國立中正大學語言學研究所博士論文

# Ph.D. Dissertation

## Graduate Institute of Linguistics

## National Chung Cheng University

# A Comparative Study of the Phonology of Taiwan Sign Language and Signed Chinese

# 比較臺灣手語與中文手語的音韻系統


研究生：李 信 賢

**Graduate Student: Hsin-Hsien Lee**

指導教授：麥 傑 教授

**Advisor: Prof. James Myers**



中華民國 105 年 8 月

**August 2016**

# Abstract

This thesis compares the phonological patterns of Taiwan Sign Language (TSL) with those of Signed Chinese (SC). TSL has a grammatical system that is different from Chinese, whereas SC basically adopts the grammar of Chinese and was invented with the goal of improving deaf children's Chinese literacy. However, SC has not succeeded in helping deaf children to improve their Chinese literacy, and it also cannot be well learned by deaf children. Factors that have been investigated for why SC is difficult to learn include incomplete SC input from teachers and complicated morphological properties of SC itself. However, at the phonological level, it is unclear whether the sign-internal composition of SC signs is similar to that of TSL, and it is also uncertain whether SC signs obey natural phonotactic constraints that hold true for TSL signs. This thesis investigates the possibility that the SC lexicon is structurally different from that of TSL (i.e., violating phonotactic constraints that are obeyed by TSL signs). In addition, two sets of experiments were run to test whether these differences would cause learning difficulties.

Comparisons of handshape, location and movement patterns between TSL and SC showed that SC adopts marked handshapes more frequently than TSL. Regarding phonotactic constraints, SC violates the Dominance Condition (by using the nondominant hand for articulating hand movement) and the Narrator Perspective Principle (by depicting Chinese characters from the viewer's perspective) more frequently than TSL. These differences might make it difficult for people to learn this system.

In order to test whether violations of the Dominance Condition and the Narrator Perspective Principle would cause learning difficulties, a difficulty judgment task was designed to test hearing nonsigners' preference regarding the choice of hand for making movements and the perspective taken for depicting Chinese characters. A memory task followed with the goal of testing whether signs violating these constraints would be harder to recall correctly. Experimental results suggested that using the nondominant hand for making movement is disfavored by novice learners. Nevertheless, nonsigners showed no clear preference as to how to sign a Chinese character. Thus, the Narrator Perspective Principle might not be as natural a principle for signing as the Dominance Condition. Results are summarized and discussed with

regard to the implications for the design principles of SC signs and deaf education.

Key words: Taiwan Sign Language, Signed Chinese, phonology

# 摘　　要

此論文比較台灣手語與中文手語的音韻系統。台灣手語的語法不同於中文，而中文手語是為了提升聽障生中文讀寫能力而發明的，其比法基本上跟中文語法一致。然而，中文手語並未能成功提升聽障生的語文能力，且聽障生似乎難以將中文手語學好。中文手語難以學習的因素包括：教師的中文手語表達並不完整、中文手語詞彙本身在構詞結構上較為複雜，但我們並不清楚中文手語本身手語的音韻組成跟自然的台灣手語有何不同，也不清楚中文手語的手語表達方式是否和台灣手語一樣遵守一些自然的音韻限制。因此，此論文分析中文手語及台灣手語在音韻組成上是否有其差異。此外，我也利用兩組實驗來測試這些音韻特性的差異是否可能會造成學習上的困難。

比較台灣手語與中文手語在手形、位置與動作三個組成成份的異同，本研究發現中文手語比台灣手語更常使用複雜的手形來組成手語。中文手語也比台灣手語更常違反主從限制 (使用副手來表達手語的動作) 及敘事者觀點原則 (從觀看者觀點表達文字手語) 這兩個音韻限制。這些差異可能會使人覺得中文手語本身比法難以學習。

為了測試違反主從限制或敘事者觀點原則是否會造成手語學習上的困難，本研究設計一個手語難易度判斷的實驗，來釐清不懂手語的聽人偏好以哪隻手來表達手語的動作，或是他們偏好從哪個觀點來描述文字手語。接著以回顧試驗來檢測是否違反這些自然音韻限制的手語較難被正確地記住。實驗的結果發現聽人確實認為使用副手來比出手語的動作是比較難的，但是他們對於應從敘事者或觀察者角度來表達文字手語並無明顯的偏好。因此，敘事者觀點這個音韻限制可能並不像主從限制一樣是一種應該被普遍遵守的自然音韻限制。本研究根據實驗的結果針對中文手語的設計規則與聽障教育提出一些看法與建議。

關鍵字: 台灣手語、中文手語、音韻系統

# Table of Contents


Chapter 1 Introduction ..... 1

1.1 Misconceptions about Taiwan Sign Language ..... 2
1.2 Rise of Signed Chinese ..... 5
1.3 SC Signs Cannot Well Be Learned by Deaf Children ..... 7
1.4 Outline of Thesis ..... 9

Chapter 2 The History of Artificial Sign Languages ..... 11

2.1 The West ..... 11
2.2 Taiwan ..... 13
2.3 Summary ..... 20

Chapter 3 The Devising Principles of the SC Lexicon ..... 22

3.1 'Natural' Signs in Signed Chinese ..... 23
3.2 Lexical Borrowing from TSL Lexicon: Liu and Tseng (2007) ..... 25
3.3 A Reanalysis of TSL Influences on the SC lexicon ..... 32
3.4 Flaws of the 2008 SC Dictionary as a Dictionary ..... 33
3.5 Summary ..... 36

Chapter 4 Learning Outcomes of Artificial Sign Languages ..... 37

4.1 The US ..... 37
4.1.1 The Poor Learning Outcome for Manually Coded English ..... 37
4.1.2 Reasons for the Poor Learning Outcome for Manually Coded English ..... 38
4.1.3 Alternatives for Improving English Literacy ..... 39
4.2 Taiwan ..... 41
4.2.1 The Poor Learning Outcome for Signed Chinese ..... 41
4.2.2 Reasons for the Poor Learning Outcome for Signed Chinese ..... 42
4.2.3 Alternatives for Improving Chinese Literacy ..... 44
4.3 Summary ..... 47

Chapter 5 Phonotactic Constraints on Natural Signs ..... 48

5.1 Phonological Parameters of Signs ..... 48
5.1.1 The Handshape Parameter ..... 50
5.1.2 The Location Parameter ..... 51
5.1.3 The Movement Parameter ..... 52
5.2 Phonotactic Constraints on Natural Signs ..... 53
5.2.1 Selected Finger Constraint on Handshape Change ..... 54

5.2.2 Symmetry and Dominance Conditions on Two-Handed Signs .....55
5.2.3 One Major Area Constraint on Location.....64
5.2.4 Simple Sequence Constraint on Movement.....64
5.2.5 No Left/Right Specificity and Narrator Perspective Principle .....68
5.2.6 Summary.....73
Chapter 6 Comparison of the TSL and SC Lexicons.....75
6.1 Comparisons of TSL and SC Handshapes .....77
6.1.1 Distribution of TSL Handshapes and Marked Features.....77
6.1.2 Distribution of SC Handshapes and Marked Features.....83
6.1.3 Comparisons between TSL and SC.....91
6.1.3.1 Comparison of TSL and SC Marked Feature Distribution .....92
6.1.3.2 Comparison of TSL and SC Handshape Changes.....96
6.1.3.3 Comparison of TSL and SC Two-handed Signs .....98
6.1.4 Interim Summary .....103
6.2 Comparison of TSL and SC Locations .....104
6.2.1 Type Frequencies of Locations in TSL and SC.....105
6.2.2 Comparison.....105
6.3 Comparison of TSL and SC Movements .....106
6.3.1 Frequencies of Movements and the Number of Movements in TSL 106
6.3.2 Frequencies of Movements and the Number of Movements in SC..108
6.3.3 Comparison.....111
6.4 Character Signs in TSL and SC .....112
6.4.1 Articulation Differences in Character Signs .....112
6.4.2 Revisiting Ann's Study .....114
6.5 Summary.....120
Chapter 7 Testing the Learnability of Signs.....123
7.1 Experiment 1: Tests for the Dominance Condition.....128
7.1.1 Experiment 1A: Difficulty Judgment Task for the Dominance Condition.....128
7.1.1.1 Materials and Design .....129
7.1.1.2 Participants.....131
7.1.1.3 Procedure .....131
7.1.1.4 Results.....134
7.1.2 Experiment 1B: Memory Task for the Dominance Condition.....137
7.1.2.1 Materials and Design .....137
7.1.2.2 Participants.....138
7.1.2.3 Procedure .....138

7.1.2.4 Results ..... 138
7.2 Experiment 2: Tests for the Narrator Perspective Principle ..... 142
7.2.1 Experiment 2A: Difficulty Judgment Task for the Narrator Perspective Principle ..... 142
7.2.1.1 Materials and Design ..... 142
7.2.1.2 Participants ..... 144
7.2.1.3 Procedure ..... 144
7.2.1.4 Results ..... 145
7.2.2 Experiment 2B: Memory Task for the Narrator Perspective Principle ..... 149
7.2.2.1 Materials and Design ..... 150
7.2.2.2 Participants ..... 150
7.2.2.3 Procedure ..... 150
7.2.2.4 Results ..... 151
7.3 Discussion ..... 154
Chapter 8 Conclusions ..... 159
8.1 Summary of Findings ..... 159
8.2 Suggestions for SC Designers ..... 161
8.3 Implications ..... 164
References ..... 168
Appendix 1. *Zhuyin Fuhao* Handshape Chart (from Ministry of Education 2008) ... 187
Appendix 2. TSL handshapes (from Tai and Tsay 2015, p. 800-801) ..... 188
Appendix 3. Fake two-handed signs for testing the Dominance Condition ..... 190
Appendix 4. Illustration webpage for experiments ..... 193
Appendix 5. Character signs for testing the Narrator Perspective Principle. Asterisks indicate invented character signs. ..... 194

# List of Figures

Figure 1. TSL ‘SIGN LANGUAGE’ from Smith and Ting (1979, p. 32) .....6
Figure 2. SC ‘SIGN LANGUAGE’ from Ministry of Education (2008, p. 579) .....6
Figure 3. TSL ‘CONSISTENT’ from Smith and Ting (1984, p. 90) .....7
Figure 4. SC ‘CONSISTENT’ from Ministry of Education (2008, p. 2).....7
Figure 5. ‘INTRODUCE’ from Ministry of Education (2008, p. 55).....8
Figure 6. Character signs: (a) ‘中’, (b) ‘川’, (c) ‘毛’ and (d) ‘中’ from Smith and Ting (1979, 1984).....15
Figure 7. Signs using tracing alone: ‘千’ and ‘人’ from Smith and Ting (1979, 1984) .....15
Figure 8. SC examples of borrowed (‘一樣’), novel (‘一律’), and character sign (‘一頓’) from Ministry of Education (2008).....16
Figure 9. SC ‘ALL’ from Ministry of Education (2008, p. 1).....19
Figure 10. SC sign for ‘seafood’ from Ministry of Education (2008, p. 902) .....25
Figure 11. SC ‘CROWDED’ from Ministry of Education (2008, p666).....26
Figure 12. SC ‘DOCTOR’ from Ministry of Education (2008, p. 1527).....26
Figure 13. SC ‘CAKE’ (Ministry of Education 2008, p. 1300).....27
Figure 14. SC ‘HAPPY’ and ‘GLAD’ (Ministry of Education 2008) .....28
Figure 15. SC ‘VIGILANT’ (Ministry of Education 2008, p. 1395).....28
Figure 16. SC ‘公斤’, ‘公兩’, ‘公錢’ and ‘公克’ (Ministry of Education 2008, p. 153) .....29
Figure 17. TSL ‘斤’ (Smith and Ting 1984, p. 112).....29
Figure 18. ‘DEPUTY’ in SC (MoE 2008, p. 185) and TSL (Smith and Ting 1979, p. 157) .....30
Figure 19. SC ‘KNOW’ and ‘UNDERSTAND’ from Ministry of Education (2008)..31
Figure 20. SEE II ‘BEAUTY’, ‘LOVELY’ and ‘PRETTY’ (Gustason 1990, p. 116).31
Figure 21. SC ‘GO UPHILL’ (p. 10) and ‘GO DOWNHILL’ (p. 13) from Ministry of Education (2008).....33
Figure 22. SC ‘傭人’ (p. 126) and ‘佣人’ (p. 80) from Ministry of Education (2008)34
Figure 23. SC ‘一日千里’ (p. 5) from Ministry of Education (2008) .....35
Figure 24. TSL minimal pairs (from Smith and Ting 1979, 1984).....49

Figure 25. TSL ‘YELLOW’, ‘THING’, ‘LAW’ and ‘HABIT’ from Smith and Ting (1979) ..... 52
Figure 26. TSL ‘FULL’, ‘SMRT’, ‘BUT’, ‘YELLOW’, ‘FLOWR’ and ‘THING’ from Smith and Ting (1979) ..... 53
Figure 27. TSL ‘POWER’ and ‘FLOWER’ (from Smith and Ting 1979, 1984) ..... 55
Figure 28. TSL ‘WEIRD’ from Smith and Ting (1984) ..... 55
Figure 29. TSL ‘OFTEN’, ‘CORRECT’, ‘HABIT’ and ‘KITE’ from Smith and Ting (1979, 1984) ..... 56
Figure 30. Unmarked handshapes (Battison 1978, p. 35) ..... 57
Figure 31. TSL examples for unmarked selected fingers (from Smith and Ting 1979) ..... 59
Figure 32. TSL examples for marked selected fingers (from Smith and Ting 1979) ..59
Figure 33. TSL ‘FULL’ (from Smith and Ting 1979, p. 99) ..... 59
Figure 34. TSL signs with different marked features (from Smith and Ting 1979) ....61
Figure 35. TSL ‘PICK UP (FOOD)’ (Smith and Ting 1984, p. 49) ..... 62
Figure 36. TSL ‘ADDRESS’ (from Smith and Ting 1979, p. 150) ..... 63
Figure 37. TSL ‘CAN’ and ‘LAW’ (from Smith and Ting 1979) ..... 64
Figure 38. TSL monosyllabic signs (from Smith and Ting 1979) ..... 65
Figure 39. TSL ‘FLY’ from Smith and Ting (1979, p. 172) ..... 66
Figure 40. ASL ‘APPOINTMENT’ (Uyechi 1996, p. 103) ..... 67
Figure 41. Character sign ‘共’ and ‘出’ (Smith and Ting 1979) ..... 68
Figure 42. Signing spatial scene (from Emmorey, Klima and Hickok 1998, p. 223)..70
Figure 43. ‘人’ in Taiwan Sign Language (Smith and Ting 1979, p. 59), Chinese Sign Language (China Association of the Deaf and Hard of Hearing 2003, p. 7) and Japanese Sign Language (Ogata 2008, p. 408) ..... 73
Figure 44. TSL marked feature distribution on the dominant hand ..... 79
Figure 45. TSL marked feature distribution on the nondominant hand ..... 81
Figure 46. Effect plot for TSL handedness × markedness interaction ..... 83
Figure 47. SC marked feature distribution on the dominant hand ..... 85
Figure 48. SC handshape chart (Ministry of Education 2008) ..... 87
Figure 49. Signs adopting extra SC handshapes (Ministry of Education 2008) ..... 87
Figure 50. SC marked feature distribution on the nondominant hand ..... 89
Figure 51. Effect plot for SC Hand × Markedness interaction ..... 91

Figure 52. Effect plot for Lexicon × Hand × Markedness interaction ..... 95
Figure 53. Lexicon × Markedness interaction plot ..... 96
Figure 54. Signs that obey/violate the Selected Finger Constraint ..... 98
Figure 55. SC character sign 'ENTERPRISE' (Ministry of Education 2008, p.64) .... 99
Figure 56. Signs that obey/violate the Revised Dominance Condition ..... 100
Figure 57. TSL character sign '區' ..... 101
Figure 58. TSL 'BANANA' and 'YEAR' (from Smith and Ting 1979) ..... 102
Figure 59. TSL 'RICE TAMALE' and 'PEEL' (from Smith and Ting 1984) ..... 103
Figure 60. TSL signs without any movement (Smith and Ting 1979) ..... 107
Figure 61. TSL character sign '區' (Smith and Ting 1979, p. 201) ..... 108
Figure 62. SC signs without any movement (Ministry of Education 2008) ..... 109
Figure 63. SC signs with multiple movements (Ministry of Education 2008) ..... 111
Figure 64. '人' in SC and TSL ..... 113
Figure 65. '仁' in SC and TSL ..... 114
Figure 66. Character Signs for '工', '中', '小', '介' and '个' (Smith and Ting 1979) ..... 115
Figure 67. '吉' by a left-handed signer (Chang 2011a, p. 174) ..... 116
Figure 68. Signs from Chang (2011a) by a left-handed signer ..... 117
Figure 69. Signs from Chang (2011b) by a left-handed signer ..... 117
Figure 70. SC '塘' and '财' from Ministry of Education (2008) ..... 118
Figure 71. SC '器' and '格' from Ministry of Education (2008) ..... 119
Figure 72. Character signs that obey/violate the Narrator Perspective Principle ..... 120
Figure 73. Sample test items ..... 129
Figure 74. Picture illustrating how participants should sign ..... 132
Figure 75. Effect of Item Type on Response for Dominance Condition ..... 135
Figure 76. Effect of Item Type on Reaction Time for Dominance Condition ..... 136
Figure 77. Effect of Item Type on Accuracy Rate for Dominance Condition ..... 140
Figure 78. Effect of Newness on Accuracy Rate for Dominance Condition ..... 141
Figure 79. Sample test item '仙' ..... 143
Figure 80. Effect of Item Type on Response for Narrator Perspective Principle ..... 146
Figure 81. Effect of Item Type on Reaction Time for Narrator Perspective Principle ..... 147

Figure 82. Effect plot for Item Type × log RT interaction ..... 149
Figure 83. Effect of Item Type on Accuracy Rate for Narrator Perspective Principle ..... 152
Figure 84. Effect of Newness on Accuracy Rate for Narrator Perspective Principle 153
Figure 85. Iconic mappings between Chinese character and character sign (viewer perspective) ..... 155
Figure 86. SC character sign ‘ENTERPRISE’ that violates both Narrator Perspective and Dominance Condition (Ministry of Education, p. 64) ..... 157
Figure 87. SC form (Ministry of Education 2008, p. 452) and adopted form for character ‘巨’ ..... 163
Figure 88. SC form (Ministry of Education 2008, p. 457) and adopted form for character ‘價’ ..... 164

# List of Tables

Table 1. *SC Word Composition from Liu and Tseng (2007)* ..... 32
Table 2. *SC Word Composition for the 2008 SC Dictionary* ..... 33
Table 3. *Phonotactic Constraints on Natural Signs* ..... 74
Table 4. *Type Frequencies of Handshapes on the Dominant Hand* ..... 78
Table 5. *Type Frequencies of Handshapes on the Nondominant Hand* ..... 80
Table 6. *Distribution Patterns of Marked Features across Both Hands* ..... 82
Table 7. *Poisson Regression Model of Handedness and Markedness* ..... 83
Table 8. *Type Frequencies of Handshapes on the Dominant Hand* ..... 84
Table 9. *Type Frequencies of Handshapes on the Nondominant Hand* ..... 88
Table 10. *Poisson Regression Model for Handedness and Markedness* ..... 90
Table 11. *Handshape Distribution Pattern in TSL and SC* ..... 92
Table 12. *Poisson Regression Model for Lexicon × Handedness × Markedness* ..... 94
Table 13. *Frequencies of Handshape Changes in TSL and SC* ..... 97
Table 14. *Signs that Obey/Violate the Selected Finger Constraint* ..... 98
Table 15. *Signs that Obey/Violate the Revised Symmetry Condition* ..... 99
Table 16. *Signs that Obey/Violate the Revised Dominance Condition* ..... 100
Table 17. *Location Patterns in TSL and SC* ..... 105
Table 18. *Signs that obey/violate the One Major Area Constraint* ..... 106
Table 19. *Frequencies of Movements in TSL* ..... 107
Table 20. *Frequencies of the Number of Movements in TSL* ..... 108
Table 21. *Frequencies of Movements in SC* ..... 109
Table 22. *Frequencies of the Number of Movements in SC* ..... 110
Table 23. *Signs that Obey/Violate the Simple Sequence Constraint* ..... 112
Table 24. *Signs that Obey/Violate the Narrator Perspective Principle* ..... 118
Table 25. *Mixed-effects Logistic Regression Model for Item Type* ..... 135
Table 26. *Mixed-effects Linear Regression Model for Item Type* ..... 136
Table 27. *Mixed-effects Logistic Regression Model for Item Type× log RT interaction* ..... 137
Table 28. *Mixed-effects Logistic Regression Model for Item Type* ..... 139
Table 29. *Mixed-effects Logistic Regression Model for Item Type* ..... 146
Table 30. *Mixed-effects Linear Regression Model for Item Type* ..... 147

Table 31. *Mixed-effects Logistic Regression Model for Item Type× log RT interaction* .....148
Table 32. *Mixed-effects Logistic Regression Model for Item Type* .....151

# Chapter 1 Introduction

In Taiwan, there are two major signed systems used by deaf students, deaf school teachers, sign language teachers and sign language interpreters. Taiwan Sign Language (TSL) is a language developed naturally within the deaf community and is the preferred communication method. Signed Chinese (SC) is an artificial signed system that was developed for pedagogical purposes and is used mainly in educational settings.

Cross-linguistic studies on natural sign languages have shown that different sign languages share similar phonological patterns (Sandler and Lillo-Martin 2006). For example, unmarked handshapes (i.e., handshapes that are articulatorily simpler, acquired early by deaf children and occur frequently in different sign languages) are more commonly used; unmarked handshapes are most often used in the nondominant hand (i.e., the left hand for most right-handers) if the handshapes of the two hands are different (Battison 1978); signs tend to be 'monosyllabic' (Brentari 1998) or simple in terms of linear sequential structure. These similar patterns, among others, suggest that there are principles that make sign languages developed in different countries look so similar phonologically. That is, deaf people around the world have developed and learned sign languages in particularly favored ways. If an artificial signed system is not designed according to these principles, deaf children might find it difficult to learn, even if most of them were exposed to it from the very beginning of their sign experience.

The poor learning outcomes of artificial signed systems suggest that deaf children often have difficulties in learning these contrived signs (Raffin 1976; Swisher 1991; Wodlinger-Cohen 1991). SC is not unique in this regard (Lin, Huang and Hsing

2001; Liu, Tseng and Chang 2006). Possible reasons for why SC signs are difficult to learn has been investigated from the perspective of morphosyntactic patterns (Liu and Tseng 2007) and process loading (Liu, Tseng and Liu 2009). These findings suggest that SC signs are morphologically more complex and also harder to remember than TSL.

