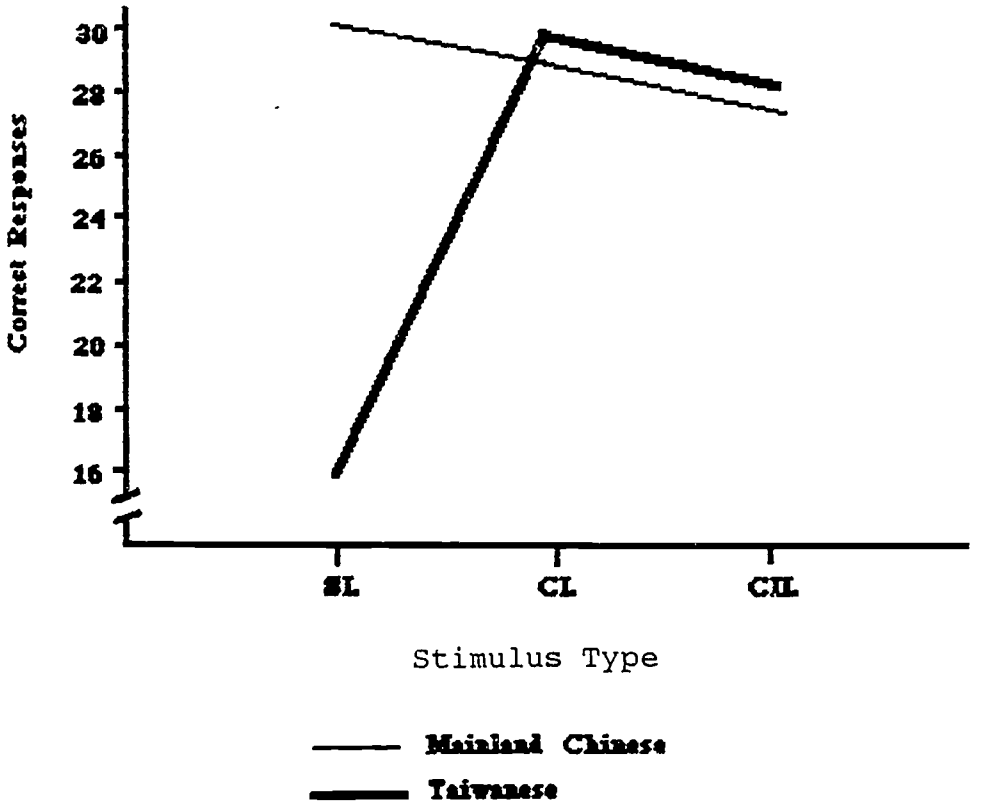


Figure 3

Mean Scores for Correct Responses

(SL=Simplified Legal, CL=Complex Legal and CIL=Complex Illegal Characters)



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Appendix A

Data Sheet for 90 Characters at Random Order

1 价	31 親	61 釋
2 憩	32 励	62 雜
3 紛	33 汉	63 頭
4 线	34 鄉	64 後
5 孀	35 头	65 乡
6 僕	36 漢	66 认
7 縲	37 莫汐	67 蛛
8 忍	38 猶	68 動
9 態	39 敬	69 鄰
10 妇	40 办	70 蘇
11 极	41 彪	71 釋
12 戰	42 后	72 鞣
13 疑	43 號	73 县
14 蝉	44 縣	74 蘇
15 戲	45 懇	75 煙
16 補	46 阶	76 階
17 賧	47 僅	77 獸
18 潮	48 難	78 線
19 战	49 縣	79 婦
20 戏	50 認	80 种
21 难	51 環	81 謝
22 总	52 孿	82 朴
23 婢	53 極	83 环
24 胜	54 杂	84 犹
25 蠻	55 体	85 酚
26 聽	56 勵	86 听
27 價	57 總	87 蝉
28 墟	58 轉	88 體
29 号	59 来	89 勝
30 種	60 动	90 转

Appendix B

Data Sheet for 90 Characters Sorted into Three Types

Simplified Legal				Complex Legal				Complex Illegal			
价				戰				鼈			
线				戲				紆			
妇				補				鴈			
极				聽				佳莫			
战				價				絲線			
戏				種				忍言			
难				親				頁豆			
总				鄉				罢工			
胜				漢				才單			
号				猶				見杀			
励				號				舸月			
汉				難				姅字			
头				縣				豈骨			
办				認				火盧			
后				環				美彡			
阶				極				母女			
杰				勵				虎月			
体				總				糸系			
来				轉				鰲糸			
动				釋				佳杀			
乡				雜				車幸			
认				頭				亚木			
释				後				郤			
县				動				虽木			
种				階				鞣朱			
补				線				雨禾			
环				場				旭重			
犹				雜				貫亻			
听				體				酋分			
转				勝				部乡			
Total											

Average _____ _____ _____

Participant's number_____