Since SC seems to be difficult for deaf learners (Lin, Huang and Hsing 2001; Liu, Tseng and Chang 2006), I suspect that it is possible that SC signs violate some phonotactic constraints that are otherwise obeyed by natural sign languages, thus causing learning or processing difficulties for deaf children. However, the differences between SC and TSL signs at the sign-internal phonological level have not been investigated thoroughly. In this thesis, I thus focused on the sign-internal phonological patterns of these two sign systems. The composition and phonological patterns of SC signs were analyzed and compared with those of TSL.

Before moving on to the comparisons, we first need to know why SC inventors created another signed system, even when the deaf community already has a naturally developed signed system. Section 1.1 describes some misconceptions about Taiwan Sign Language. Section 1.2 describes how SC was developed due to misconceptions about TSL. Section 1.3 describes reasons that have been investigated about why SC cannot be well learned, and proposes the need for a systematic investigation of SC's sign-internal pattern. Section 1.4 describes the organization of this thesis.

### 1.1 Misconceptions about Taiwan Sign Language

TSL has a different grammatical system from spoken Chinese. Specifically, the phonological structure of signs (i.e., how minimally contrastive units like handshape, location and movement are organized in signs), word formation morphology and word order of TSL are all different from Chinese grammar (Smith and Ting 1979, 1984; Tai

and Tsay 2009; Tai and Tsay 2015). Although TSL is a natural language with its own grammar, linguistic studies on TSL began quite late. According to Smith (2005), early works throughout 1960s and 1970s on TSL were mainly collections of TSL signs. Smith's linguistic research on TSL began in the mid-1970s and he wrote the first linguistic dissertation on TSL in 1989 (Smith 1989). Since then there has been a recent increase in research on TSL grammar (Ann 1993; Ann 1996; Myers and Tai 2005; Tai and Tsay 2009; Tai and Tsay 2015). Starting in the 2000s, Prof. James H-Y. Tai and his colleagues began a series of studies on TSL phonology, morphology and syntax (Myers and Tai 2005; Tai and Tsay 2009; Tai and Tsay 2015), and built Taiwan's first on-line TSL video dictionary at National Chung Cheng University (Tai and Tsay 2010; Tsay, Tai and Chen 2015). However, TSL is still not recognized as a language by many professionals and educators of deaf education. In fact, many of them still claim that even if TSL is a true language, it is not as perfect as Chinese, because TSL is short of some special Chinese constructions (e.g., numerical classifiers of Chinese are not seen in TSL expressions) or even lacks grammar of any kind. For example, Kuo (1985), as an expert on special education and former Minister of the Ministry of Education of Taiwan (1993-1996), describes sign language as being an 'unstructured language' that has no 'syntax' and is confusing and unintelligible[1]. Similarly, Huang (2001), as a deaf school teacher, claims that there are several flaws in sign language, with two particularly relevant here. First, he claims that, unlike Taiwan's phonetic system *zhuyin fuhao* (注音符號), sign language has no basic elements for constructing all possible Chinese words[2]. Second, like Kuo (1985), he claims that the biggest flaw of a sign language is that it has no grammar at all, with

[1] "手語是一種「無結構的語言」(unstructured language)，既無「造句法」(syntax)之存在，亦乏一般口語所具的文法結構，所以不但語意含混，易生誤解" (Kuo 1985, p. 170)

[2] "口語能把一切國字的讀音歸納成三十七個注音符號，用這三十七個符號，配合四聲，唸出所有的國字，反觀手語，卻無法創出基礎手式，再以此基礎手式去打所有的國字" (Huang 2001, p. 82)

the natural sign language used by deaf people especially grammarless and unintelligible[3]. Huang's first point basically suggests that he does not realize that signs can be decomposed into smaller basic elements, or that there is no reason for one language (e.g., a sign language) to have elements for forming constructions in another language (e.g., a different sign language or a spoken language). Regarding his second point, it is problematic to conclude that TSL has no grammar just because TSL is not signed following the word order of Mandarin Chinese, or because hearing people cannot easily understand what deaf people are signing. TSL is just a different language from Chinese, like English.

Educators who do not entirely deny the benefit of using sign language often assume that TSL is some kind of naturally developed set of mimic gestures and facial expressions for deaf people to convey their feelings (Chang 2001; Yao 2001). Therefore, they call the naturally developed sign system 'natural sign language' (自然手語), in the sense that 'natural' signs are not as elaborated as spoken language. In other words, those who do not recognize TSL as a natural 'language', when they refer to 'natural' signs, often imply that it is just a low level communicative system or only as an alternative for deaf people to communicate.

In addition to grammatical differences from Chinese, TSL has two dialects: the Tainan dialect and the Taipei dialect (Smith 1989, 2005). Many educators believe that the dialectal differences might cause comprehension difficulty among deaf people (Lin 2001; Yao 2001; Lin 2015b). In addition, deaf students' poor Chinese literacy makes educators worry even more about their communicative ability in Chinese. Lin and Li (1987), Chang (1989) and Lin and Huang (1997) all found that the literacy level of high school deaf students is only about that of hearing third graders. Some

[3] "手語與口語最大的不同，也是最大的流弊，就是不講文法。...在聾人社會中，更有其獨特的自然手語打法，不但難了解，也絕無文法可言" (Huang 2001, p. 83)

educators (e.g., Chang 2001; Yao 2001; Lin 2006) attribute deaf children's poor Chinese literacy to TSL's broken grammar and its limited lexicon.

### 1.2 Rise of Signed Chinese

Since the grammar of TSL is different from that of Chinese, some educators attribute deaf students' poor Chinese literacy to their use of TSL. For example, in a conference celebrating 100 years of deaf education in Taiwan, Lin (2015b) claims that the mismatch between deaf people's natural sign language and Chinese word order will cause the reversal of word order, omissions of words, and incomplete sentences when deaf students learn to write Chinese through natural sign language[4].

In 1975, Taiwan's Ministry of Education gathered together some professionals and deaf school teachers to devise a signed system that can manually express Chinese grammar, basically character by character, hoping to improve deaf students' Chinese literacy, expand their lexicon and unify the use of signs (Lin 2001; Ministry of Education 2008; Lin 2015a). The first volume of '手語畫冊' ('sign language album') was published in 1978 (Li 1978) and since then this signed system had become the standard for deaf school teachers to use in class. This signed Chinese system is called '文法手語' ('grammatical sign language') by the Ministry of Education because it follows the word order and morphological structure of Mandarin Chinese, and thus this contrived sign system has a 'grammar' (i.e., Chinese grammar). This Signed Chinese (henceforth SC) system has since been revised and expanded several times by the Ministry of Education (Ministry of Education 1999, 2000, 2008).

Note that Signed Chinese has borrowed some lexical items from TSL, but it also has signs invented to express Chinese orthography and morphology. Specifically, in

[4] "聽障者所使用的自然手語，並不合健聽者所說的口語語法或語順，以手語學習口語、筆談、作文時，常造成語句顛倒、省略、不完整、不通順的現象" (Lin 2015b, p. 71)

Signed Chinese, each sign often represents a Chinese character, whereas in TSL, each sign basically represents a word or a morpheme. For instance, TSL signers would use just one TSL sign to express the word meaning ‘sign language’ (as shown in Figure 1). By contrast, this word would require two SC signs to represent the Chinese characters ‘手’ (‘hand’) and ‘語’ (‘language’), respectively (as shown in Figure 2).

Figure 1. TSL ‘SIGN LANGUAGE’ from Smith and Ting (1979, p. 32)

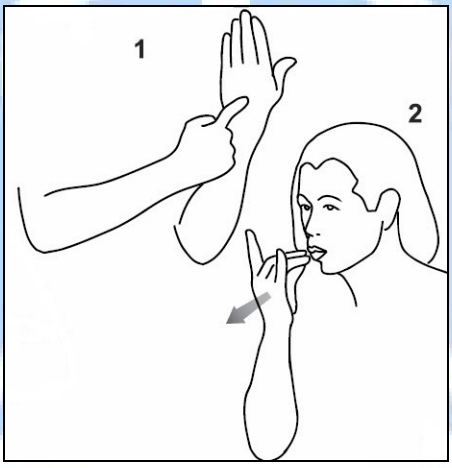



Figure 2. SC ‘SIGN LANGUAGE’ from Ministry of Education (2008, p. 579)

In another example, TSL signers also use just one TSL sign to express the word meaning ‘consistent’ (as shown in Figure 3). SC word would require two SC signs to represent the Chinese characters ‘一’ and ‘律’, respectively (as shown in Figure 4). In this case, not only two signs are required to represent ‘一律’, but the form (i.e.,

handshape and movement of the left hand) of the second sign was also altered (from TSL '一律'). Only the form of the right hand remains the same as TSL sign.

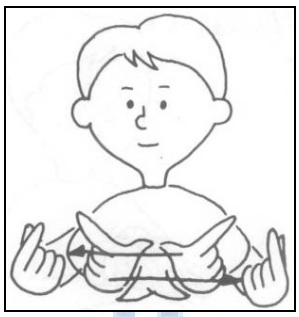


Figure 3. TSL 'CONSISTENT' from Smith and Ting (1984, p. 90)

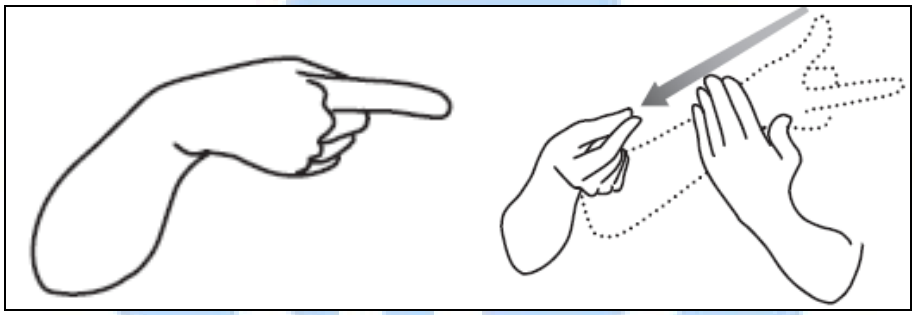


Figure 4. SC 'CONSISTENT' from Ministry of Education (2008, p. 2)

### 1.3 SC Signs Cannot Well Be Learned by Deaf Children

Although Signed Chinese was devised with the goal of improving deaf children's Chinese literacy, recent studies suggest that Signed Chinese has not succeeded in achieving this important goal, and it is not well learned (Lin, Huang and Hsing 2001) or understood (Liu, Tseng and Chang 2006) by deaf children. The puzzle is that even after many years of exposure to Signed Chinese from the very beginning of learning a sign language (since most deaf children do not learn to sign until enrolled into a deaf school), deaf people do not learn much signed Chinese (Lin, Huang and Hsing 2001). They still choose to use lexical signs from TSL in their daily conversation, and only a

few character-derived signs have been adopted into TSL, and mainly for expressing Chinese surnames and proper names. Moreover, this artificial signed system is not welcomed by the deaf community in Taiwan (Chao 1998, 2011).

Although SC is not well accepted by the deaf community, deaf people do not entirely reject this system. Many SC signs have been adopted or borrowed into TSL for expressing place names and Chinese surnames (Chang 2011a, 2011b) and have the potential to expand TSL's lexicon (Chao 1998). Some SC signs have even become nativized in TSL. For example, the character sign '介' ('INTRODUCE') has been adopted into TSL as an inflectable agreement verb. By moving from a location to another location, it can mark the subject/object relationship between referents (as shown in Figure 5).

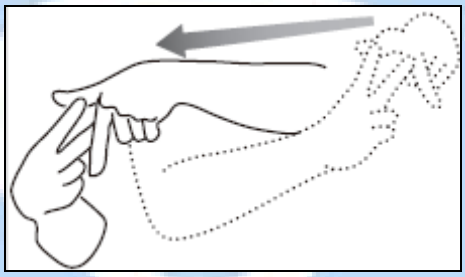


Figure 5. 'INTRODUCE' from Ministry of Education (2008, p. 55)

Why are SC signs difficult to learn for deaf children? Two possible reasons have been investigated. First, teachers themselves may not function as good language models for deaf children to learn from. Hsing (2000, 2003) found that teachers do not use Signed Chinese consistently. Second, Signed Chinese itself might lack some morphological or syntactic features that are crucial for natural sign language (Liu and Tseng 2007) or it might burden learners with greater memory load requirements (Liu, Tseng and Liu 2009).

One gap in research on Signed Chinese learning and processing, however, is its

sign-internal phonological organization. Ann (1998) claimed that handshape combinations between two hands of SC signs might be different from native TSL signs. Lin, Yang and Tai (2001) described the distribution pattern of location and movement parameters of SC signs. However, no comparisons between TSL and SC location and movement were made in their study. Lee, Tsay and Myers (2001) compared the handshape distribution pattern between TSL and SC signs and found no significant difference. Clearly, the sign-internal phonological organization of Signed Chinese signs and its differences from native TSL signs need to be investigated more thoroughly and systematically.

### 1.4 Outline of Thesis

This thesis investigates the sign-internal phonological organization of SC and TSL signs, and makes comparisons between them. I predict that SC signs might violate certain phonological constraints that are otherwise obeyed by natural sign systems around the world. A systematic investigation of the distribution patterns of handshape, location and movement in SC signs could help us understand more about its internal organization and the possible causes for why it is phonologically difficult to learn for deaf children.

This thesis is organized as follows. A brief overview of the history and development of artificial sign languages in the West and Taiwan is outlined in Chapter 2. In Chapter 3, by adopting Liu and Tseng's (2007) criterion, I analyze the devising principles of SC signs and show that most SC signs are basically signed following the morphology of Mandarin Chinese. Results of my analyses suggest that only a small portion of the TSL lexicon was directly adopted into the SC lexicon; thus SC is basically a sign system that tries to manually convey Chinese lexical items. Chapter 4 reviews studies on the learning outcomes of artificial sign languages in the US and

Taiwan, showing that artificial sign systems are difficult to learn and have not succeeded in achieving the goal of improving deaf students' literacy. It also describes some alternatives for improving deaf children's literacy. In Chapter 5, I introduce the three basic phonological parameters of signs (i.e., handshape, location and movement) and then discuss several phonotactic constraints that are relevant for the comparisons between SC and TSL signs. In addition to the three phonological parameters and their relevant phonotactic constraints, I also describe studies showing how deaf signers usually sign when they describe spatial scenes. I wonder whether deaf signers' preference for signing spatial scenes from their own viewing perspective is also adopted when they depict Chinese characters manually in character signs. In Chapter 6, I take a closer look at how handshape, location and movement parameters are organized in TSL and SC. Based on the phonotactic constraints discussed in Chapter 5, similarities and differences between TSL and SC are analyzed and discussed. These differences might help to explain why SC lexicon is difficult to learn. To test whether constraints overtly violated by SC lexicon can really cause learning difficulties, two experiments (both contain a difficulty judgment task and a memory task) are reported in Chapter 7 to see whether certain formational properties are intrinsically difficult for novice learners to learn. Factors like hand choice for moving and the perspective of signing were manipulated to test their learnability. The differences in phonological patterns between SC and TSL are summarized in Chapter 8. The potential implications of this study for deaf education and design principles for Signed Chinese are also discussed in Chapter 8.

## Chapter 2 The History of Artificial Sign Languages

This chapter briefly reviews the history of artificial sign languages developed in the West and Taiwan. Section 2.1 introduces several artificial sign systems that were developed in the West. Section 2.2 introduces the development of Signed Chinese in Taiwan. Section 2.3 summarizes this chapter.

### 2.1 The West

According to Stedt and Moores (1990), artificial sign language was used in the instruction of deaf children much earlier than natural sign language. Juan Bonet's *The Reduction of Letters and the Art of Teaching the Mute to Speak*, published in Spain in 1620, might be the first work written on using signs in deaf education. In 1776, the Abbé Charles Michael de l'Epée invented a manual code (termed 'methodical signs' by Epée) to represent the syntax and morphology of written French, based on signs used by deaf people in Paris and the Spanish Manual Alphabet. 'Initialized' signs were invented by changing the handshape of an existing sign to include a manual alphabet handshape to represent the initial letter of French words. For example, the manual B handshape was used to represent French *bon* ('good'). This sign system included invented signs for French bound morphemes and function words. In addition, each word was represented with multiple signs to stand for its root and bound morphemes. This artificial sign system was later modified in 1818 by Epée's successor, the Abbé Roch Ambroise Cucurron Sicard. When Thomas Hopkins Gallaudet returned to the United States with Laurent Clerc (a deaf teacher taught by Sicard) in 1816, this French sign system was introduced into the U.S. deaf education. Based on the French system, Clerc developed an English-based methodical sign system. Similar ways of inventing initialized signs were also adopted by Clerc. For

instance, initialized signs using handshapes from the manual alphabet were invented to represent English spelling, as in days of the week (M for *Monday*) or colors (Y for *yellow*). The manual alphabet could also be used to spell out English words manually in a letter by letter manner (known as 'fingerspelling'). This sign system was absorbed into what eventually became American Sign Language (ASL) and was widely used in American schools for the deaf before the middle third of the nineteenth century until the rise of oralism, which opposed manual communication. Although there might have been an indigenous sign language on Martha's Vineyard back to the 1690s (Gorce 1985), its influence on the development of ASL is unknown due to the lack of information.

Information about the use of signs for instruction is sparse from the beginning of the twentieth century to the 1960s due to the rise of oralism (i.e., educating deaf children by means of spoken language). This situation did not change until Stokoe (1960) published his groundbreaking work on American Sign Language (ASL) in 1960. Much research on ASL brought sign language back to people's attention. Since the revival of signs in deaf education, several manual codes for English have been developed, including Seeing Essential English (SEE I, Anthony 1966), Signing Exact English (SEE II, Gustason, Pfetzing, and Zawolkow 1972) and Signed English (Bornstein, Saulnier and Hamilton 1983). Both SEE I and SEE II invented signs to represent English inflections and affixes. They differ in that SEE II incorporates more ASL-like signs and invented fewer sign markers than SEE I. For example, the English word 'understand' would be signed with UNDER and STAND in SEE I, but SEE II directly adopts the ASL sign for UNDERSTAND. The Signed English system is intended to be learned as easily as possible by deaf children and novice teachers and parents. This system has only the 14 most common inflectional and derivational sign markers (there are 74 sign markers in SEE II). According to Bornstein (1990), SEE II

and Signed English are the most widely used systems by deaf school teachers in the United States.

All of these contrived English-based sign systems have one common purpose, namely, to teach deaf pupils English literacy, given the fact that most high school deaf students' reading or writing level does not reach above the fourth-grade level (Allen 1986; Paul 2001; Qi and Mitchell 2012). The logic is to expose deaf children to a signed form of English so that hopefully they may pick up English literacy. Thus, although ASL lexical signs are adopted in these contrived sign systems, signs are signed following English word order, and novel sign markers for English inflection are invented for expressing English morphology.

**2.2 Taiwan**

The first two deaf schools in Taiwan were established in 1915 and 1917, in Tainan and Taipei, respectively. Since deaf education in Taiwan began during Japan's occupation of Taiwan (1895-1945), teachers of deaf schools were sent from Osaka and Tokyo, who used different varieties of Japanese Sign Language (Chao 1998; Smith 2005). The third deaf school in Fengyuan township of Taichung city started as a division school of the Tainan deaf school in 1956, and teachers were all sent from the Tainan deaf school. The Fengyuan deaf school later became the Taichung deaf school in 1968. It is generally assumed that signs used in the Taichung deaf school are basically the same as that of the Tainan deaf school (Chao 1998; Chang 2001). Thus, it has been generally assumed that there are two varieties of TSL in Taiwan.

Studies on deaf children's literacy suggest that deaf children cannot read or write Chinese very well (Lin and Li 1987; Chang 1989; Lin and Huang 1997). Educators also worry that the dialectal differences might cause comprehension difficulty among deaf people (Lin 2001; Yao 2001). In 1975, in order to improve deaf students' Chinese

literacy and to unify signs used among three deaf schools in Taiwan, the Ministry of Education started a project to compile and invent a signed system based on TSL for pedagogical purposes (Yao 2001). This signed Chinese system adopts some TSL lexical items and invents many novel signs as well as character signs for representing Chinese words manually in a character-by-character manner.

Signed Chinese is characterized by having many invented '文字手語' ('character signs') for depicting the shape or orthography of Chinese characters. Character signs are also found in Chinese Sign Language, Japanese Sign Language, Hong Kong Sign Language and Korean Sign Language (Ann 1998, 2001; Fischer and Gong 2010, 2011).

Ann (1998) has identified four types of character signs in TSL, based on how they are formed. First, character signs may be constructed by means of handshape combination alone. For instance, the character sign for '中' ('MIDDLE', shown in the Figure 6a) is constructed by combining the two handshapes so that the constructed sign is similar to or identical with the Chinese character. Second, character signs may be constructed by means of handshape and movement. For instance, the character sign for '川' ('RIVER', shown in Figure 6b) is constructed by moving the 'W' handshape downward to depict the strokes of '川'. Third, character signs may be constructed by means of a combination of handshape and tracing (i.e., writing either the whole or part of a Chinese character in front of the signer). For instance, the character sign for '毛' (Chinese surname 'MAO', shown in Figure 6c) is constructed by combining a handshape representing the upper part of '毛' with an index finger tracing the last-written stroke of '毛'. Fourth, character signs may be constructed by means of the combination of handshape and mouth. For instance, another character sign for '中' (shown in Figure 6d) is constructed by combining the index finger with the mouth to depict the character '中'. Note that character signs may also be constructed by means

of tracing alone (as shown in Figure 7), but in Ann's data, this type of sign is rare.

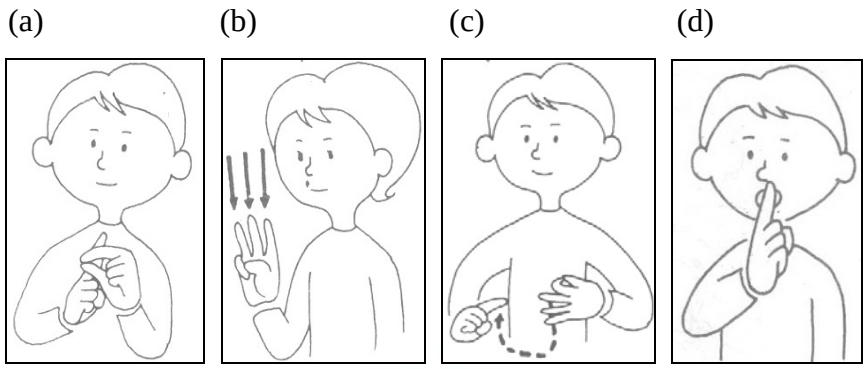



Figure 6. Character signs: (a) '中', (b) '川', (c) '毛' and (d) '中' from Smith and Ting (1979, 1984)

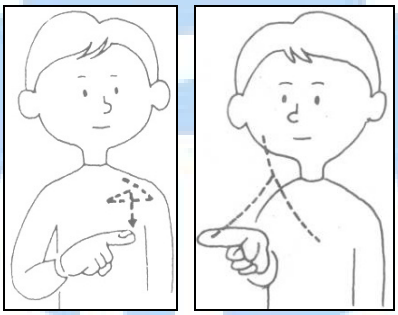


Figure 7. Signs using tracing alone: '千' and '人' from Smith and Ting (1979, 1984)

We should not confuse the term '文法手語' with the term '文字手語' (character signs). Signed Chinese is not composed entirely of character signs. It includes signs borrowed from the TSL lexicon and invented novel signs as well as character signs (Yao 2001). For example, the lexical item '一樣' ('SAME') is directly adopted from the TSL sign (shown in Figure 8a). In this case, only one sign is required to express the two-character word '一樣'. In Figure 8b, the lexical item '一律' ('CONSISTENT'), is signed character by character, and a novel sign representing '律' is invented, despite the fact that TSL already has a simple sign (as shown before in Figure 3) for this concept. Note that the contrived sign for '律' is not a character sign,

since it does not try to depict the shape of this character. In this case, it copies some properties from the TSL lexicon (i.e., the handshape change and the sideway path movement) and alters some (i.e., the handshape and movement of the non-dominant hand is altered) of the native lexicon. In Figure 8c, the lexical item '一頓' ('A MEAL') is also signed character by character. But in this case a character sign depicting the left-side radical of '頓' is invented. Thus, signing a 'grammatical sign language' often means that signs (including borrowed TSL signs, invented novel signs and character signs) are signed following the word order and morphology of Mandarin Chinese, as shown in '一律' and '一頓'.

(a) (b) (c)

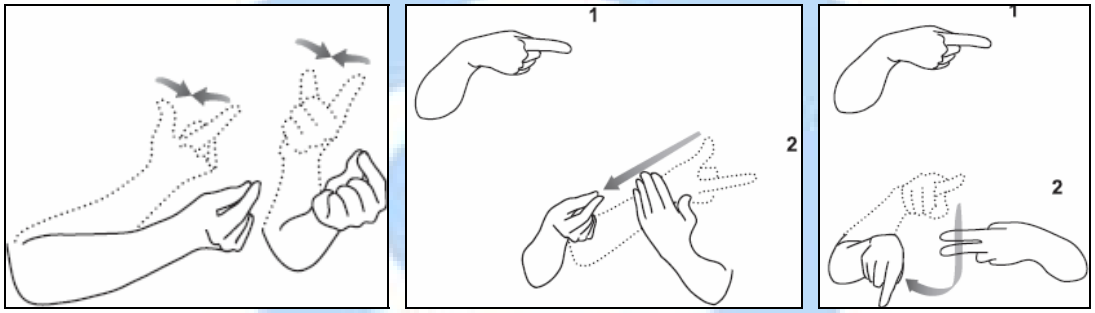



Figure 8. SC examples of borrowed ('一樣'), novel ('一律'), and character sign ('一頓') from Ministry of Education (2008)

The first published book of Signed Chinese is the first volume of '手語畫冊' ('sign language album'), which was published in 1978 (Li 1978). In 1987, the second volume of '手語畫冊' was published (Ministry of Education 1987). The first two volumes of Signed Chinese containing a total of 1859 lexical items. In 1999, the two volumes of Signed Chinese were revised and expanded (Ministry of Education 1999) to have a total of 3212 lexical items. Two newly photographed and expanded sign albums for common Chinese words were later published in 2000, including 4282 lexical items (Ministry of Education 2000). Another Signed Chinese book for

common Chinese idioms was published in 2001 (Ministry of Education 2001), and it includes 1697 Chinese idioms. This book's front matter specifically mentions that 'natural signs' are included for some Chinese idioms[5]. Therefore, in this book, some Chinese idioms are illustrated with two versions of signs. Version (A) is the standard Signed Chinese, in which signs are signed following the morphological structure of Mandarin Chinese, with each character represented by a corresponding sign. Version (B) adopts 'natural sign language' and follows the morphological and syntactic properties of TSL. For example, the Chinese idiom '一日千里' (i.e., 'to make progress at a tremendous pace') is signed character by character in version (A), but it is signed as a sequence of '進步' ('PROGRESS') and '快速' ('FAST') in version (B). Note, however, that version (B) only shows illustrated sign sequences, without explaining or glossing the meaning of each sign. It is unclear whether novice teachers or learners who do not know TSL can learn to express Chinese idioms in TSL forms from this version of signing.

In summary, these published sign language materials invented many novel signs and character signs to represent the morphology of written Chinese, including numeral classifiers, function words, and character signs for representing some Chinese characters. Unlike natural sign languages, in which each sign represents a lexical meaning, in Signed Chinese, words are basically signed character by character.

Signed Chinese has been under development for more than three decades, and complaints about it have never ceased in the deaf community. Some deaf people complain that Signed Chinese is difficult to understand; some complain about its lack of facial expressions; some complain that using Signed Chinese is much too slow; some complain that some invented signs are novel and unacceptable. Simply put,

[5] "文法手語若過於抽象不易了解，宜儘量加以具體化，亦即以事、物之特徵或表情、動作、姿勢等自然手語…故部分詞彙及成語同時呈現文法手語(A)及自然手語(B)兩種打法" (Ministry of Education 2001, p. 8)

Signed Chinese ruins the natural sign language shared by deaf community by imposing Chinese grammar onto TSL (Chao 1998, 2011). Deaf people prefer TSL signs over novel signs and character signs, and often complain that their language is not as well respected as it should be.

Despite all these complaints, a newly expanded version of Signed Chinese dictionary was published in 2008 (Ministry of Education 2008) with the goal of promoting and unifying the use of signs. The 2008 dictionary is a digital dictionary, including an ebook and 9 DVDs showing videos about how signs are articulated. There were a total of 9615 entries in this dictionary, including 8892 lexical items and Chinese idioms, and 723 Chinese synonyms. In this dictionary's front matter, it mentioned that they expect this dictionary to help improving deaf children's Chinese and English literacy (since each Chinese lexical item was accompanied with its English translation). In addition, it also specifically mentioned that more 'natural signs' are adopted in it and some Chinese idioms or lexical items are expressed with two versions of signs. But this time the presentation order of different version of signs is reversed. Version (A) adopts 'natural signs' and is signed following the morphological and syntactic properties of TSL. Version (B) is the standard Signed Chinese, in which signs are signed following the morphological structure of Mandarin Chinese, with each character represented by a corresponding sign. The TSL handshape chart from Smith and Ting (1979, 1984) was adopted to specify handshape(s) of each sign (as shown in Figure 9), and 9 additional handshapes were added to help learning sign language (according to the Ministry of Education 2008).

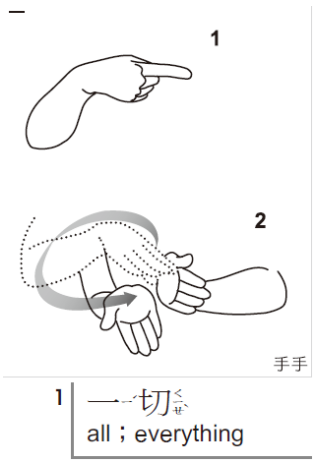



Figure 9. SC ‘ALL’ from Ministry of Education (2008, p. 1)

Due to the improvement of information technology and the prevalence of mobile phones, the Ministry of Education appointed National Taiwan Normal University (National Taiwan Normal University 2016, Version 1.1) to revise the 2008 SC dictionary and develop Taiwan’s first official sign language App on Android and iOS platforms in 2015 (Lin 2015a), so that learners can have access to this dictionary on their mobile phones. According to Lin (2015a), this App version of SC dictionary is basically the same as the 2008 SC dictionary, but it deletes some low frequency lexical items (leaving 8807 Chinese lexical items) and adds 3670 Chinese synonyms, resulting a total of 12477 entries. Lexical items of this sign language dictionary App were sorted by subjects like time, people, food, education, medicine, law and so on. This App also includes some conversations and quizzes.

Although not very satisfactory, Signed Chinese is the only officially recognized signed system by the Ministry of Education in the field of deaf education. However, the decreasing use of signing for educating deaf or hard-of-hearing children due to the trend of inclusive education in the field of special education since 1970s causes another problem. Most deaf or hard-of-hearing students in Taiwan do not attend deaf schools nowadays, but go to regular classes (together with other hearing students) or

special classes for students with hearing impairment in a regular school. According to Lin's (2015b) survey, the number of students studying at deaf schools decreases from 2334 (in 1976) to 589 (in 2014), whereas the number of students studying at regular schools rises from 153 (in 1978) to 4031 (in 2013). Although teachers at deaf schools and regular schools recruiting hard-of-hearing students will receive a copy of the SC dictionary (Lin 2001), the Ministry of Education merely encourages teachers to learn this system, but does not require them to learn and use signing in class since the oral method is the dominant way of educating deaf children. Signed Chinese is also not formally taught to teachers; it is just a sign system at teachers' disposal if they want to lecture to deaf students in sign. Hsing (2003) pointed out that teachers can freely choose their favored communication method, and most teachers of deaf or hard-of-hearing children are never trained to sign in teacher preparation programs. Moreover, teachers' basic signing skills were not assessed by deaf schools until recently (Min-Hua Hsing, personal communication, June 23, 2016). It is possible that teachers at a deaf school may know little or nothing about signing but are still qualified to teach deaf students, as long as they are otherwise qualified teachers of special education. Since deaf schools are often the last possible educational placement for students with severe or profound hearing loss, when the oral method is not helpful, these deaf students will need to learn sign language as a tool for communication, academic learning, social interaction and so on. However, it seems that there is no guarantee that deaf school teachers can serve as good language models for deaf or hard-of-hearing children to learn Signed Chinese.

### 2.3 Summary

We can see that artificial sign languages developed in the West and Taiwan were both invented with the goal to teach deaf children literacy. US systems invent signs

for English inflections and affixes. In addition, the manual alphabet was adopted to fingerspell English words letter by letter, and handshapes of the manual alphabet were used to create initialized signs. Signed Chinese, in addition to borrowing some lexical items from TSL, also invents many novel signs and character signs for representing Chinese words manually in a character-by-character manner. Thus, both systems encode the majority languages (i.e., English and Chinese) of the hearing society manually, by means of creating signs that closely match the morphological structure of the majority languages.

## Chapter 3 The Devising Principles of the SC Lexicon

Signed Chinese is a signed form of Chinese that is designed for teachers to learn and use in their classes in order to improve deaf students' Chinese literacy. The idea is that teachers can function as a language model for Chinese by signing following Chinese grammar, so that deaf students can learn Chinese (and Signed Chinese) from teachers' manually coded Chinese (Lin 2015a). At the sentence level, it adopts Chinese grammar and is signed following Chinese word order. At the lexical level, SC words are basically signed character by character (Yao 2001), but it also directly adopts some TSL lexical items. Lin (2015a) claims that because Signed Chinese is signed character by character, following the word order of spoken Chinese, it can thus help deaf student to write grammatical Chinese sentences[6]. However, Lin also claims that most of the SC lexical items are natural signs.

In this chapter, I investigate to what extent natural TSL signs are adopted into Signed Chinese words in the 2008 version of the SC dictionary (Ministry of Education 2008). The 2008 version of the SC dictionary was chosen for further analyses mainly because the design principles of the 2008 dictionary are the same as those of the 2016 App (Lin 2015a). In addition, each item of the 2008 dictionary can be easily referred to by its page number, whereas references to page number or item number are not available for the 2016 App.

This chapter is organized as follows. Section 3.1 shows that the proportion of natural signs is high in the SC dictionary only if a very naive criterion of natural signs (e.g., Ministry of Education 2000) is adopted. Section 3.2 introduces Liu and Tseng's (2007) classification of SC words in detail, based on their relation to TSL signs. Liu

[6] "文法手語一字一字打，合乎口語的語順，可以幫助聽障生寫出合乎中文語法的句子" (Lin 2015a, p. 158)

and Tseng showed that for the 2000 version of the SC dictionary (Ministry of Education 2000), SC words are basically signed character by character and only 21% of SC words are directly adopted from TSL signs. In section 3.3, I analyze the composition of the 2008 version of the SC dictionary (Ministry of Education 2008) based on Liu and Tseng's (2007) criterion and show that 35% of SC words are directly adopted from TSL signs. In section 3.4, I discuss a few flaws in the 2008 SC dictionary, from the perspective of novice learners. Section 3.5 summarizes this chapter.

### 3.1 'Natural' Signs in Signed Chinese

In the front matter of the 2008 Signed Chinese dictionary, several principles for the choice of signs for inclusion are described (Ministry of Education 2008, p. 7). First, in order to show some respect for the natural sign language of the deaf community, if both kinds of signs (i.e., natural and artificial SC) are collected in the dictionary, the natural signs are listed first, followed by the SC signs using Chinese morphology. Second, if there are no corresponding TSL signs for the intended Chinese words, invented novel signs and character signs are used. Third, words that were already included in previous versions of SC dictionaries remain unchanged. The 2008 SC dictionary claimed that 90% of the SC words are 'natural' signs.

But what does the Ministry of Education (MoE) mean by 'natural'? The answer can be found in the front matter of '常用詞彙手語畫冊' ('Sign language album for common Chinese words', Ministry of Education 2000, p. 7), where four types of signs are distinguished according to their function: '表形' ('conveying the shape'), '表意' ('conveying the meaning'), '表字' ('conveying the character'), and '表音' ('conveying the sound'). Signs are 'natural' if they belong to the first two categories (i.e., '表形' and '表意'), and only the later two categories (i.e., '表字' and '表音') are

counted as ‘grammatical signs’ (i.e., 文法手語). Based on this criterion, Lin (2006, p. 279) provided a survey of this dictionary and showed that ‘表意’ (67.51%) and ‘表形’ (22.58%) are the two most common types of signs. She thus concluded that in this dictionary, about 90% of signs were ‘natural’ signs. The same criterion for distinguishing ‘natural signs’ from ‘grammatical signs’ was repeated again in Lin (2015a).

This naive criterion reflects a common misconception about natural signs and Signed Chinese. That is, ‘natural’ signs are for conveying meanings but not for conveying characters (‘表意不表字’, Department of Labor of Taipei City Government 2010, p. 25), and Signed Chinese signs are for conveying characters. This misconception is often repeated by deaf people, who try to emphasize that natural signs have their own conventionalized lexical signs and need not adopt Chinese characters in their signing to convey a meaning like SC signs (Chao 1998). It has also often been repeated by hearing people, who try to emphasize that natural signs have only very limited corresponding signs for conveying different Chinese words with similar meanings (Yao 2001; Chang 2001). In fact, TSL itself has adopted some character signs into its sign system (Chang 2011a), and the Chinese morphology was sometimes borrowed by TSL to convey some lexical items like ‘可能’ (‘POSSIBLE’, by signing ‘可(以)’ and ‘能’), ‘可愛’ (‘CUTE’, by signing ‘可(以)’ and ‘愛’) and ‘機會’ (‘CHANCE’, by signing ‘機(器)’ and ‘會’). The difference between natural signs and SC signs, I believe, is in how they are constructed to convey a specific lexical meaning, not in their ability to convey the meaning. Conventionalized TSL signs most often use their own lexical items and morphological principles for conveying a specific lexical meaning, whereas SC signs adopt Chinese morphology and basically sign character by character to convey the same lexical meaning. In addition, languages could differ in what is lexically coded. For instance, native TSL

lexicon has no sign for '海鮮' ('SEAFOOD') and often uses a list of signs (e.g., 'FISH', 'SHRIMP' and 'CRAB') for expressing this concept[7]. SC designers invent a new sign for the Chinese character '鮮', and combine it with the sign meaning '海' ('SEA') to express this concept in a character by character manner (as shown in Figure 10). Therefore, 'All roads lead to Rome': both TSL and SC signs can convey a certain lexical meaning or concept, just in different ways.

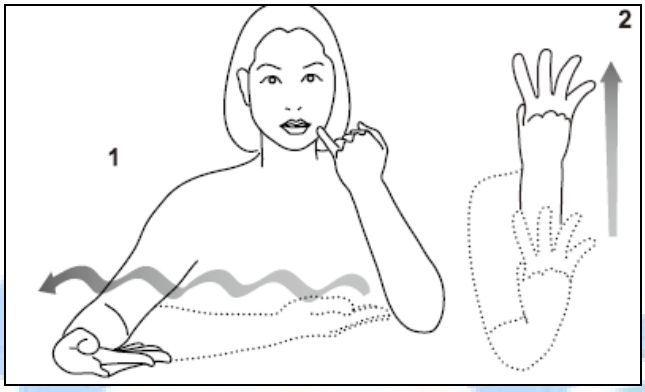



Figure 10. SC sign for 'SEAFOOD' from Ministry of Education (2008, p. 902)

Interestingly, Lin (2006, p. 280) reported another analysis of this dictionary, showing that only 25% of SC words could be counted as 'natural' if a stricter criterion was adopted. Specifically, for a SC word, if any of its component Chinese characters was represented by using an invented (i.e., non-TSL) novel sign or a character sign, it cannot be counted as 'natural'. Lin's finding was similar to that of Liu and Tseng (2007), in which they found that only about 21% of SC words are adopted directly from TSL lexicon.

### 3.2 Lexical Borrowing from TSL Lexicon: Liu and Tseng (2007)

Liu and Tseng (2007) analyzed a random sample of 100 Signed Chinese words

[7] TSL, like ASL, lacks single signs for superordinate categories, and they are often "formed by compounding basic level signs" (Klima and Bellugi 1979, p. 230). See Lin (2007) for detailed analyses on the representation of TSL superordinate categories.

and identified four types of SC signs, based on their relation with TSL signs. The first type of Signed Chinese words are signs that are directly borrowed from TSL signs. For example, the SC sign for '擁擠' ('CROWDED', as shown in Figure 11) directly adopts TSL's sign and thus uses only one sign to represent this two-character word. In other cases, more than one sign might be used to represent a SC word, but the signs are signed following the morphological properties of TSL. For example, the SC sign for '醫生' ('DOCTOR', as shown in Figure 12) directly adopts TSL's compound word 'DOCTOR' (which are formed by combining 'MEDICINE' and 'MALE'[8], Smith and Ting 1979), and thus uses two signs to represent this two-character word.

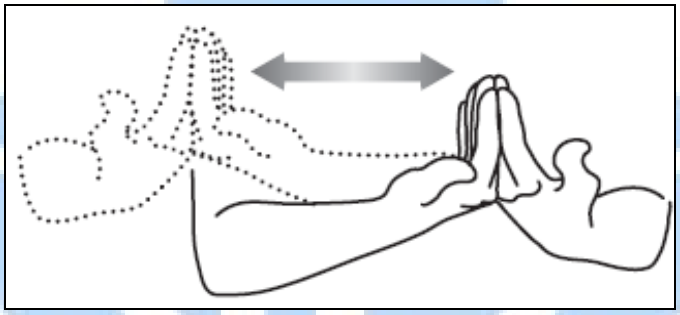


Figure 11. SC 'CROWDED' from Ministry of Education (2008, p666)

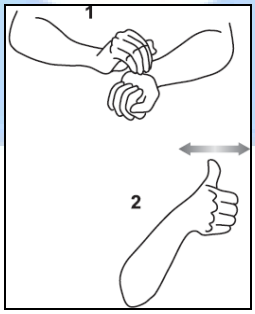



Figure 12. SC 'DOCTOR' from Ministry of Education (2008, p. 1527)

Liu and Tseng's second type of SC words adopt TSL signs, but add redundant sign(s) to represent other character(s) present in the Chinese word. For example, the

[8] Note that 'MALE' here serves as a person marker and is also used in many other TSL compounds like 'FARMER' and 'FISHERMAN'.

SC word for ‘蛋糕’ (‘CAKE’) is signed with two signs: ‘蛋’ and ‘蛋糕’ (as shown in Figure 13). Since the second sign is borrowed from the TSL sign for ‘cake’, the first sign is a ‘redundantly added’ pleonasm (‘贅加’ in Liu and Tseng 2007, p. 78) in the sense that the second sign is already enough for conveying this word.

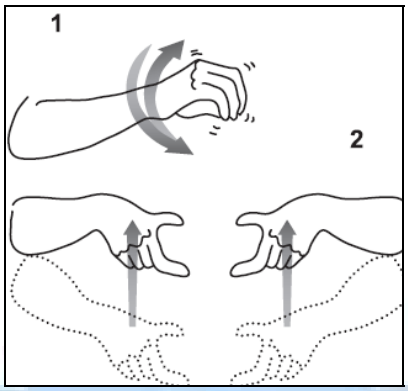



Figure 13. SC ‘CAKE’ (Ministry of Education 2008, p. 1300)

In addition, I notice that this type of word formation process is also used by SC designers as a tool to expand the SC lexicon. Specifically, SC distinguishes Chinese words that have a different Chinese orthographic form, but are signed exactly the same in TSL (because of their similar meaning). For instance, the SC signs for ‘快樂’ (‘HAPPY’) and ‘高興’ (‘GLAD’) (as shown in Figure 14), would be signed exactly the same in TSL. In TSL, only the second sign of Figure 14a would be used to express these similar meanings. In SC, an additional sign representing the first character of the words would be added to distinguish ‘快樂’ (by adding a sign for the character ‘快’) from ‘高興’ (by adding a sign for the character ‘高’).

(a) (b)

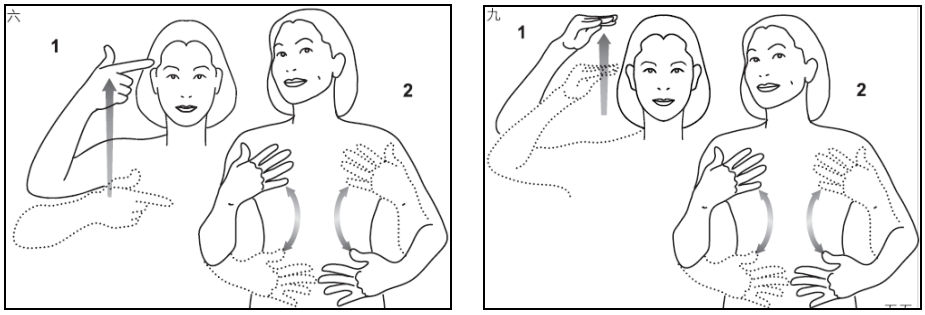



Figure 14. SC ‘HAPPY’ and ‘GLAD’ (Ministry of Education 2008)

Liu and Tseng’s third type of SC word is signed character by character. Signs for each character may also be adopted from TSL signs, but in this type of SC word, none of the represented signs can express the meaning of the whole word by itself. For example, the SC sign ‘警覺’ (‘VIGILANT’, shown in Figure 15) is constructed by concatenating two TSL signs that would be glossed as ‘警察’ (‘police’) and ‘感覺’ (‘FEEL’), respectively. Neither the first sign (‘POLICE’) nor the second sign (‘FEEL’) can fully express the meaning of ‘vigilant’. Moreover, these two TSL signs are chosen for concatenation because their Chinese glosses (i.e., the first character of ‘警察’ and the second character of ‘感覺’) have an identical character with the SC word ‘警覺’.

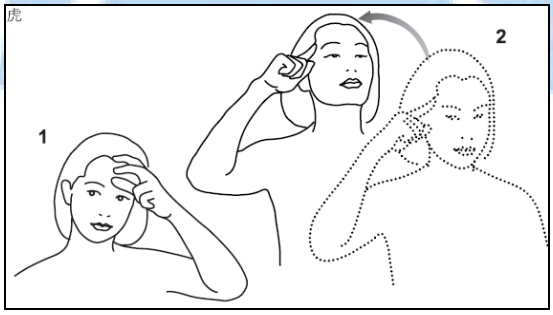



Figure 15. SC ‘VIGILANT’ (Ministry of Education 2008, p. 1395)

This type of word formation process is also used by SC designers to create SC words, where novel signs or character signs have been invented for representing each

corresponding character to expand the SC lexicon. For instance, a set of novel signs was invented for representing Chinese measure words in the metric system: '公斤' ('KILOGRAM'), '公兩' ('HECTOGRAM'), '公錢' ('DECAGRAM') and '公克' ('GRAM') (Figure 16). In these SC words, the first character (i.e., '公') is identical and is also adopted into TSL. But TSL does not have a series of native signs for expressing these different weight units, except for '斤' (shown in Figure 17). Signed Chinese invents a series of novel signs for the second character of these words, differing from each other only in the handshape of the right hand.

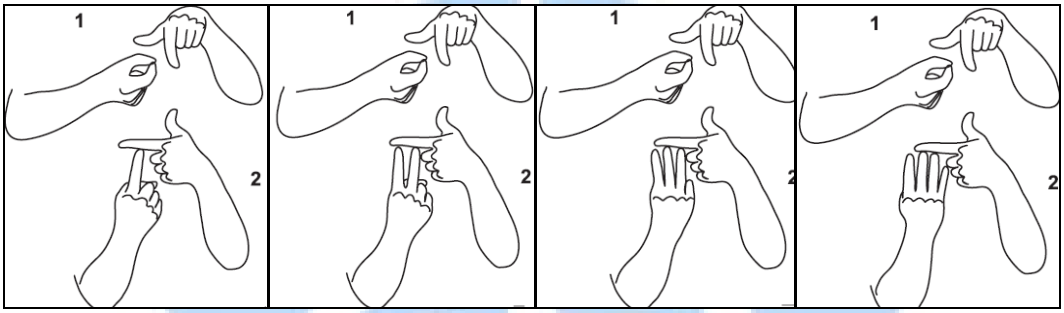



Figure 16. SC '公斤', '公兩', '公錢' and '公克' (Ministry of Education 2008, p. 153)

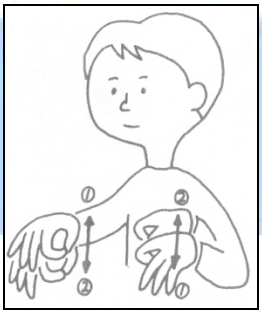


Figure 17. TSL '斤' (Smith and Ting 1984, p. 112)

Liu and Tseng's fourth type of SC words are those that are signed in a different form from TSL signs (i.e., novel signs) or those that do not have a consistent corresponding TSL expression. For instance, the SC word '副手' ('DEPUTY') is signed by a novel sign (as shown in Figure 18a). This meaning is signed with a

different handshape on the dominant hand in TSL (as shown in Figure 18b). However, there is no obvious reason why Ministry of Education has to alter the handshape of the dominant hand, given the fact that the other three SC words (‘副刊’ ‘SUPPLEMENT’, ‘副業’ ‘SIDE JOB’ and ‘副作用’ ‘SIDE EFFECT’) where the first character is also ‘副’ still adopt the TSL form.

(a) (b)

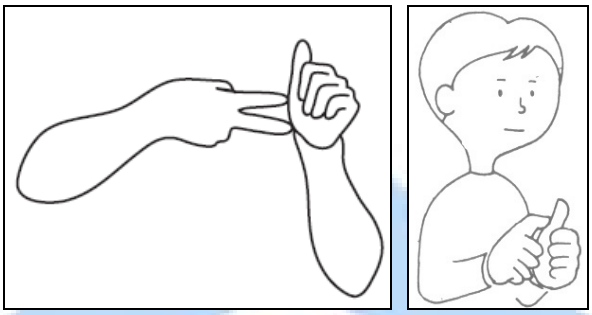


Figure 18. ‘DEPUTY’ in SC (MoE 2008, p. 185) and TSL (Smith and Ting 1979, p. 157)

Type 4 SC words are also invented to expand the SC lexicon by distinguishing Chinese synonyms that are signed exactly the same in TSL. For example, the SC signs for ‘知道’ (‘KNOW’, as shown in Figure 19a) and ‘了解’ (‘UNDERSTAND’, as shown in Figure 19b) would be signed exactly the same in TSL. In TSL, both words would be signed using the form of the first sign in Figure 19. In SC, the handshape is altered to distinguish ‘知道’ from ‘了解’. This is similar to the US sign systems. English words like ‘beauty’, ‘lovely’, and ‘pretty’ are signed identically in ASL, but in SEE II, the basic ASL sign for ‘BEAUTY’ (as shown in Figure 20a) is altered by adopting manual alphabet handshapes to distinguish these English words: L handshape for ‘LOVELY’ (Figure 20b) and P handshape for ‘PRETTY’ (Figure 20c).

(a) (b)

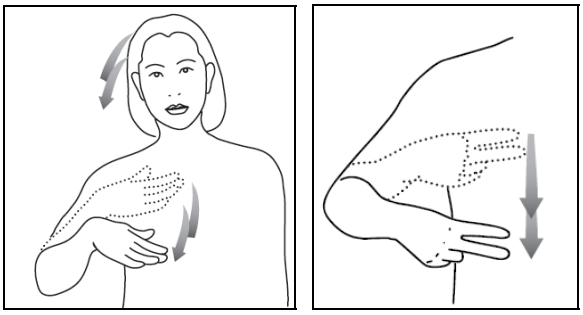


Figure 19. SC ‘KNOW’ and ‘UNDERSTAND’ from Ministry of Education (2008)

(a) (b) (c)

Figure 20. SEE II ‘BEAUTY’, ‘LOVELY’ and ‘PRETTY’ (Gustason 1990, p. 116)

The word formation process and proportion of these four types of SC words is shown in Table 1. Liu and Tseng (2007) concluded that most of the SC (two-character) words in the dictionary (Ministry of Education 2000) were not constructed by adopting TSL lexical signs or compounds. Specifically, only 21% of SC words were constructed by directly adopting TSL expressions, and 53% of SC words (i.e., pleonasms and concatenations) were constructed by combining two TSL signs. Thus, SC words are basically signed character by character.

Table 1. *SC Word Composition from Liu and Tseng (2007)*

| Type | SC Example | Proportion |
|---|---|---|
| Borrowing | 醫+男 | 21% |
| Pleonasm | 蛋+蛋糕 | 29% |
| Concatenation | 警察+感覺 | 24% |
| Other | 副手 | 26% |

### 3.3 A Reanalysis of TSL Influences on the SC lexicon

In this section, I investigate the composition of the newest version of the SC dictionary (Ministry of Education 2008) based on Liu and Tseng's (2007) criterion. A random sample of 2000 items in the dictionary is chosen for further analysis. For the 2000 items, there are a total of 2109 token words (since some lexical items list both 'natural' and SC signs). The word formation strategy of these token words are analyzed, following the classification of Liu and Tseng (2007). The results are listed in Table 2. We can see that about 35% of the examined SC words directly adopt TSL lexical signs or are signed following TSL morphology and syntax, and about 50% of the examined SC words are signed using the 'character-to-sign' strategy (i.e., the 'pleonasm' and 'concatenation' types). Thus, around 35% of the SC words in the 2008 dictionary are borrowed from natural TSL signs. Though not as high as claimed by the Ministry of Education (i.e., 90%), the proportion of TSL-like signs did increase from 21% (for the 2000 SC dictionary, as shown in Table 1) to 35% (for the 2008 SC dictionary).

Table 2. *SC Word Composition for the 2008 SC Dictionary*

| Type | Tokens | Proportion |
|---|---|---|
| Borrowing | 731 | 34.7% |
| Pleonasm | 312 | 14.8% |
| Concatenation | 734 | 34.8% |
| Other | 332 | 15.7% |

### 3.4 Flaws of the 2008 SC Dictionary as a Dictionary

Although the 2008 SC dictionary does include more natural TSL signs than before, it is never specific about which type of word formation strategy should be chosen for constructing a lexical item. For example, '上山' ('GO UPHILL', shown in Figure 21a) is signed character by character (i.e., '上' and then '山'), whereas the semantically related word '下山' ('GO DOWNHILL', shown in Figure 21b) is signed using the classifier construction borrowed from TSL. It is unclear why only 'GO UPHILL' is signed character by character while a classifier construction is adopted for 'GO DOWNHILL'. It is also unclear why this dictionary does not illustrate both types of signs (i.e., TSL version and SC version) for both lexical items.

(a) (b)

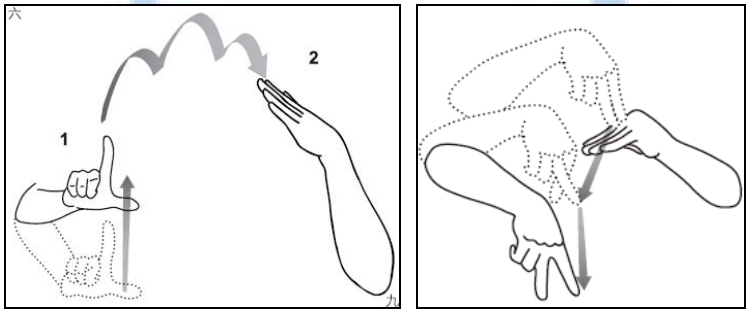



Figure 21. SC 'GO UPHILL' (p. 10) and 'GO DOWNHILL' (p. 13) from Ministry of Education (2008)

In another case, the second character of both ‘傭人’ and ‘佣人’ (both mean ‘servant’, shown in Figure 22a, 22b) is the character ‘人’. Both ‘傭人’ and ‘佣人’ would be analyzed as the second type of SC word, since the first sign is a direct borrowing of a TSL sign meaning ‘servant’. The second sign for the character ‘人’ was redundantly added to it so that these SC words follow the ‘character-to-sign’ strategy. In ‘傭人’, ‘人’ is signed using a character sign depicting the strokes of this Chinese character. However, although ‘佣人’ is a synonym of ‘傭人’, the second character is not signed using the same character sign. A classifier handshape that is usually used to refer to human beings (Smith 1989) in TSL is used instead. In addition, the Chinese words differ in the first morpheme, while the SC signs differ in the second morpheme. It is again unclear why this is the case.

(a) (b)

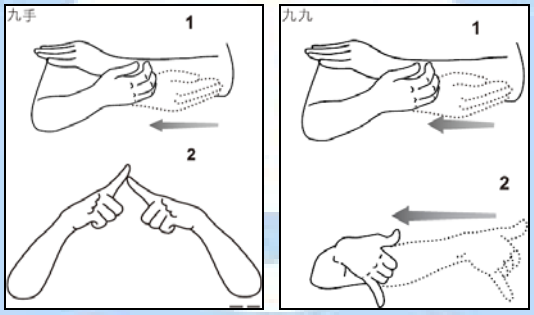



Figure 22. SC ‘傭人’ (p. 126) and ‘佣人’ (p. 80) from Ministry of Education (2008)

Another disadvantage of this dictionary for novice teachers is that for entries (lexical items or idioms) that are signed following TSL grammar, no gloss is provided for each component sign. Since SC is designed for teachers to use as an instructional tool in class, and most teachers do not learn to sign before they get a job at a deaf school, the lack of explanation about TSL expressions in the SC dictionary might lead to teachers having difficulties in learning TSL-like expressions. For example, the Chinese idiom ‘一日千里’ (‘to make progress at a tremendous pace’, shown in Figure

23) is illustrated with two versions. For version B, novice teachers might be able to pick up some corresponding signs for representing Chinese characters since it is signed character by character. For version A of this idiom, novice teachers are provided with no clue what these two signs are trying to convey. In this case, version A is signed in the sequence of '進步' ('PROGRESS') and then '快速' ('FAST'), and this is also probably what deaf signers would sign when they try to explain this Chinese idiom. I can only guess this because I already possess a certain amount of knowledge about TSL grammar.

Moreover, in this case, '進步' is not illustrated with its standard two-handed form. Specifically, the non-dominant hand is dropped from the articulation of this sign. This 'Weak Drop' phenomenon (Padden and Perlmutter 1987) is optional for two-handed signs, and it occurs most often in rapid signing. Maybe the SC dictionary is trying to show that the editors of this dictionary not only have adopted some TSL signs, but they also know how signers might produce the signs in natural signing (since some of the editors are deaf signers). This dictionary should clarify these alternated TSL forms for novice teachers or learners by providing some glosses or explanations, or otherwise novice teachers might just ignore the TSL version or have difficulties figuring out what the signs were trying to convey.

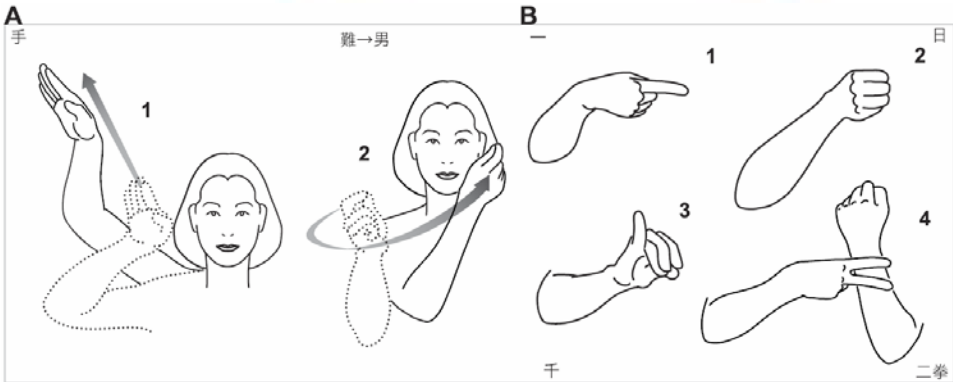


Figure 23. SC '一日千里' (p. 5) from Ministry of Education (2008)

### 3.5 Summary

To summarize, we can see that SC words are constructed by direct borrowing from TSL signs, by adding a redundant sign to a TSL sign, by concatenating two existing signs or novel signs, and by inventing novel signs or constructed signs in a different way from TSL. Although the 2008 SC dictionary claims that 90% of its vocabulary is ‘natural’, I show that this is due to misconception about natural signs. I adopt a stricter criterion and show that only about 35% of its vocabulary was adopted from TSL signs. Finally, as an officially published sign language dictionary, its principle for when to adopt TSL signs is not clear, the usage of TSL signs for conveying Chinese idioms is not glossed or explained, and some character signs were not used consistently in the dictionary.

# Chapter 4 Learning Outcomes of Artificial Sign Languages

This chapter describes the poor learning outcomes of artificial sign languages in the US and Taiwan. Reasons for why artificial signs are poorly learnt and alternatives for improving deaf children's literacy are also discussed. Section 4.1 describes the findings in the US. Section 4.2 describes the findings in Taiwan. Section 4.3 summarizes this chapter.

## 4.1 The US

### 4.1.1 The Poor Learning Outcome for Manually Coded English

Manually coded sign systems such as SEE II and Signed English were invented to improve deaf children's literacy. Although the use of artificial sign language in educational settings is widespread (Bornstein 1990), deaf children's English literacy has not significantly improved compared to the past and they remain far behind their hearing counterparts (Allen 1986; Paul 2001; Qi and Mitchell 2012). Despite the null effect on improving literacy, however, some teachers and researchers still think that deaf children should begin to use signed form of English as early as possible (Gaustad, Kelly, Payne and Lylak 2002; Luetke-Stahlman and Nielsen 2003; Mayer and Akamstsu 2000; Nielsen, Luetke and Stryker 2011; Stewart 1983). It has been found that deaf children have difficulty learning these contrived sign systems. Raffin (1976) found that deaf children's acquisition of signed bound morphemes is late. Deaf children often used some of these signed forms of English bound morphemes as if they were free morphemes, "sprinkled with extra *–s*'s and *–ing*'s" (Swisher 1991, p. 127) in their production. Even when deaf children realize that bound morphemes should be attached to a root, they cannot use these bound morphemes consistently, and the error pattern persists as they grow older (Wodlinger-Cohen 1991).

### 4.1.2 Reasons for the Poor Learning Outcome for Manually Coded English

Two possible reasons for this poor learning outcome have been investigated. First, the input for deaf children is incomplete. Specifically, teachers or parents did not learn or express their manually coded English consistently. The impoverished input might hinder deaf children from learning this system. For example, Marmor and Petitto (1979) found that teachers' signing conforms neither to the grammar of English nor to the grammar of ASL. Woodward and Allen (1988) found that fewer than 15% of signing teachers who claim to be using one type of manually coded English (e.g., SEE II or Signed English) can actually use any signed form of English following the devising principles of their signed systems. Supalla (1990) found that SEE II teacher did not use SEE II morphology consistently. Specifically, 44% of English affixes that are crucial for representing English inflections were missing in the teacher's production of content words that were required to be affixed with a bound morpheme.

The second reason for the poor learning outcome is the contrived nature of the signed system itself. Specifically, Supalla (1990) questioned whether manually coded English can function as a learnable signed system, given its pervasive linear affixation processes borrowed from English. In a word segmentation task, Supalla found that non-signers who had never been exposed to any signed system consistently judged or perceived affixed SEE II signs (e.g., IMPROVE + MENT) as two signs rather than treating them as an affixed single sign. Thus, young deaf children learning SEE II made segmentation errors as to these affixed SEE II signs. One possible remedy (Swisher 1985) for the segmentation error is to articulate affixed signs following the assimilation rules as in ASL lexicalized compounds (Klima and Bellugi 1979; Liddell and Johnson 1986). This was tested in another of Suppala's segmentation tasks using signs from a foreign sign language. The task was performed by ASL signers, SEE II

signers and non-signers. Specifically, signs from New Zealand Sign Language were chosen as roots and linear affixes to form linearly combined non-signs. Test items included uninflected signs, non-linearly affixed signs, linearly affixed signs (like SEE II morphology), linearly affixed signs with partial assimilation and linearly affixed signs with full assimilation. Uninflected signs and non-linearly affixed signs were expected to be judged as one sign. Linearly affixed signs were expected to be judged as two signs. Test results supported these expectations. The results suggest that participants consistently perceived affixed signs with partial assimilation as two signs, but perceived affixed signs with full assimilation as one sign. Supalla thus concludes that linear affixation exceeds the perceptual limits of a simple sign and the preference for simple structure is a modality constraint of sign formation.

This modality constraint has also been observed in the articulation of artificial signs. The relatively slow movement of manual articulators of signs (Bellugi and Fischer 1972) might force signers to utilize other strategies to encode comparable content more efficiently (Wilbur 2003), when producing artificial signs. For instance, Supalla (1991) found that deaf children who were exposed only to SEE II utilized some form of spatial movement to mark subject and object, which is absent in SEE II but is similar to ASL agreement morphology. Moreover, the tense marker (which is a crucial element in SEE II for representing English affixes) was completely absent in children's use of SEE II signs. Similarly, Wilbur and Peterson (1998) found that deaf signers who knew ASL consistently use facial expressions to encode linguistic information while producing a manual code of English.

### 4.1.3 Alternatives for Improving English Literacy

From the literature reviewed above, we can see that the linearly sequenced structure of artificial signs might exceed learners' cognitive load and is difficult to

learn. Supalla and McKee (2002) suggest that since the linearly affixed structure of manually coded English exceeded both hearing and deaf people's perceptual limits for word segmentation, it is thus questionable to assume that a signed form of English can help to improve deaf children's English literacy.

In fact, deaf children's English literacy has been shown to be positively correlated with their ASL proficiency (Strong and Prinz 1997; Freel, Clark, Anderson, Gilbert, Musyoka, and Hauser 2011; Hrastinski and Wilbur 2016). Wilbur (2000) suggests that ASL should be used as a metalanguage to support the learning of English literacy, since ASL is naturally developed and its structure is also favored by deaf children who were never exposed to ASL. If ASL can be easily acquired by deaf children as their first language (L1), it can function as a metalanguage to help deaf children's learning of a second language (L2) or any other academic subjects like physics, mathematics, and so on, just as thousands of deaf students studying at Gallaudet University and the National Technical Institute for the Deaf (of Rochester Institute of Technology) do in their classes. Hrastinski and Wilbur's (2016) multiple regression model consisting of five predictors regarding age of enrollment, hearing devices, secondary disabilities, ASL proficiency and home language showed that ASL proficiency (i.e., L1 proficiency) is the only factor that can significantly predict higher scores on reading comprehension, English language use, and mathematics, suggesting that mastering proficient ASL is not only beneficial for deaf children's learning of English, but also for other academic subjects.

Clearly, ASL can be used as a tool to help improve deaf children's English literacy. For instance, fingerspelling (by spelling out English orthography manually), as an integral part of ASL, has been shown to successfully serve as a visual phonological bridge for decoding English orthography (Haptonstall-Nykaza and Schick 2007; Mounty, Pucci, and Harmon 2014). Haptonstall-Nykaza and Schick

(2007) showed that when deaf children were taught lexicalized fingerspelling signs (i.e., “fingerspelled version that included a sign-like movement pattern”, p. 177) in addition to English print, children could better recognize and produce new words in print. The benefits of using fingerspelling as a bridge between ASL and English to help children read and write were evidenced in Mounty, Pucci, and Harmon’s (2014) qualitative interviews with ASL/English bilinguals. Interviewees believed that deaf children “should be exposed to fingerspelling very early, long before they can be expected to understand, just as hearing babies are exposed to spoken language right from the start” (p. 340).

## 4.2 Taiwan

### 4.2.1 The Poor Learning Outcome for Signed Chinese

Despite deaf people’s criticisms of Signed Chinese (Chao 1998, 2011), it is the only officially recognized signed system in Taiwan, and is still used by most deaf school teachers as an instructional tool for improving deaf children’s Chinese literacy. However, deaf students seem to have difficulties mastering SC. Lin, Huang and Hsing (2001) conducted a carefully designed test to evaluate deaf students’ comprehension of Signed Chinese. 200 deaf students from three deaf schools were tested for their comprehension of Signed Chinese by presenting them with a total of 68 signed questions: 23 lexical choice questions, 15 lexical comprehension questions, 15 sentence comprehension questions and 15 meaning comprehension questions. All of the questions were signed (without speaking) by an experienced teacher to make sure that all of the sentences were well constructed. The results showed that the overall comprehension level for the four types of questions for elementary school students, junior high school students and senior high school students was about 50%, 62% and 69% respectively. That is, deaf students could only understand a little more than half

of well constructed Signed Chinese. Clearly, this is not a very satisfying result.

The effect of Signed Chinese on improving deaf students' Chinese literacy has been questioned. In a study of deaf students' comprehension of stories in different forms, Liu, Tseng and Chang (2006) found that deaf students understand stories told in TSL better than in written Chinese. Moreover, deaf students' comprehension of written Chinese is better than that of Signed Chinese. They concluded that the use of Signed Chinese in deaf schools does not really help to improve deaf students' Chinese literacy. Given the fact that deaf students communicate with each other in TSL, not Signed Chinese, it is not surprising to find out that deaf students cannot understand Signed Chinese very well. What is really surprising is that even after many years of exposure to Signed Chinese from the beginning of learning a sign language (since most deaf children do not learn to sign until enrolled into a deaf school), deaf people still do not learn much Signed Chinese. I observe that deaf people still choose to use lexical signs from TSL in their daily conversation, with only a few created artificial signs adopted into TSL.

### 4.2.2 Reasons for the Poor Learning Outcome for Signed Chinese

Lin (2001) conducted a survey of teachers' opinions about signed systems used in Taiwan's deaf education and found that more than 80% of teachers agreed that it is necessary to use Signed Chinese as early as possible for improving deaf pupils' Chinese ability. However, only 22% of the surveyed teachers had learned to use Signed Chinese before they began to teach deaf students. Hsing (2000, 2003) investigated hearing teachers' SC patterns in the simultaneous communication mode (i.e., teachers sign and speak simultaneously) and found that the teachers' signed message did not match their spoken message very well. In Hsing's (2003) studies of deaf school teachers' consistency for simultaneously produced Signed Chinese and

speech, the mean of exact message equivalence between the signed and spoken channels for the surveyed teachers was about 25%, and 17% of teachers' signed messages were ungrammatical according to Chinese grammar. Message mismatches between sign and speech mainly involved missing verbs (21%), adverbs (21%), auxiliaries (17%), pronouns (13%) and nouns (12%) in the signed channel, and mistaken forms in signing. Clearly, teachers did not function very well as a model for deaf children to learn this signing system.

Is the SC lexicon, like manually coded English, intrinsically difficult for deaf children and hearing learners to learn? Liu and Tseng (2007) used three different types (i.e., borrowing, pleonasm and concatenation) of Signed Chinese words to investigate which type is most difficult to be understood by deaf students. Thirty-six deaf students from National Taichung Deaf School were recruited for the comprehension task. Participants were presented with different types of sign words and had to respond by choosing one of four pictures shown on the screen with a corresponding meaning with the stimulus sign. They found that lexical items in Signed Chinese that are directly borrowed from TSL were understood by deaf students significantly better (accuracy rate: 73%) than items that are constructed by adding a redundant pleonastic sign (accuracy rate: 62%), which in turn were understood significantly better than items that are concatenated according to Chinese morphology (accuracy rate: 36%). Their results thus suggest that deaf students cannot understand the later two types of SC words very well[9].

Liu, Tseng and Liu (2009) provide some evidence showing that both deaf and hearing signers can memorize TSL-like signs better than concatenated Signed Chinese signs that are constructed character by character (either by redundant addition or

[9] A potential confound of this study is the fact that the average word length of pleonasms (3500 ms) and concatenations (3350 ms) are both significantly longer than borrowed words (2890 ms).

concatenation). Four types of words were used to test the short-term memory span for signed words in TSL and Signed Chinese. These four types of words were TSL simple words, TSL compound words, SC pleonasms and SC concatenated words. For each type of word, a total of 25 words were selected to compile ten memory test questions: two three-word questions, two four-word questions, two five-word questions, two six-word questions and two seven-word questions. All four types of memory test were performed on deaf students, deaf adults and hearing signers. For each test question, participants were shown a list of signs and had to remember them. Participants were then asked to repeat signs following the same shown order of that test question. They found that the memory span of deaf students and deaf adults for TSL simple words (2.98 and 3.6, respectively) and TSL compound words (2.68 and 2.95, respectively) is larger than SC pleonasms (2.57 and 2.4, respectively) and SC concatenated words (2.59 and 2.5, respectively). Similar performance patterns were also found for hearing signers (memory span for TSL simple words, compound words, SC added pleonasms and SC concatenated words were 3.8, 3.5, 3.2, and 2.4, respectively).

### 4.2.3 Alternatives for Improving Chinese Literacy

Myers, Tsay and Su (2011) provide some evidence showing that SC should not be used as a tool for teaching deaf children. Specifically, they demonstrate that TSL has significantly greater 'representation efficiency' (defined as proposition per syllable) than spoken Chinese, and TSL can also transmit information equally efficiently (i.e., the 'transmission efficiency', the rate of propositions per second) as spoken Chinese. Since SC is a sign system that converts spoken/written Chinese (i.e., lower representation efficiency) into manual gestures, its representation efficiency would be lower than TSL (i.e., SC needs more signs to convey the same amount of information), and its transmission efficiency would also be lower than TSL. (i.e., SC

needs more time to convey the same amount of information). Thus, teaching deaf children with SC not only requires producing more signs (thus more effort), but it is also more time-consuming for teachers. In addition, they found that the simultaneous communication method that is commonly adopted by deaf school teachers could also reduce the transmission efficiency. They thus suggest that the language that should be used to instruct deaf children in Taiwan is TSL, not Signed Chinese or simultaneous communication.

Since Hrastinski and Wilbur (2016) showed that mastering a proficient sign language is beneficial for learning a second language, it may be better for deaf children to use TSL to help them learn Chinese. Huang (2014) included TSL as a teaching language and showed that a TSL/Chinese bilingual picture book instruction method seemed to help improve deaf children's reading comprehension and story retelling ability, when they were evaluated in sign language tests (whereas their performance was still poor if tested in oral tests). Five three-to-six-year-old deaf children were instructed with picture books in bilingual settings twice a week for sixteen months. Stories were narrated in TSL by an experienced TSL deaf teacher, and a sign language interpreter simultaneously interpreted the stories into Chinese. Huang's results showed that deaf children could comprehend and retell stories better in signed forms than in spoken forms, suggesting the importance of TSL as a metalanguage for deaf children who might have very limited access to spoken messages.

We can see from section 4.1.3 that fingerspelling in ASL can function as a visual phonological bridge between ASL and English orthography to help learning English. Unlike English, which has an alphabetic writing system (i.e., each letter represents a consonant or a vowel), the writing system of Mandarin Chinese is logographic (i.e., each character represents a word or a morpheme). The closest TSL parallel to ASL

fingerspelling system might be signs for representing *zhuyin fuhao* (注音符號) that was invented by a deaf school teacher Caipin Chen (陳彩屏) in 1976 and taught at Taipei School for the Deaf (Lin 2006). This system represents consonants (聲符) on the left hand and represents vowels (韻符) and tone (聲調) on the right hand (see Appendix 1). However, this sign system is not widely adopted by deaf schools and I observe that most deaf people are not familiar with this system. This is probably due to the fact that the *zhuyin fuhao* system is only taught and used during the first year of elementary school. Teachers mainly use the logographic writing system of Chinese afterward. More importantly, Lin (2006) reported that this *zhuyin fuhao* system has no effect on improving children's Chinese literacy. In addition, signing *zhuyin fuhao* would be much slower (i.e., inefficient), even slower than signing character-by-character. For instance, it would require three signs for just conveying the character '好', since this character is spelled as ㄏㄠˇ in the *zhuyin fuhao* system.

In addition to using signs as a tool for improving deaf children's literacy, picture books were also shown to be helpful (Zhang and Liu 2014; Liu and Liu 2015). Zhang and Liu (2014) adopted the predictable-pattern-book instruction method ('PPBI') to teach deaf children and found that PPBI could help children read better. Predictable-pattern books are books with easier language, repetitive and predictable structures for new readers (Wu 2005). In Zhang and Liu's study, eighteen elementary school deaf students were recruited and divided into two groups. Nine were in the experimental group and nine were in the control group. After have received eight weeks of PPBI interventions, students in the experimental group significantly outperformed those in the control group in the reading comprehension posttests. Similarly, Liu and Liu (2015) also showed that picture books were beneficial for deaf students' Chinese literacy. Their case studies on seven deaf students (from grade 1 to

grade 3, all studied at regular schools and trained in the oral method for an extended period of time) showed that using picture books as a tool can significantly improve students' oral vocabulary comprehension, word recognition, and story comprehension.

### 4.3 Summary

From the literature reviewed above, we can see that both manually coded English and Signed Chinese are difficult for deaf learners to learn, and they have both failed to improve deaf children's literacy. This poor learning outcome might be due to teachers' incomplete signing input, or it might be due to the linear concatenation structure of contrived signs that make them difficult to process by learners. Several alternatives have been proposed to help improving deaf children's literacy. For instance, the use of natural signs as an instructional language seems to be beneficial to deaf children. Some studies suggest that picture books can also be helpful for improving deaf children's literacy.

# Chapter 5 Phonotactic Constraints on Natural Signs

Studies on artificial sign languages have suggested that these contrived sign systems are not well learned by deaf children (Supalla 1991; Swisher 1991; Lin, Huang and Hsing 2001). As we have seen, two possible causes for this poor learning outcome have been investigated. First, hearing teachers may not function as a good language model because their signing does not follow the devising principles of the contrived system and the message conveyed in the signed channel often does not match the message expressed in the spoken channel (Woodward and Allen 1988; Hsing 2000, 2003). Second, the linearly affixed structure of sign words might exceed learners' cognitive load and is thus difficult for deaf children to process and learn (Supalla 1990; Liu and Tseng 2007).

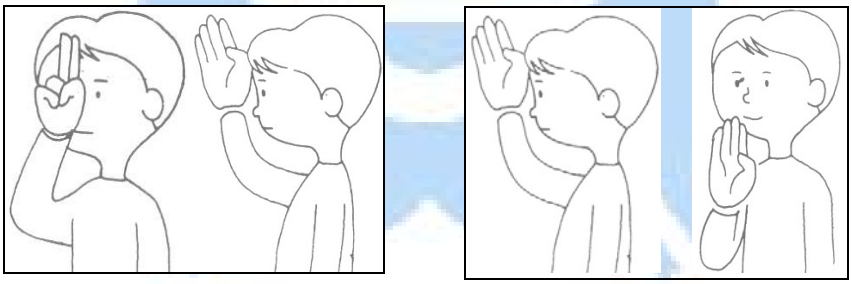
However, another possible source of difficulty for learning SC signs has not been investigated sufficiently in depth. Specifically, the sign-internal phonological organization of contrived signs might be difficult for deaf children to learn. In order to investigate the sign-internal phonological organization of SC and TSL signs, it is necessary to introduce phonological parameters for analyzing signs and relevant phonotactic constraints for well-formed signs. The three phonological parameters and some terminology useful for analyzing signs are introduced in section 5.1. In Section 5.2, I introduce some phonotactic constraints that are derived mostly from the ASL literature, but they seem to be universal for all natural sign languages, and are thus crucial for the subsequent comparisons between SC and TSL in Chapter 6. Section 5.3 summarizes these phonotactic constraints.

## 5.1 Phonological Parameters of Signs

Since Stokoe's (1960) pioneering study on American Sign Language, it has been

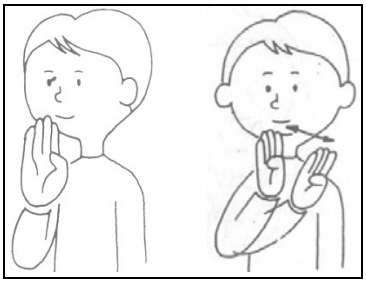
accepted that signs are composed of three basic phonological parameters. Every sign is articulated with a particular handshape at a specific location executing some kind of movement. Battison (1978) identified orientation as the fourth phonological parameter of signs, which was later analyzed as a feature specification of the handshape parameter in many phonological models (e.g., Sandler 1989; Sandler and Lillo-Martin 2006; Crasborn and van der Kooij 1997). In this chapter, TSL examples will be provided for illustration whenever possible. These three phonological parameters are like phonemes or phonological features in spoken languages in that they can serve contrastive function for minimal pairs. For example, the TSL signs 'NOON' and 'PLEASE' (Figure 24a) are minimal pairs differing only in their handshapes. The TSL signs 'PLEASE' and 'BE' (Figure 24b) differ only in their locations. The TSL sign 'BE' and 'USELESS' differ only in their movement types (Figure 24c). See Tsay and Myers (2009) for further discussion of the parameters of TSL signs.

(a) (b)



'NOON' 'PLEASE' 'PLEASE' 'BE'

(c)



'BE' 'USELESS'

Figure 24. TSL minimal pairs (from Smith and Ting 1979, 1984)

### 5.1.1 The Handshape Parameter

Of the three phonological parameters, handshape is the most complex one. First, handshape is abundant in terms of its inventory (Lee 2003; Tai and Tsay 2015). The fingers and the thumb can be selected for articulation in various combinations. Handshapes may differ in the configuration of the finger joints. Finger joints can be divided into two groups (Uyechi 1996; Brentari 1998): the base joint (i.e., the metacarpophalangeal joint, which is the joint connecting the finger and the palm) and the nonbase joints. This distinction is motivated by the fact that the nonbase joints always move together during flexion or extension. Different joint configurations can be distinguished according to the extent of finger flexion of finger joints. For example, if all joints of a finger are fully extended, it is 'open' or 'extended'; if all joints of a finger are fully flexed, it is 'closed'; if the base joint of a finger is flexed whereas the nonbase joints remain extended, it is 'bent'; if the nonbase joints of a finger are flexed whereas the base joint remains extended, it is 'curved' or 'hooked'.

In many signs, handshapes can change from one configuration to another. Mandel (1981) makes a useful distinction between 'selected' and 'unselected' fingers for any handshape. Specifically, in a handshape change, fingers that change their joint configuration are 'selected fingers', whereas fingers that do not change their joint configuration are 'unselected fingers' (cf. Lee 2003 for a discussion of the limitations of Mandel's definition). Thus, in a handshape change, the selected fingers change their joint configuration together as a unit. By contrast, the unselected fingers cannot change their joint configuration and may only be either extended or closed.

The notion of 'selected finger' has also been adopted to describe static handshapes that differ in the selection of fingers, as in TSL 'NOON' and 'PLEASE' (shown in Figure 19a). In TSL 'NOON', only the index and middle fingers are selected for articulating the sign, whereas in TSL 'PLEASE' all four fingers are

selected.

Every sign language has two articulators (i.e., hands) for articulation, so signs may be one-handed or two-handed, and in two-handed signs, the two articulating hands might assume the same or different handshapes. For two-handed signs where one hand moves whereas the other hand holds still, Battison (1978) distinguishes between the active (moving) and the passive hand. Similarly, Padden and Perlmutter (1987) make a distinction between the strong and weak hands (p. 338). This distinction is useful because right-handed signers tend to use their right hand for articulating a one-handed sign or making movements in two-handed signs, whereas left-handed signers would prefer to use their left hand for articulation. The distinction between the dominant hand (the hand preferred for most motor tasks) and the nondominant hand (i.e., the left hand for right-handers) is adopted by sign phonologists to describe typical sign articulations.

### 5.1.2 The Location Parameter

Signs can be articulated at a specific location (like TSL ‘YELLOW’, shown in Figure 25a) or moved from one location to another (like TSL ‘THING’, shown in Figure 25b). It is generally assumed that only four distinct major body areas are required for distinguishing among signs (Sandler 1989, Brentari 1998). Major body areas include the head (e.g., TSL ‘YELLOW’, shown in Figure 20a), trunk (e.g., TSL ‘THING’, shown in Figure 25b), arm (e.g., TSL ‘LAW’, shown in Figure 25c) and non-dominant hand (e.g., TSL ‘HABIT’, shown in Figure 25d). Different subareas can be distinguished by specifications like ipsilateral, contralateral, distal, proximal, high and low (Sandler 1989). In TSL ‘PLEASE’ and ‘BE’ (shown in Figure 24b) for example, both signs are articulated at the head area, with ‘PLEASE’ at a higher location and ‘BE’ at a lower location.

(a) (b) (c) (d)

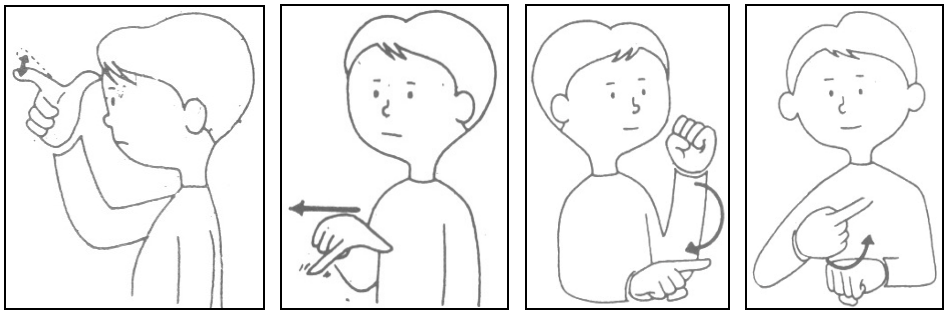


Figure 25. TSL ‘YELLOW’, ‘THING’, ‘LAW’ and ‘HABIT’ from Smith and Ting (1979)

### 5.1.3 The Movement Parameter

Three types of movements are distinguished in lexical signs. First, path movement is a hand movement made by the shoulder and elbow joints. In a path movement, hand(s) move from one location to another. The shape of path movements might be straight, arc-shaped, or circular. Second, hand-internal movement (Sandler 1989), also called local movement (Liddell and Johnson 1989; Liddell 1990), is hand movement made by the hand and wrist joints. Hand-internal movement includes handshape change and orientation change. Third, trilled movement (Padden and Perlmutter 1987; Brentari 1996), also called secondary movement (Perlmutter 1992), is characterized by its rapid and repeated hand movements. Trilled movement types include circling (repeated circling movements), wiggling (repeated alternating finger movements), closing (repeated closing movements), releasing (repeated opening movements), hooking (repeated changes into a curved posture), flattening (repeated changes into a bent posture), nodding (repeated orientation changes parallel to the arm), twisting (repeated orientation changes rotating relative to the arm), and rubbing (repeated, back and forth rubbing of the thumb and the finger pads on other selected fingers).

Some signs are articulated with a path movement only (e.g., TSL ‘FULL’, shown in Figure 26a), some with a hand-internal movement or trilled movement only (e.g., TSL ‘SMART’, ‘BUT’ and ‘YELLOW’, shown in Figure 26b, 26c and 26d), and some with a simultaneous combination of a path movement and a hand-internal movement or trilled movement (e.g., TSL ‘FLOWER’ and ‘THING’, shown in Figure 26e and 26f).

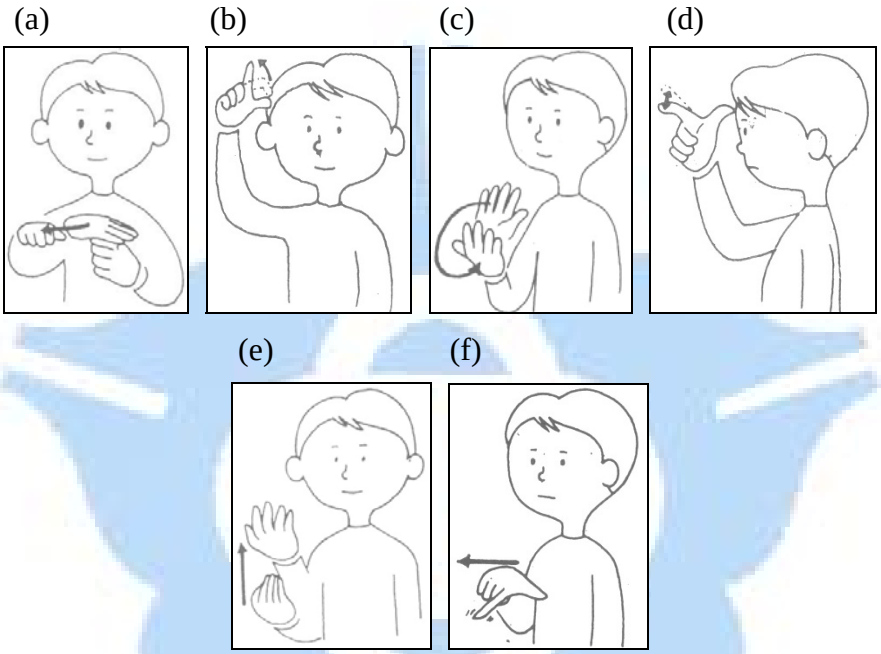



Figure 26. TSL ‘FULL’, ‘SMRT’, ‘BUT’, ‘YELLOW’, ‘FLOWR’ and ‘THING’ from Smith and Ting (1979)

**5.2 Phonotactic Constraints on Natural Signs**

This subsection introduces several phonotactic constraints for natural sign languages on handshape, location and movement parameters. In addition, the non-contrastive nature of handedness for lexical sign, and the preference of describing spatial scenes from the narrator’s perspective are also introduced. Although these constraints or principles were first observed in ASL studies, they seem to be true for TSL (and possibly for other natural sign languages) and are thus relevant for the

comparisons between natural TSL and artificial SC that are proposed in Chapter 6.

### 5.2.1 Selected Finger Constraint on Handshape Change

Mandel (1981) has shown that in monomorphemic ASL signs with a handshape change, there is a relationship between the first and final handshapes. Specifically, the selection of fingers (i.e., the selected fingers) always remains the same throughout a handshape change. The joint configuration of the selected fingers changes from an open variant to its closed variant (e.g., TSL 'POWER', shown in Figure 27a) or vice versa (e.g., TSL 'FLOWER', shown in Figure 27b), and the joint configuration of the unselected fingers is usually predictable (Corina 1993). This type of handshape change is termed 'handshape contour' (Corina 1993; Brentari 1998). Another type of handshape change is also attested, where the selected fingers for the first and final handshapes are different. For example, the TSL sign 'WEIRD' (as shown in Figure 28) starts with a handshape where the index finger is extended while the rest of the fingers are closed, and ends with a handshape where the thumb and index finger are curved while the rest of the fingers are closed. Thus, in the initial handshape, the extended index is the selected finger and the rest of the fingers are the unselected fingers. In the final handshape, both the curved index and thumb are the selected fingers and the rest of the fingers are the unselected fingers. This type of handshape change is termed 'handshape cluster' (Corina 1993) or 'handshape contrast' (Brentari 1998), and it is rare in monomorphemic signs (Corina 1993; Brentari 1998; Lee 2003, 2008). Basically, for signs with a handshape change, the selection of finger remains the same and only the joint configuration of the selected finger(s) changes.

(a) (b)

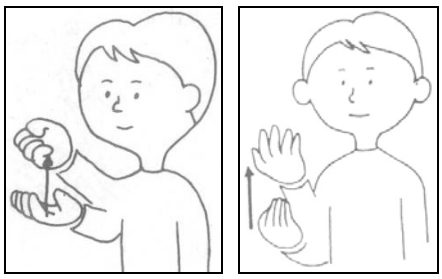


Figure 27. TSL ‘POWER’ and ‘FLOWER’ (from Smith and Ting 1979, 1984)

Figure 28. TSL ‘WEIRD’ from Smith and Ting (1984)

### 5.2.2 Symmetry and Dominance Conditions on Two-Handed Signs

As introduced in section 5.1, signs can be one-handed or two-handed. Battison (1978) identified three types of two-handed signs. In Type 1 signs, both hands move either identically or in an alternating manner, and they have the same handshape (e.g., TSL ‘OFTEN’, shown in Figure 29a). In Type 2 signs, one hand (the dominant hand) is active and one hand (the nondominant hand) is passive, but both hands assume the same handshape (e.g., TSL ‘CORRECT’, shown in Figure 29b). In Type 3 signs, one hand is active and one hand is passive, and the two hands assume different handshapes (e.g., TSL ‘HABIT’, shown in Figure 29c). According to van der Hulst (1996), Frishberg (1993) identifies another type of two-handed signs, the Type 4 signs. In Type 4 signs, both hands move either identically or in an alternating manner, but with two different handshapes on each hand (e.g., TSL ‘KITE’[10], shown in Figure

[10] Although the TSL sign ‘KITE’ is phonologically complex, but its perceived iconic relation to the

29d). Type 4 signs are rare in native ASL and more common in manually coded English, and children tend to change the handshape on one hand so that both hands can have an identical handshape (i.e., Type 1 signs). Frishberg (1975) also reported that ASL handshapes in two-handed signs tend to become identical diachronically.

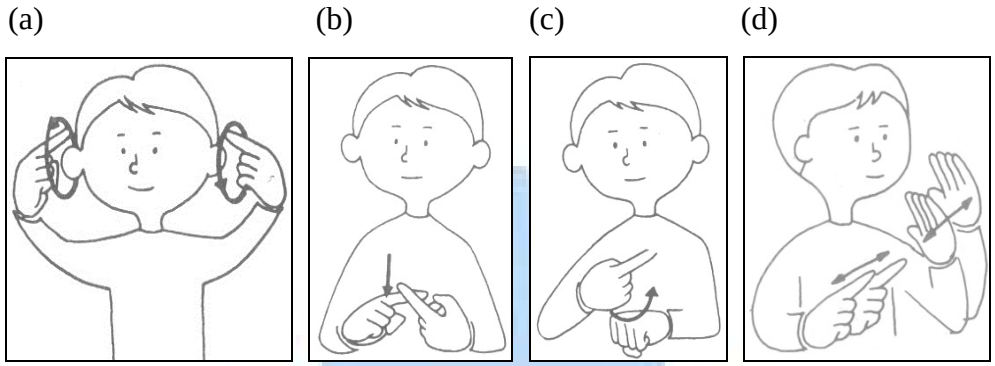



Figure 29. TSL ‘OFTEN’, ‘CORRECT’, ‘HABIT’ and ‘KITE’ from Smith and Ting (1979, 1984)

Battison (1978) proposed two conditions for constraining possible combinations of handshapes on the two hands. The Symmetry Condition states that “if both hands move independently during its articulation, then both hands must be specified for the same location, the same handshape and the same movement” (p. 33). Type 1 signs are governed by this condition. The Dominance Condition states that if the handshapes of a two-handed sign are not the same, “one hand must be passive while the active hand articulates the movement” and the passive hand (usually the nondominant hand) always assumes one of the seven most unmarked handshapes (p. 35, as shown in Figure 30). According to Battison, Type 3 signs obey the Dominance Condition with very few exceptions. These handshapes are unmarked in the sense that they are easier to articulate (Ann 1993, 1996, 2005, 2006; Mandel 1981), are found in many sign

---

referent might make TSL keep this form.

languages (Battison 1978), are processed faster (Grosvald, Lachaud and Corina 2012), and are acquired early by deaf children (McIntire 1977). For most signs with a handshape change, at least one of the handshape is an unmarked handshape (Battison 1978).

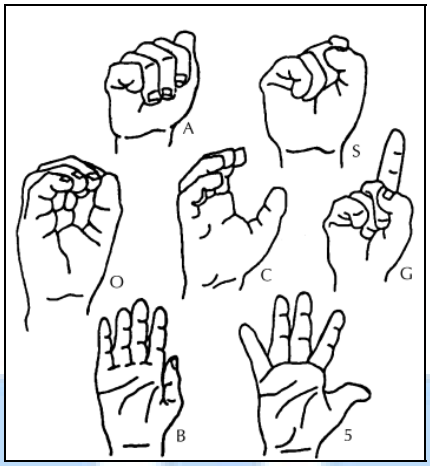



Figure 30. Unmarked handshapes (Battison 1978, p. 35)

However, these two conditions say nothing specific about Type 2 signs in which handshapes of both hands are identical but only one hand moves. Battison's Dominance Condition was revised by Sandler and Lillo-Martin (2006). Their Revised Dominance Condition states that if the non-dominant hand does not move in a two-handed sign, it must either copy the handshape of the dominant hand, or it must be an unmarked handshape. Namely, if the non-dominant hand does not move, it would assume an identical handshape with the dominant hand (as in Type 2 signs) or assume an unmarked handshape (as in Type 3 signs).

The Dominance Condition was further revised by Eccarius and Brentari (2007) to explain the fact that some marked handshapes do occur on the non-dominant hand. They reanalyzed Type 3 signs and classifier constructions using a measure of featural complexity based on "the structural complexity of each joint configuration and

selected finger combination" (p. 1180) of a handshape (see Brentari 1998 for detailed theoretical background on this feature-markedness analysis), and found that featural complexity explains more two-handed signs than either Battison's Dominance Condition or Sandler and Lillo-Martin's Revised Dominance Condition. Brentari's (1998) feature geometry model on ASL considered handshapes to be unmarked if their phonological tree structure had 0 or 1 branches in her model (i.e., they had the simplest structures for joints and selected fingers). Specifically, selected finger combinations are unmarked only if all four fingers (or all five fingers) are selected (e.g., handshapes used in TSL 'BE' and 'FLOWER', as shown in Figure 31a, 31b), only the index finger is selected (e.g., handshape used in TSL 'OFTEN', as shown in Figure 31c), or only the thumb is selected (e.g., handshape used in TSL 'DEPUTY', as shown in Figure 31d). Selected finger combinations other than those described above are considered marked. For example, TSL 'NOON' (shown in Figure 32a) is articulated using a handshape where the index and middle finger are selected. This type of selected finger combination is marked according to Eccarius and Brentari's (2007) criterion. The selected finger combination for the handshape used in TSL 'RIVER' (shown in Figure 32b) is also marked since the selected fingers include the index, middle and pinky fingers. Joint configuration is unmarked only if the fingers are fully extended or fully flexed. For instance, TSL 'FULL' (shown in Figure 33) is a two-handed sign, with one hand adopting a handshape where all fingers are fully extended and the other hand adopting a handshape where the fingers are fully flexed. Joint configuration is marked if the fingers are not fully extended or fully flexed. For instance, the dominant hand of TSL 'DEPUTY' (as shown in Figure 31d) is articulated with a curved thumb, and it would be analyzed as a marked joint configuration.

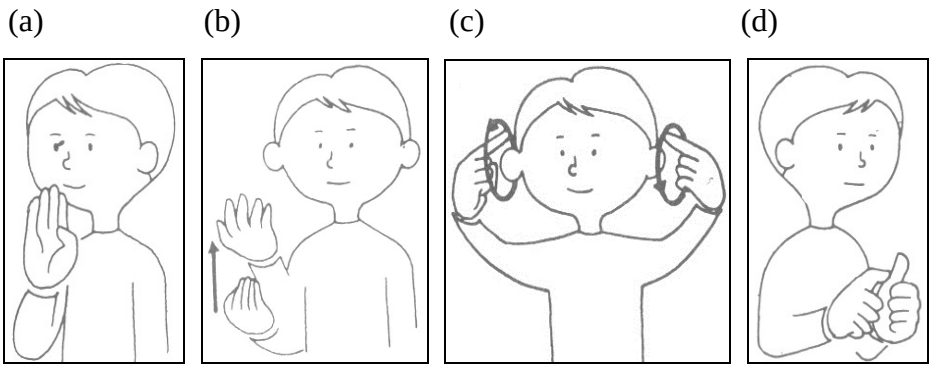



Figure 31. TSL examples for unmarked selected fingers (from Smith and Ting 1979)

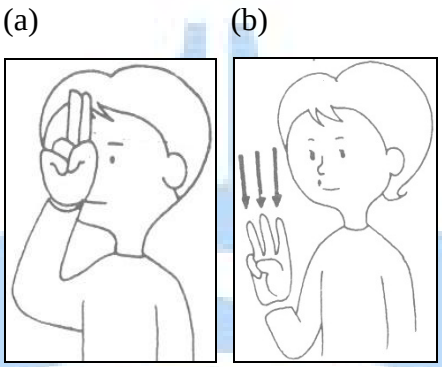



Figure 32. TSL examples for marked selected fingers (from Smith and Ting 1979)

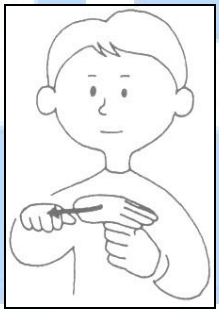


Figure 33. TSL 'FULL' (from Smith and Ting 1979, p. 99)

In addition to Eccarius and Brentari's (2007) analyses of handshape markedness (based on Brentari's (1998) phonological feature model), Ann (1993, 1996, 2005, 2006) also proposed a model to define how marked a handshape is. Ann's model was based on hand physiology, with algorithms to calculate an 'ease score' for each handshape. In Ann's model, the lower the ease score, the easier a handshape is to

articulate. This model has been used to show that there is a correlation between the ease of articulation and the frequency of occurrence in ASL and TSL (Ann 2005). Basically, the easy handshapes tend to occur more often than the hard handshapes. However, Ann's model did not make any theoretical claims regarding the handshape patterns of two-handed signs. Thus, Eccarius and Brentari's (2007) feature model was adopted here as a tool for comparing handshape patterns of two-handed signs in TSL and SC.

By adopting Eccarius and Brentari's (2007) featural model, we could identify the number of marked feature(s) for each handshape. If both the selected finger and joint configuration of a handshape are unmarked, it has no marked feature. For instance, both the selected finger and joint configuration of the handshape used in TSL 'BE' (shown in Figure 34a) are unmarked. If either the selected finger or joint configuration of a handshape is marked, it has one marked feature. For instance, the handshape on the dominant hand of TSL 'DEPUTY' (shown in Figure 34b) has one marked feature because of its curved (i.e., marked) joint configuration. The handshape of TSL 'NOON' (shown in Figure 34c) has one marked feature because of its marked finger selection (i.e., index and middle fingers). If both the selected finger and joint configuration of a handshape are marked, it has two marked features. For instance, the handshape of TSL 'TWENTY' (shown in Figure 34d) has two marked features since both of its joint configuration (i.e., curved) and finger selection (i.e., index and middle fingers) are marked.

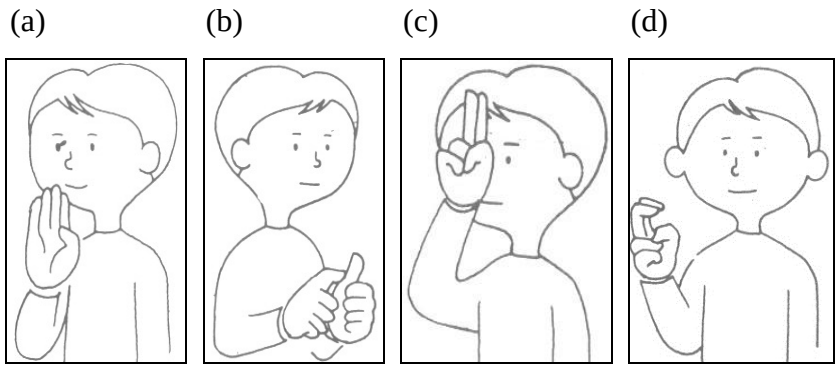



Figure 34. TSL signs with different marked features (from Smith and Ting 1979)

Eccarius and Brentari (2007) found that over 98% of ASL signs have a maximum of two marked features across both hands. Their Revised Dominance Condition states that if both hands do not share the same specification for finger selection and joint configuration (i.e., have different handshapes), then one hand must hold still while the active hand articulates the movement, and "the form as a whole (i.e., selected fingers and joints for both hands) is limited to two marked phonological structures, only one of which can be on the passive hand" (p. 1187). For example, TSL 'PICK UP (FOOD)' (as shown in Figure 35) is articulated with two different handshapes, and the marked features across both hands are two. In this sign, both the dominant hand and the nondominant hand has one marked feature. Specifically, the dominant hand has one marked feature because of its marked finger selection, and the nondominant hand has one marked feature because of its marked joint configuration selection. Morgan and Mayberry (2012) have also shown that the newly revised Dominance Condition can correctly constrain marked features across both hands to a maximum of two.

Figure 35. TSL ‘PICK UP (FOOD)’ (Smith and Ting 1984, p. 49)

The Symmetry Condition was also revised by Eccarius and Brentari (2007) to account for the symmetrical distribution of marked features of two-handed classifier handshapes. Their Revised Symmetry Condition states that, in addition to Battison’s original Symmetry Condition, “if the number of marked features on both hands exceeds two, then both hands will be specified for the same selected finger combination and/or the same joint specification” (p. 1187). Thus, non-identical moving hands are still fine if they share selected fingers (with different joint configuration) or joint configurations (with different selected fingers). In so doing, feature complexity can be compensated for by making selected fingers or joint configurations symmetrical across the two hands. Thus marked features of both hands can be counted only once and the overall marked features of both hands can be reduced to an acceptable level. For example, the number of marked features on the handshape of the dominant hand of TSL ‘ADDRESS’ (shown in Figure 36) is two because of its marked finger selection and marked joint configuration, and the number of marked features on the handshape of the nondominant hand is one because of its marked finger selection. Without adopting the Revised Symmetry Condition, marked features across both hands would be three. If the Revised Symmetry Condition is adopted, since the selected fingers of both hands are identical (i.e., index and middle fingers), we only need to count this marked finger selection once, reducing the overall

markedness score of both hands from three to two.

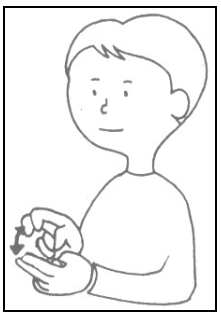


Figure 36. TSL ‘ADDRESS’ (from Smith and Ting 1979, p. 150)

The Revised Symmetry Condition and Revised Dominance Condition are valid for ASL, Swiss German Sign Language, Hong Kong Sign Language (Eccarius and Brentari 2007) and Kenyan Sign Language (Morgan and Mayberry 2012), suggesting that these two constraints can regulate not only handshapes in lexical signs, but also can better constrain handshapes in classifier constructions, though to different degrees.

Crucially, Grosvald, Lachaud and Corina (2012) found that there was a significant handshape Markedness (marked and unmarked) × sign Type (one-handed signs, two-handed symmetrical signs and two-handed asymmetrical signs [11]) interaction during handshape monitoring. Participants were shown a series of video clips and had to decide as quickly as possible whether or not the sign shown in each clip was formed using a particular handshape. In general, marked handshapes were processed slower than unmarked handshapes for two-handed signs, whereas marked handshapes were processed faster than unmarked handshapes for one-handed signs. They speculate that in monitoring an one-handed sign where only one articulator is relevant, the marked handshape stands out more readily and makes it an easy target to

[11] Signs are symmetrical if handshape and movement of both hands are identical.

discriminate. By contrast, in monitoring two-handed signs, “the presence of multiple sources of information may overload the discrimination process and in these cases the increased handshape complexity reduces discriminability (or increases confusability), leading to slower detection times for marked handshapes” (p. 134).

### 5.2.3 One Major Area Constraint on Location

As introduced earlier, four major body areas are generally assumed for specifying a sign’s location. It is also generally accepted that monomorphemic signs are restrained to be articulated entirely within a major body area (Battison 1978, Sandler 1989, Brentari 1998) and no more than two specifications can be specified for a sign in the same body area. For instance, TSL ‘CAN’ (shown in Figure 37a) is articulated within the trunk area, moving from the contralateral side to the ipsilateral side. In another case, TSL ‘LAW’ (shown in Figure 37b) is articulated at the arm area, moving from wrist to the elbow.

(a) (b)

Figure 37. TSL ‘CAN’ and ‘LAW’ (from Smith and Ting 1979)

### 5.2.4 Simple Sequence Constraint on Movement

Movement is crucial in defining syllables in many models of sign language phonology (Liddell and Johnson 1989; Sandler 1989, 1993; Perlmutter 1992; Brentari 1998; Sandler and Lillo-Martin 2006; Wilbur 2011; but see Channon 2002 for

arguments that the syllable is not necessary for describing sign movements). According to Brentari (1998), the number of sequential movements in a sign defines the number of syllables in that sign. When several shorter movements (e.g., local movements or trilled movements) co-occur with a single movement of longer duration, the single movement defines the syllable. For example, as shown in Figure 38, the TSL sign ‘STRANGE’ (Figure 38a) has just a trilled movement, ‘TOGETHER’ (Figure 38b) has just a path movement, and ‘FLOWER’ (Figure 38c) has a path movement and a co-occurring hand-internal movement. These TSL signs are all monosyllabic signs according to Brentari’s (1998) definition. Given this definition, signs articulated with two sequential movements would be disyllabic signs. For example, as shown in Figure 39, the TSL sign ‘FLY’ is disyllabic due to having two sequential movements.

(a) (b) (c)

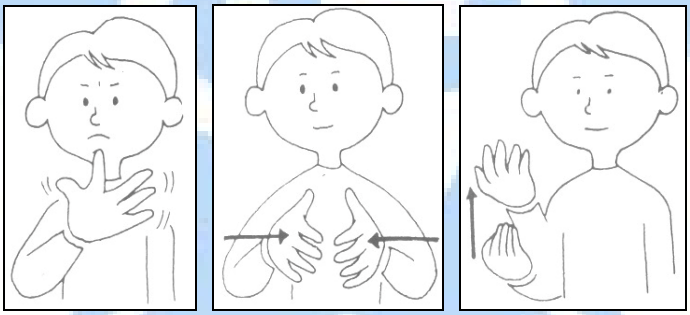


Figure 38. TSL monosyllabic signs (from Smith and Ting 1979)

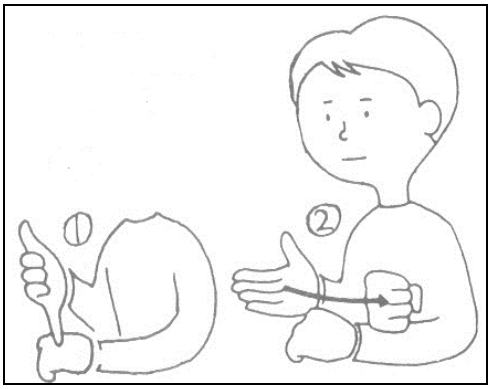



Figure 39. TSL ‘FLY’ from Smith and Ting (1979, p. 172)

Most monomorphemic ASL signs have just a path movement, a hand-internal movement or a trilled movement. It is also common to find signs that are articulated with a simultaneous overlap of a path movement with a hand-internal movement or trilled movement. Thus, it is generally accepted that signs are basically monosyllabic. Movement sequences in monomorphemic ASL signs are restricted in the type and number of movements. Specifically, the upper limit on the number of path movements in ASL is two (Perlmutter 1992; Sandler 1993; Uyechi 1996; Brentari 1998), and a path movement never forms a movement sequence with a hand-internal movement or a trilled movement. Perlmutter (1992) has shown that movement sequences of path movement + hand-internal movement, hand-internal movement + path movement, path movement + trilled movement, or trilled movement + path movement are unattested in ASL. Signs with two path movements are disyllabic, but the possible movement sequence is restricted. For example, Uyechi (1996) discovered that it is possible to have a movement sequence of circular + straight movement as in the ASL sign ‘APPOINTMENT’ (shown in Figure 40), but the sequence of straight + circular is not attested in monomorphemic signs in ASL.

Figure 40. ASL ‘APPOINTMENT’ (Uyechi 1996, p. 103)

Most ASL signs are not well-formed without some kind of movement (Brentari 1990, 1998). However, possible exceptions have been observed for number signs and fingerspelled signs, although Brentari observed that ASL numeral signs add an epenthetic path movement when used as independent words. Similar epenthetic movements have also been observed by Geraci (2009) for Italian Sign Language. I have also observed that in actual signing, some TSL character signs are often articulated with some sort of movement (e.g., repeated finger contact or a path movement, thus satisfying the syllable requirement), even they were illustrated with no movement at all in TSL dictionaries. For instance, the character sign ‘共’ (‘COMMUNAL’, as shown in Figure 41a) is often signed articulated by signers with repeated finger contact. Another character sign ‘出’ (‘EXIT’, as shown in Figure 41b) is often signed by signers with an outward path movement.

(a) (b)

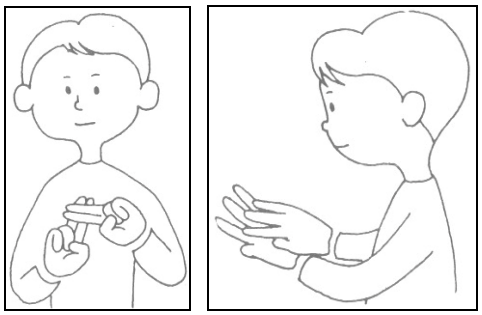


Figure 41. Character sign '共' and '出' (Smith and Ting 1979)

Based on the ASL patterns described above, we propose that the Simple Sequence Constraint can function as a natural constraint for constraining possible movement patterns in a natural sign language. Specifically, the Simple Sequence Constraint postulates that monomorphemic signs should be simple in movement sequence, and no more than two (path) movements are allowed.

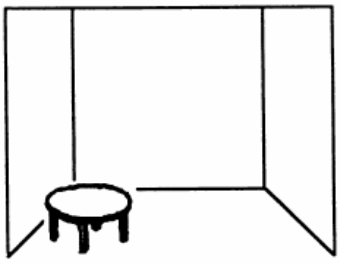
### 5.2.5 No Left/Right Specificity and Narrator Perspective Principle

Signs can be one-handed or two-handed, but handedness is generally not contrastive (Battison 1978; Emmorey 2002; Liddell and Johnson 1989; Padden and Perlmutter 1987; Stokoe 1960). Signers can freely use their right hand or left hand to articulate a one-handed sign without affecting the sign's meaning or intelligibility. For two-handed signs with two identical moving handshapes (i.e., Battison's Type 1 signs), there is obviously no distinction required. However, for two-handed signs where one hand moves whereas the other hand holds still (i.e., Battison's Type 2 and Type 3 signs), this distinction is useful because although handedness is not contrastive, right-handed signers tend to use their right hand for articulating a one-handed sign or making movements (for Type 2 and Type 3 signs), whereas left-handed signers would prefer to use their left hand for articulation. Thus, the left/right hand distinction is

meaningless for lexical signs. Instead, the distinction between the dominant hand (i.e., the right hand for right-handers) and the nondominant hand (i.e., the left hand for right-handers) has been adopted by sign linguists to describe sign articulations. The fact that the left/right hand distinction is meaningless for lexical signs can be described as the No Left/Right Specificity principle.

Although the No Left/Right Specificity principle seems to hold true for lexical signs, at the sentence level, there is ample evidence that deaf signers prefer describing spatial scenes iconically by placing classifier signs in space from their own perspective rather than from the viewers' perspective (Emmorey 1996; Emmorey, Klima and Hickok 1998; Pyers, Perniss and Emmorey 2008; Pyers, Perniss and Emmorey 2015). Pyers , Perniss and Emmorey (2008) found that signers across eight different sign languages consistently produced spatial relations from the signers' perspective. Thus, when describing a spatial relationship such as 'a table is on my left as I enter a room' (as shown in Figure 42a), signers most often describe the spatial relationship from their own point of view, so that the face-to-face viewer needs to perform a 180° mental rotation (i.e., to form a mirror reversal) to correctly comprehend the narrator's description. Specifically, as shown in Figure 42b, since the table is on the signer's left (from the narrator's viewing perspective), signed expressions (e.g., classifier constructions) for specifying the table's spatial location are articulated on the left side of the signer's signing space (a 3D space in front of the signer) such that the signed expressions would be isomorphic or iconic to the spatial relation in the real world.

(a)




(b)

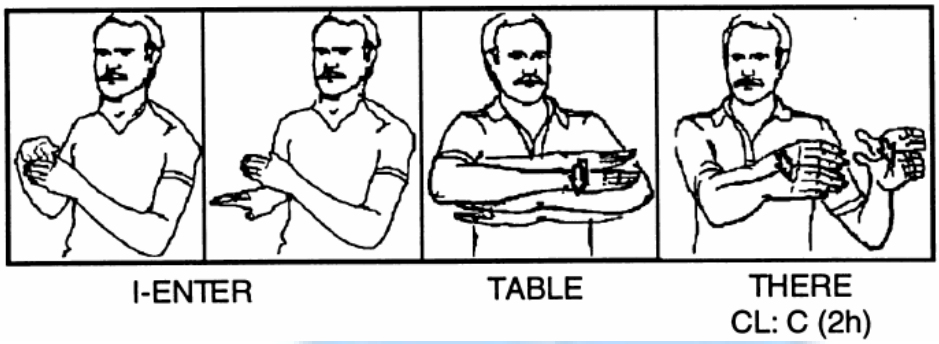



Figure 42. Signing spatial scene (from Emmorey, Klima and Hickok 1998, p. 223)

Signers not only prefer to describe spatial scenes from the narrator's perspective, but they also seem to prefer viewing spatial descriptions that adopt the narrator's perspective. Emmorey, Klima and Hickok (1998) found that ASL viewers were more accurate when spatial scenes were described from the narrator's perspective than from the viewer's perspective. In a scene-description matching task, deaf ASL signers were first shown a video presenting a room (containing several pieces of furniture), followed by a signed description of the room. Signers were then required to decide whether the signed description matched the room shown in video. Their results suggested that ASL viewers were more accurate when spatial scenes were described from the narrator's perspective. Thus, it seems that both narrators and viewers of ASL prefer spatial descriptions from the narrators' perspective, despite the demands of mental rotation for viewers.

The preference for describing spatial scenes from the narrator's perspective was

also found in hearing nonsigners' gestural productions (Pyers, Perniss and Emmorey 2015). In a communication task, Pyers et al. (2015) found that when nonsigners were asked to produce a gestured description of the picture they viewed to a hearing viewer, they also predominantly conveyed the spatial relations from their own point of view, although hearing viewers often did not interpret the producers' gestures from the producers' perspective. In another experiment by Pyers et al. (2015), when nonsigners were explicitly instructed to gesture and interpret spatial relations either adopting a narrator perspective or a viewer perspective, producers' gestural production was significantly more accurate when describing spatial relations from the narrator's perspective than from the viewer's perspective. Perceivers' interpretation accuracy was not significantly different between narrator and viewer perspectives. Thus, the cognitive cost of adopting a viewer perspective was greater for producers (i.e., inhibit their own view, produce the opposite and receive conflicting visual feedback from their signing) than for viewers. Sign languages seem to have developed the most cognitively efficient means of expressing spatial relations. Based on the findings described above, it seems that the Narrator Perspective Principle is a natural way of describing spatial scenes, and this way of signing is also strongly preferred by deaf viewers (though not by hearing viewers). Specifically, the Narrator Perspective Principle postulates that signs describing spatial scenes should be signed from the narrator's perspective.

The strong preference for the Narrator Perspective Principle has a positive impact on signers' performance in other nonlinguistic domains involving mental rotation. Emmorey, Kosslyn and Bellugi (1993) hypothesized that since ASL viewers make use of mirror reversals for correctly comprehending narrators' spatial descriptions all the time, ASL signers might thus have an enhanced visual imaginary ability when participating in a task in which mental rotation is required. They found

that both deaf and hearing ASL signers have an enhanced ability to detect mirror image reversals, compared to non-signers. Their results suggested that signers' enhanced visual imaginary abilities might be tied to their experience with ASL, in which mental transformation is always required for perceiving spatial descriptions.

Similarly, in another of Emmorey et al.'s (1998) experiments, deaf signers and hearing nonsigners saw videos showing objects sequentially appearing on a board. Participants were required to place objects on their board (an actual board in front of the participant) matching the same location and orientation shown in the video. They found that while both signers and nonsigners were less accurate when mental rotation was required, deaf signers significantly outperformed hearing nonsigners, suggesting that signers' experience for processing canonical linguistic expressions (i.e., grammar) might override the difficulty imposed by mental rotation.

The above No Left/Right Specificity principle seems to be true for native lexical signs, but it would be violated by signs that try to manually mimic the shape of Chinese characters (i.e., character signs) in the signing space. Specifically, every Chinese character has a rigid form and we cannot freely switch the position of its subparts. Thus, articulating character signs would force signers to ignore the freedom of switching handedness, and signers might either mimic a character sign from their own viewing perspective or they might mimic a character sign from viewers' viewing perspective. Although the Narrator Perspective Principle plays a vital role in describing spatial scenes, I wonder whether the Narrator Perspective Principle is also adopted in the articulation of character signs. Specifically, would signers also adopt the narrator's perspective and mimic Chinese characters iconically from their own perspective? Or would they prefer to articulate character signs from viewer's perspective such that viewers can comprehend character signs more easily (i.e., the viewer perspective)? It seems that natural sign languages that have character signs

also prefer to produce these characters from narrator's perspective. For instance, the Chinese character '人' ('PERSON') is signed following the Narrator Perspective Principle in Taiwan Sign Language (Figure 43a), Chinese Sign Language (Figure 43b) and Japanese Sign Language (Figure 43c). How character signs are articulated in TSL and SC, and how each system follows or violates this principle, will be further discussed in Chapter 6.

(a) (b) (c)

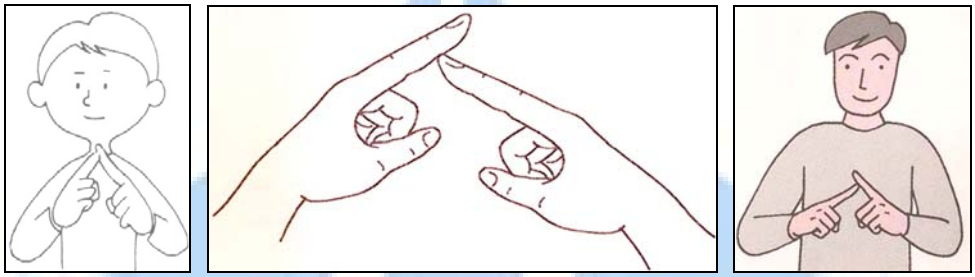


Figure 43. '人' in Taiwan Sign Language (Smith and Ting 1979, p. 59), Chinese Sign Language (China Association of the Deaf and Hard of Hearing 2003, p. 7) and Japanese Sign Language (Ogata 2008, p. 408)

### 5.2.6 Summary

As we have seen, the three parameters of handshape, location and movement are all subject to phonotactic constraints in ASL. First, the Selected Finger Constraint states that for signs with a handshape change, the choice of selected fingers remains constant, with only the finger joints changing configuration (Mandel 1981). Second, the Revised Symmetry Condition states that for two-handed lexical signs, if both hands move, they almost always have identical handshapes, and if handshapes are not identical, the selected finger and/or finger configuration would still be identical. The Revised Dominance Condition states that if one hand remains still, it almost always has the same handshape as the moving hand or assumes certain unmarked handshapes.

Moreover, the overall marked features across both hands are almost always restricted to a maximum of two (Eccarius and Brentari 2007). Third, the One Major Area Constraint states that monomorphemic signs are articulated at a major body area, with possible movements restricted to within the same major body area (Battison 1978; Sandler 1989; Brentari 1998). Fourth, the Simple Sequence Constraint states that signs prefer to have a single movement (a path movement or a path movement with a hand-internal movement or trilled movement). Movement sequences are possible, but they are restricted in number and type (Uyechi 1996).

In addition to constraints relevant to each phonological parameter, there are principles that are especially relevant for the comparisons of character signs between SC and TSL. The No Left/Right Specificity principle states that the choice of dominant hand is never lexically contrastive (Battison 1978; Liddell and Johnson 1989). The Narrator Perspective Principle describes a strong preference for describing spatial scenes from the narrator's perspective (Pyers, Perniss and Emmorey 2008; Pyers, Perniss and Emmorey 2015).

Constraints introduced in this chapter are listed in Table 3.

Table 3. *Phonotactic Constraints on Natural Signs*

| Constraint | Focus |
|---|---|
| Selected Finger Constraint | Handshape change |
| Revised Symmetry Condition | Two-handed sign |
| Revised Dominance Condition | Two-handed sign |
| One Major Area Constraint | Location |
| Simple Sequence Constraint | Movement |
| No Left/Right Specificity | Handedness |
| Narrator Perspective Principle | Character sign |

## Chapter 6 Comparison of the TSL and SC Lexicons

Based on the literature review given in Chapter 4, which shows that SC signs seem to be difficult to learn and process by deaf learners due to their linear morphological structures. I wonder whether SC signs might also violate some phonotactic constraints described in Chapter 5, thus causing learning or processing difficulties for deaf learners. Although the phonotactic constraints described in Chapter 5 are drawn mostly from ASL studies, they seem to be valid for other natural sign languages (Sandler and Lillo-Martin 2006). In this chapter, I compare the distribution pattern of the three phonological parameters in TSL and SC signs, and see whether they conform to the phonotactic constraints described in Chapter 5.

The source of the TSL data analyzed here is the set of 1349 lexical entries in Smith and Ting's (1979, 1984) two volumes on the TSL lexicon. This source was used instead of the larger and more recent collection of about 3500 entries in Tsay, Tai and Chen (2015) [12] because the database analyzed here is likely to consist of the more widely used signs, both in having higher frequency and in being used across the two major dialects of TSL. In addition, each sign is illustrated in picture format that can be easily quoted and also can be referred to by its page number. There were a total of 1349 lexical entries in the surveyed TSL data. The source of the SC data is the same randomly chosen 2000 SC items that are analyzed earlier in Chapter 3. As shown in Chapter 3, many TSL signs have been adopted into the 2008 version of the SC dictionary, so in order to get a better understanding of the phonological properties of the SC lexicon, I follow Lee, Tsay and Myers (2001) in only analyzing newly

[12] The TSL data of Tsay et al (2015) were collected after 2001, based on Smith and Ting's books, interpreter training materials published by Taipei City Government (Department of Labor of Taipei City Government 2010), and signs collected during their fieldwork for the reference grammar and other TSL-related research projects.

invented SC signs that do not occur in Smith and Ting (1979, 1984). There were a total of 618 lexical entries in the surveyed SC data.

For my analyses, each item in both dictionaries was transcribed for related information about the three formational parameters of that item[13]. For the handshape parameter, each item was transcribed for the number of hands, handshape symbol (adopted from Smith and Ting 1979, 1984 and Ministry of Education 2008), and marked features (Eccarius and Brentari 2007). These handshape symbols were originally developed by Smith and Ting (1979, 1984), and are widely used in Taiwan by sign language teachers and researchers. However, since these Chinese symbols are named after the signs in which they appear (Tsay and Myers 2009), they would be difficult to understand by international audiences. For readers who are unfamiliar with Smith and Ting's system, Tai and Tsay (2015) have renamed these symbols following international ASL conventions (see Appendix 2 for revised TSL handshape names). For the location parameter, each item was transcribed for its major body area. For the movement parameter, each item was transcribed for the type of movement (i.e., path, hand-internal or trilled), number of movements (if it has a sequence of movements), and the active hand (i.e., dominant hand moves or nondominant hand moves). The active hand is given particular attention because I have observed that some two-handed SC character signs are articulated by moving the nondominant hand, leaving the dominant hand still, which violates the Dominance Condition.

In section 6.1, I compare distribution patterns of marked features (Eccarius and Brentari 2007) in TSL and SC, and see whether they follow phonotactic constraints for handshape change (i.e., the Selected Finger Constraint) and two-handed signs (i.e.,

[13] A certified TSL interpreter helped to code the handshape and location parameters of part of the TSL data, based on Smith and Ting's two volumes. The coding process was straightforward, since handshape and location specifications are already provided in the dictionary. Her job was just to make an Excel chart for me to do further analyses on constraint violations. The SC data were all built by myself, based on the 2008 SC dictionary.

the Revised Symmetry Condition and the Revised Dominance Condition). In section 6.2, I compare the location parameter in TSL and SC, and see whether they follow the One Major Area Constraint for location. In section 6.3, I compare movement patterns in TSL and SC, and see whether they follow the Simple Sequence Constraint. In section 6.4, I discuss how character signs are articulated in TSL and SC, and see whether they follow the No Left/Right Specificity principle or the Narrator Perspective Principle. Section 6.5 summarizes the findings.

## 6.1 Comparisons of TSL and SC Handshapes

This section investigates the handshape parameter in TSL and SC. Type frequencies of different handshapes across both hands for each sign system were listed. Eccarius and Brentari's (2007) featural analysis was adopted to investigate the distribution pattern of marked features across both hands. Handshapes involved in handshape changes were further investigated to see whether the Selected Finger Constraint also holds for TSL and SC. For two-handed signs, special attention was paid to the handshapes of both hands to see whether they are constrained by the Revised Symmetry Condition or the Revised Dominance Condition.

### 6.1.1 Distribution of TSL Handshapes and Marked Features

Table 4 shows the type frequencies of 56 different handshapes on the dominant hand. In addition, the number of marked features following Eccarius and Brentari (2007) of each handshape is indicated in the parenthesis behind the Chinese handshape symbol. We can see that some handshapes occur more often than other handshapes. For example, the three unmarked handshapes '手', '一' and '拳' occur on the dominant hand in 251 signs (18.6%), 174 signs (12.9%) and 78 signs (5.8%), respectively. Some handshapes occur with very low frequency. For instance, 24

handshapes are used in no more than 5 TSL signs each.

Table 4. *Type Frequencies of Handshapes on the Dominant Hand*

| Handshape | Type frequency | Handshape | Type frequency |
|---|---|---|---|
| 手 (0) | 251 | 女 (1) | 9 |
| 一 (0) | 174 | 虎 (2) | 9 |
| 拳 (0) | 78 | 四 (0) | 8 |
| 錢 (2) | 70 | 龍 (2) | 8 |
| 二 (1) | 58 | 卅 (2) | 5 |
| 五 (0) | 55 | 蟲 (2) | 5 |
| 同 (1) | 50 | 隻 (2) | 5 |
| 呂 (2) | 49 | 很 (2) | 4 |
| 男 (0) | 49 | 副 (1) | 4 |
| 九 (1) | 45 | 筆 (2) | 4 |
| 六 (1) | 45 | 鴨 (2) | 4 |
| 零 (1) | 39 | 兄 (1) | 3 |
| 民 (1) | 31 | 守 (1) | 3 |
| 十 (1) | 27 | 姊 (1) | 3 |
| 萬 (1) | 26 | WC (2) | 2 |
| 句 (2) | 23 | 百 (2) | 3 |
| 借 (2) | 21 | 八 (1) | 1 |
| 方 (1) | 20 | 八十 (2) | 1 |
| 棕 (1) | 20 | 千 (2) | 1 |
| 難 (2) | 18 | 欠 (2) | 1 |
| 廿 (2) | 17 | 四十 (1) | 1 |
| 胡 (0) | 17 | 飛機 (1) | 1 |
| 七 (1) | 15 | 博 (2) | 1 |
| 果 (1) | 14 | 童 (1) | 1 |
| 三 (1) | 12 | 祖母 (2) | 1 |
| 菜 (1) | 12 | 語 (2) | 1 |
| 紳 (1) | 11 | 臂 (0) | 1 |
| 像 (2) | 11 | 薑 (1) | 1 |

*Note*. A total of 1349 signs are analyzed in this survey.

Adopting Eccarius and Brentari's (2007) featural analysis, all handshapes were

also coded with their marked features. Figure 44 shows the type frequencies of handshapes with no, one and two marked features on the dominant hand. We can see that 634 signs (47%) adopt a handshape without any marked feature, 440 signs (33%) adopt a handshape with one marked feature and 275 signs (20%) adopt a handshape with two marked features. Since the dependent variable is categorical, an one-way chi-squared test for analyzing categorical count data was run using Excel[14] (an Excel file written by Prof. Myers for running one-way and two-way chi-squared tests) to see whether the frequencies of handshapes with no, one and two marked features are the same, the results suggest that the distribution difference between the frequencies for all of the levels of this factor is significant ($\chi^2$ (2) = 143.6, $p$ < .001, $n$ = 1349). We can see from Figure 44 that, for the dominant hand, handshapes with no marked feature are used more than handshapes with one marked feature, which in turn are used more than handshapes with two marked features.

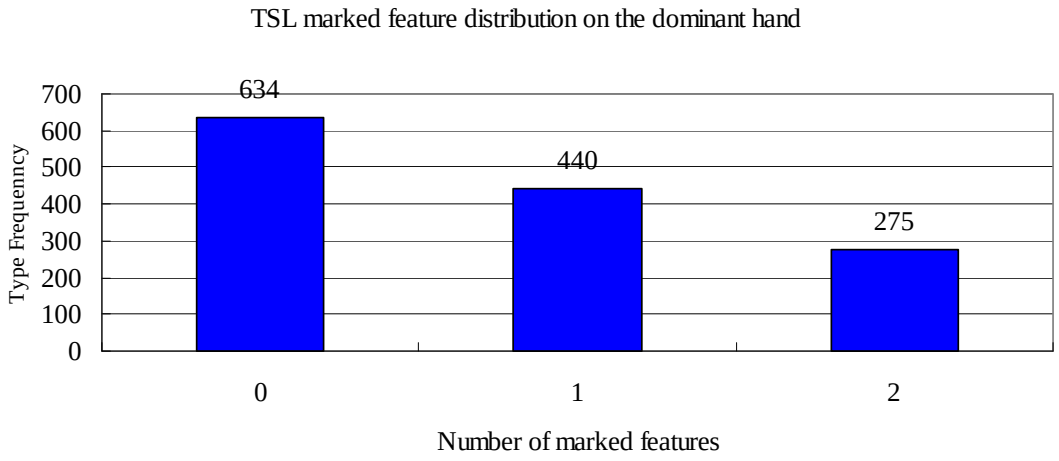



Figure 44. TSL marked feature distribution on the dominant hand

Table 5 shows the type frequencies of 44 different handshapes on the

[14] This Excel file can be retrieved from http://www.ccunix.ccu.edu.tw/~lngmyers/statsresources.html.

nondominant hand, with marked feature of each handshape indicated in the parenthesis behind the handshape name. We can also see that some handshapes occur more often than other handshapes. For example, the unmarked handshapes '手', '一' and '拳' occur on the nondominant hand in 296 signs (34.7%), 53 signs (6.2%) and 66 signs (7.7%), respectively. Some handshapes occur in very few TSL signs. For instance, 19 handshapes are used in no more than 5 TSL signs each.

Table 5. *Type Frequencies of Handshapes on the Nondominant Hand*

| Handshape | Type frequency | Handshape | Type frequency |
|---|---|---|---|
| 手 (0) | 296 | 七 (1) | 6 |
| 男 (0) | 70 | 女 (1) | 6 |
| 拳 (0) | 66 | 果 (1) | 6 |
| 一 (0) | 53 | 十 (1) | 5 |
| 五 (0) | 38 | 像 (2) | 5 |
| 六 (1) | 30 | 廿 (2) | 4 |
| 零 (1) | 28 | 四 (0) | 4 |
| 同 (1) | 26 | 龍 (2) | 4 |
| 錢 (2) | 25 | 卅 (2) | 3 |
| 方 (1) | 23 | 臂 (0) | 3 |
| 呂 (2) | 22 | 百 (2) | 2 |
| 九 (1) | 15 | 兄 (1) | 1 |
| 二 (1) | 14 | 守 (1) | 1 |
| 民 (1) | 13 | 姊 (1) | 1 |
| 萬 (1) | 13 | 虎 (2) | 1 |
| 棕 (1) | 12 | 很 (2) | 1 |
| 紳 (1) | 10 | 隻 (2) | 1 |
| 三 (1) | 9 | 副 (1) | 1 |
| 句 (2) | 9 | 筆 (2) | 1 |
| 菜 (2) | 8 | 鴨 (2) | 1 |
| 胡 (0) | 7 | 蟲 (2) | 1 |
| 借 (2) | 7 | 難 (2) | 1 |

*Note*. A total of 853 two-handed signs are analyzed in this survey.

Figure 45 shows the type frequencies of handshapes with no, one and two marked features on the nondominant hand. We can see that, for the nondominant hand, 535 signs (63%) adopt a handshape without any marked feature, 222 signs (26%) use a handshape with one marked feature and 96 signs (11%) use a handshape with two marked features. A one-way chi-squared test suggests that the distribution difference between handshapes with no, one and two marked features is also significant ($\chi^2$ (2) = 359.4, $p$ < .001, $n$ = 853). We can see from Figure 45 that, the nondominant hand is similar to the dominant hand in that handshapes with least marked features are used most in TSL signs and handshapes with most marked features are least used in TSL signs.

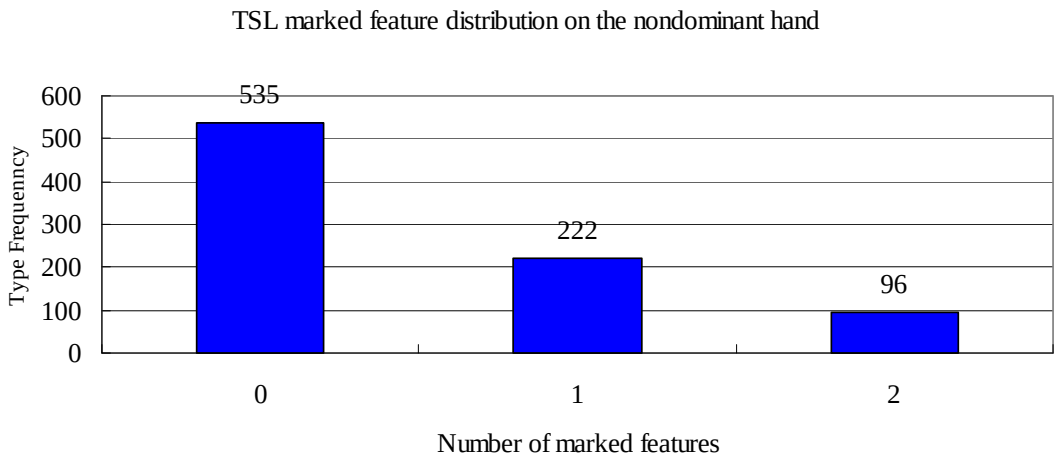



Figure 45. TSL marked feature distribution on the nondominant hand

A two-way table separating the counts of signs by hand (dominant/nondominant) and by marked feature (0/1/2) factors is shown in Table 6. A two-way chi-squared test for analyzing categorical count data was run using Excel to see whether the distribution pattern of marked features of the dominant hand differs significantly from the distribution pattern of marked features of the nondominant hand. The results

suggest that the distribution pattern of marked features between the dominant hand and the nondominant hand is significantly different ($\chi^2$ (2) = 57.7, $p$ < .001, $n$ = 2202). The two-way chi-squared test merely tells us that the distribution patterns of marked features are different across both hands, but says nothing about how they are different. A Poisson regression analysis for modeling count data (Gries 2013) was performed using R (an open-source programming language for statistical computing and graphics, R Core Team 2016) to investigate whether handedness (i.e., the dominant/nondominant hand) and markedness (i.e., the number of marked features) are correlated with the frequency of signs in TSL. The results are reported in Table 7[15]. As we can see from Table 7, there was a negative main effect of markedness, suggesting that handshapes with more marked features occur less often in TSL signs. In addition, the handedness effect was also significant, suggesting that the dominant hand has more signs in TSL data. More importantly, there was a significant interaction between handedness and markedness. As shown in Figure 46, the markedness effect was stronger on the nondominant hand than on the dominant hand.

Table 6. *Distribution Patterns of Marked Features across Both Hands*

| Marked Feature | 0 | 1 | 2 |
|---|---|---|---|
| Dominant hand | 634 (47%) | 440 (33%) | 275 (20%) |
| Nondominant hand | 535 (63%) | 222 (26%) | 96 (11%) |

[15] The coefficient of the Intercept represents the expected value when the predictors all equal zero, the intercept results are of no theoretical importance since a zero value for predictors might be meaningless.

Table 7. *Poisson Regression Model of Handedness and Markedness*

| Effects | *Coefficient* | *SE* | *z* | *P* |
|---|---|---|---|---|
| (Intercept) | 6.37158 | 0.02806 | 227.067 | < .0001* |
| Hand | 0.09187 | 0.02806 | 3.274 | 0.00106 * |
| Markedness | -0.63756 | 0.03039 | -20.982 | < .0001* |
| Hand:Markedness | 0.22727 | 0.03039 | 7.480 | < .0001* |

*Note*. The asterisks indicate significant effects ($p < .05$).

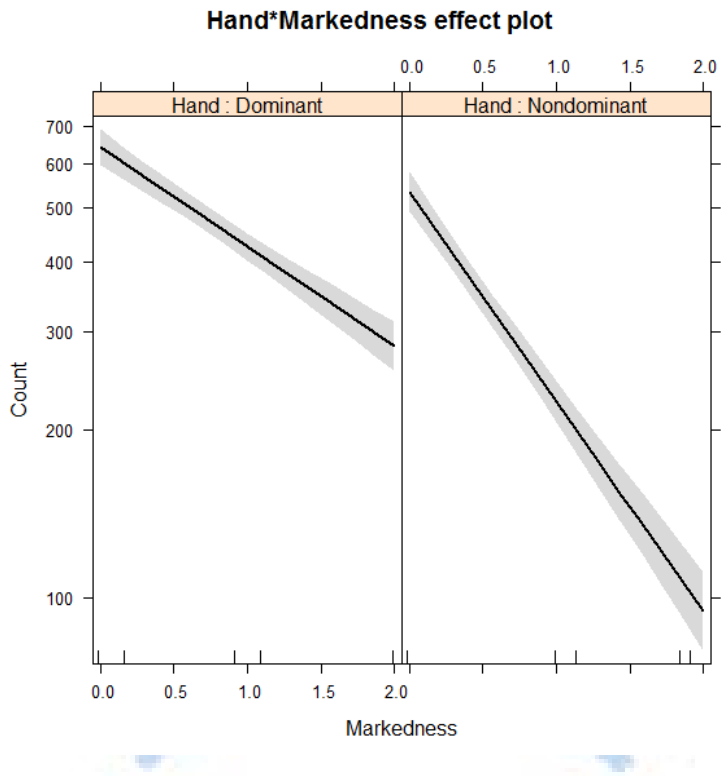



Figure 46. Effect plot for TSL handedness × markedness interaction

### 6.1.2 Distribution of SC Handshapes and Marked Features

Table 8 shows the type frequencies of 52 different handshapes on the dominant hand. We can see that some handshapes occur more often than other handshapes. For example, the two unmarked handshapes '手' and '一' occur on the dominant hand of 78 signs (18.6%) and 72 signs (12.9%), respectively. Some handshapes occur with

very low frequency. For example, 24 handshapes are used in no more than 5 SC signs each.

Table 8. *Type Frequencies of Handshapes on the Dominant Hand*

| Handshape | Type frequency | Handshape | Type frequency |
|---|---|---|---|
| 手 (0) | 78 | 果 (1) | 6 |
| 一 (0) | 72 | 菜 (2) | 6 |
| 男 (0) | 37 | 童 (1) | 5 |
| 九 (1) | 34 | 難 (2) | 5 |
| 五 (0) | 32 | 卅 (2) | 4 |
| 六 (1) | 28 | 借 (2) | 4 |
| 同 (1) | 28 | 少 (2) | 3 |
| 三 (1) | 26 | 副 (1) | 3 |
| 二 (1) | 25 | 龍 (2) | 3 |
| 萬 (1) | 25 | 蟲 (2) | 3 |
| 句 (2) | 15 | 夕 (2) | 2 |
| 方 (1) | 14 | 日 (2) | 2 |
| 拳 (0) | 14 | 百 (2) | 2 |
| 棕 (1) | 14 | 胡 (0) | 2 |
| 像 (2) | 13 | 筆 (2) | 2 |
| 錢 (2) | 13 | M (2) | 1 |
| 民 (1) | 12 | WC (2) | 1 |
| 零 (1) | 12 | 土 (2) | 1 |
| 七 (1) | 10 | *淑 (2) | 1 |
| 十 (1) | 9 | *戶 (2) | 1 |
| 女 (1) | 9 | 守 (1) | 1 |
| 虎 (2) | 8 | 秀 (1) | 1 |
| 鴨 (2) | 8 | *藥 (2) | 1 |
| 廿 (2) | 7 | 很 (2) | 1 |
| 四 (0) | 6 | 資 (2) | 1 |
| 呂 (2) | 6 | 鵝 (2) | 1 |

*Note*. A total of 618 SC signs are analyzed in this survey. Asterisks indicate handshapes that are not listed in Ministry of Education (2008).

Figure 47 shows the type frequencies of handshapes with no, one and two

marked features on the dominant hand. We can see that 236 signs (38.2%) use a handshape without any marked feature, 275 signs (44.5%) use a handshape with one marked feature and 107 signs (17.3%) use a handshape with two marked features. A one-way chi-squared test suggests that the distribution difference between handshape with no, one and two marked features is significant ($\chi^2$ (2) = 75.1, $p$ < .001, $n$ = 618). We can see from Figure 47 that, for the dominant hand, handshapes with one marked feature are used more than handshapes with no marked feature, which in turn are used more than handshapes with two marked features. This pattern is different from that of TSL signs, where both hands prefer the least marked handshapes.

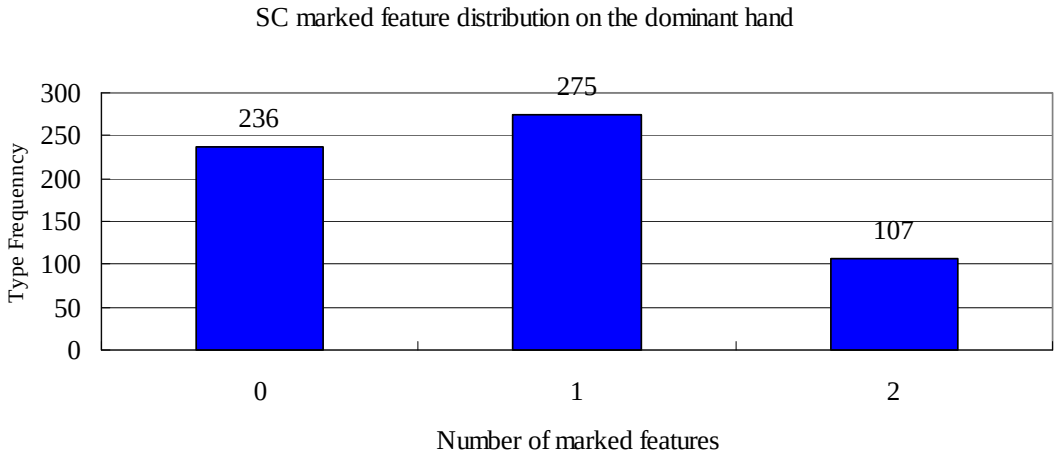



Figure 47. SC marked feature distribution on the dominant hand

Note that three extra handshapes that are not listed in the SC handshape chart (Figure 48, Ministry of Education 2008) were found in this sampled survey. These handshapes are '淑' ('LADY'), '戶' ('FAMILY') and '藥' ('MEDICINE') (handshape names are borrowed from the names of SC signs where these handshapes are used, as shown in Figure 49) and each is used only in one lexical item in this survey. The handshape used in the SC '淑' is coded as '二 + 女'; the handshape used in the SC

‘戶’ is not coded with any handshape symbol; the handshape used in the SC ‘藥’ is coded as ‘姊’ (but it is different from the original 姊 handshape where the pinky finger is extended and the rest of fingers are closed). In fact, as shown in Figure 48, in addition to the 51 native TSL handshapes that were adopted from Smith and Ting (1979, 1984), SC already invents 9 new handshapes. It is unclear why the 2008 SC dictionary still needs to coin new handshapes shown in Figure 49, or why these handshapes are not included in the SC handshape chart.

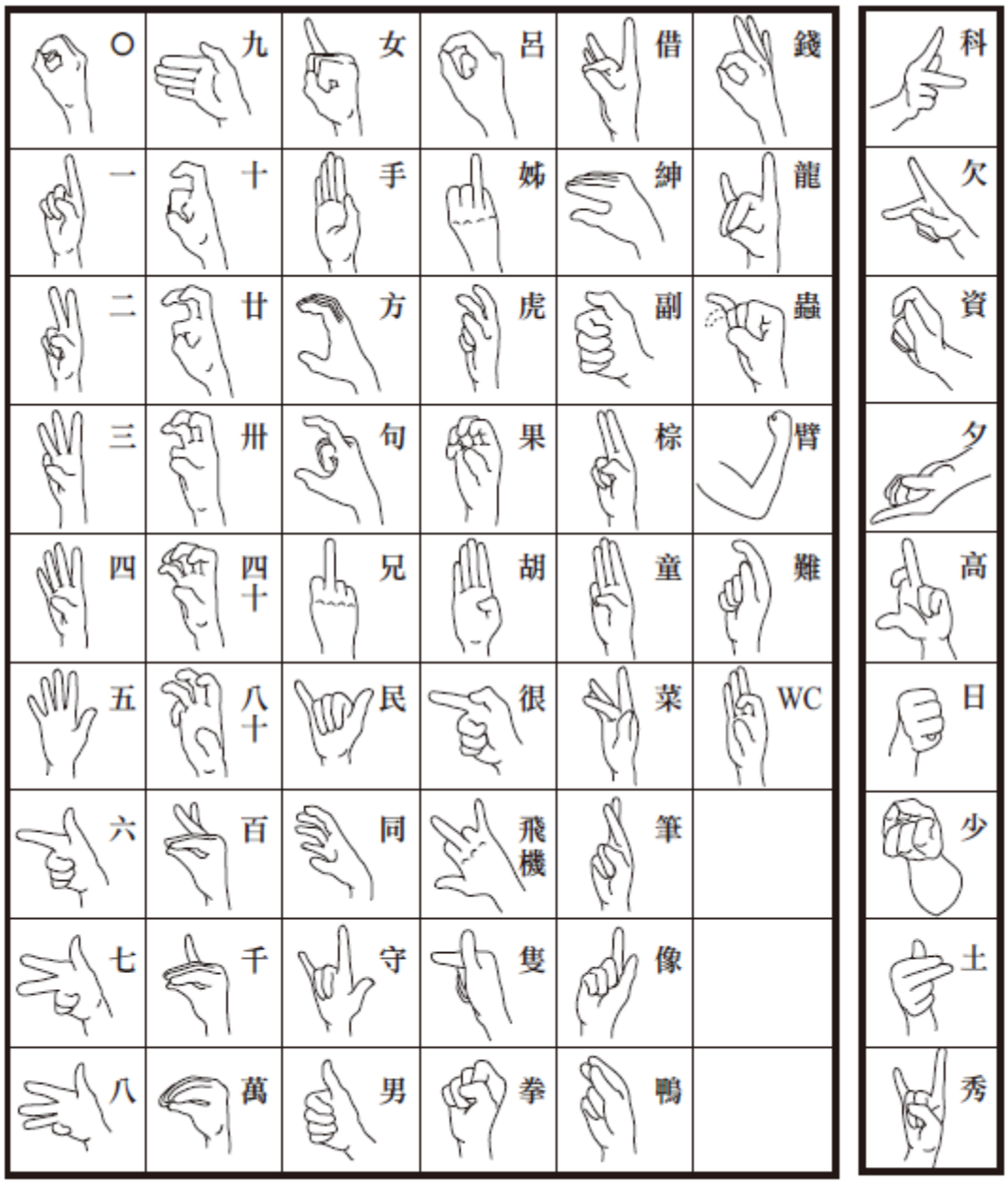



Figure 48. SC handshape chart (Ministry of Education 2008)

(a) (b) (c)

Figure 49. Signs adopting extra SC handshapes (Ministry of Education 2008)

Table 9 shows the type frequencies of 44 different handshapes on the nondominant hand. We can also see that some handshapes occur more often than other handshapes. For example, the three unmarked handshapes '手', '一' and '拳' occur on the nondominant hand of 139 signs (22.5%), 34 signs (5.5%) and 35 signs (5.7%), respectively. Some handshapes occur in very few SC signs. For instance, 25 handshapes are used in no more than 5 SC signs each.

Table 9. *Type Frequencies of Handshapes on the Nondominant Hand*

| Handshape | Type frequency | Handshape | Type frequency |
|---|---|---|---|
| 手 (0) | 139 | 像 (2) | 5 |
| 男 (0) | 35 | 胡 (0) | 4 |
| 拳 (0) | 35 | 臂 (0) | 4 |
| 一 (0) | 34 | 卅 (2) | 3 |
| 九 (1) | 23 | 土 (2) | 2 |
| 五 (0) | 23 | 廿 (2) | 2 |
| 三 (1) | 22 | 很 (2) | 2 |
| 同 (1) | 19 | 借 (2) | 2 |
| 二 (1) | 13 | 菜 (2) | 2 |
| 句 (2) | 13 | 鴨 (2) | 2 |
| 六 (1) | 12 | 龍 (2) | 2 |
| 萬 (1) | 12 | 難 (2) | 2 |
| 方 (1) | 11 | WC (2) | 1 |
| 民 (1) | 11 | 十 (1) | 1 |
| 七 (1) | 10 | 女 (1) | 1 |
| 棕 (1) | 10 | 兄 (1) | 1 |
| 零 (1) | 9 | 百 (2) | 1 |
| 錢 (2) | 7 | 果 (1) | 1 |
| 四 (0) | 6 | 隻 (2) | 1 |
| 呂 (2) | 5 | 副 (1) | 1 |
| 虎 (2) | 5 | 童 (1) | 1 |
| 紳 (1) | 5 | 蟲 (2) | 1 |

*Note*. A total of 501 two-handed signs are analyzed in this survey.

Figure 50 shows the type frequencies of handshapes with no, one and two marked features on the nondominant hand. We can see that, for the nondominant hand, 278 signs (55.5%) use a handshape without any marked feature, 167 signs (33.3%) use a handshape with one marked feature and 56 signs (11.2%) use a handshape with two marked features. A one-way chi-squared test suggests that the distribution difference between handshape with no, one and two marked features is significant ($\chi^2$ (2) = 147.6, $p$ < .001, $n$ = 501). We can see from Figure 43 that, the SC nondominant hand also shows a pattern that handshapes with least marked features are used most in signs and handshapes with most marked features are least used in signs.

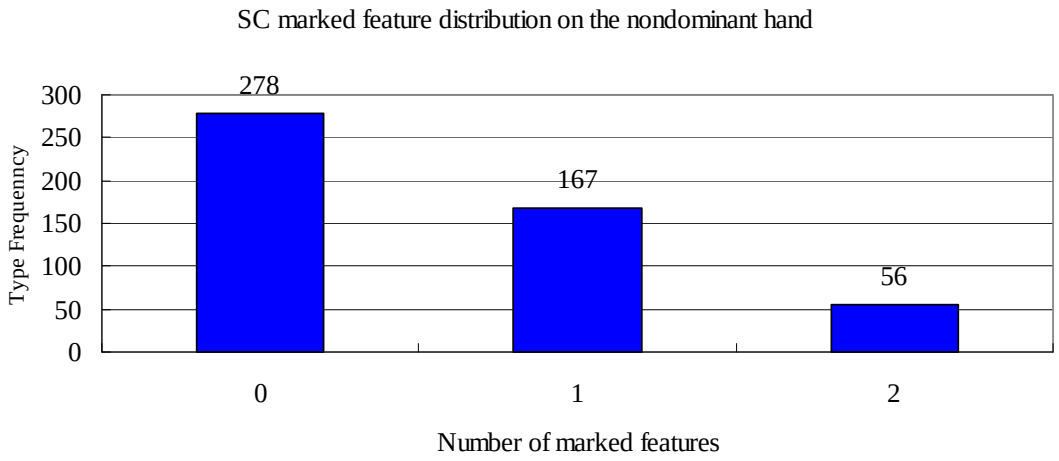



Figure 50. SC marked feature distribution on the nondominant hand

A two-way chi-squared test suggests that the distribution pattern of marked features between the dominant hand and the nondominant hand is significantly different ($\chi^2$ (2) = 33.9, $p$ < .001, $n$ = 1119). A Poisson regression analysis was performed to investigate whether handedness and markedness are correlated with the frequency of signs in SC. The results are reported in Table 10. As we can see from Table 10, there was a main effect of markedness, suggesting that handshapes with

more marked features were less shown in SC signs. However, the handedness effect was not significant, suggesting that both hands appear in a similar number of signs in the SC data (since most of the surveyed SC signs were two-handed). There was a significant interaction between handedness and markedness. As shown in Figure 51, the markedness effect was also stronger on the nondominant hand than on the dominant hand, like TSL.

Table 10. *Poisson Regression Model for Handedness and Markedness*

| Effects | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 5.64266 | 0.04000 | 141.076 | < .0001* |
| Hand | -0.02992 | 0.04000 | -0.748 | 0.454 |
| Markedness | -0.51958 | 0.03994 | -13.009 | < .0001* |
| Hand:Markedness | 0.20121 | 0.03994 | 5.038 | < .0001* |

*Note*. The asterisks indicate significant effects ($p < .05$).

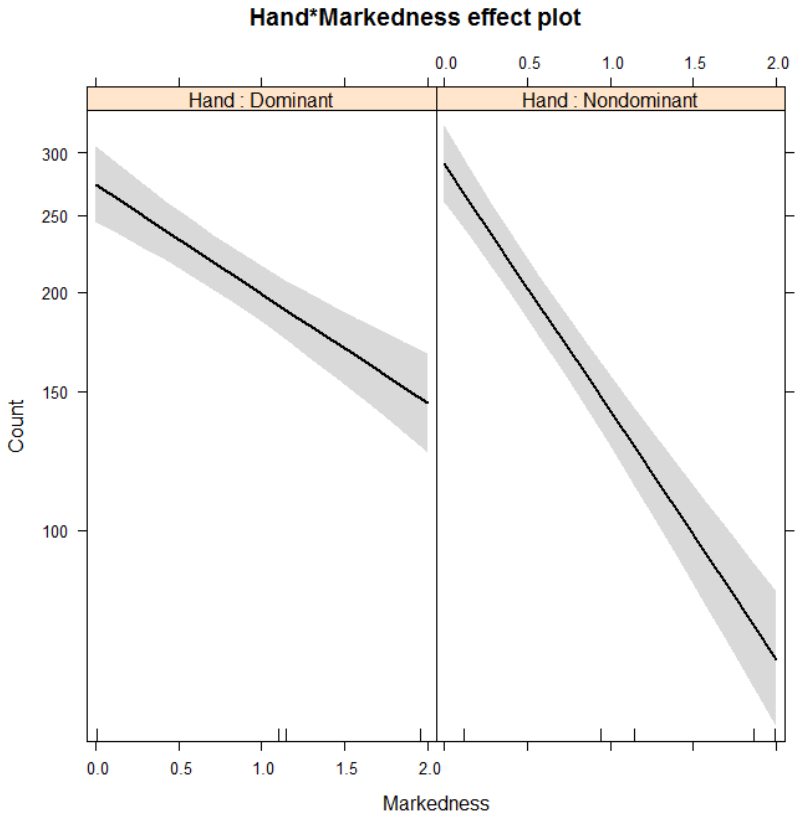



Figure 51. Effect plot for SC Hand × Markedness interaction

### 6.1.3 Comparisons between TSL and SC

Section 6.1.1 and Section 6.1.2 merely investigated the interaction between handedness and markedness within TSL and SC, respectively. One possible difficulty for learning Signed Chinese is that Signed Chinese shows a different markedness effect from TSL. Maybe SC uses more marked handshapes than TSL. However, Lee, Tsay and Myers (2001) have compared an earlier version of SC (Ministry of Education 2000) with TSL and found that the frequencies of occurrence of different handshapes in the signed systems are not significantly different. Specifically, some handshapes (e.g., a handshape where the thumb or index finger is fully extended) occur more often than other handshapes (e.g., a handshape where the pinky finger is fully extended) in both signed systems, but when the frequencies of the same set of handshapes were compared between SC and TSL, no significant differences were

found between them. They concluded that although TSL is natural and SC is artificial, differences between TSL and SC lexicon cannot be found in the distribution of handshapes alone.

In this new study, in addition to comparing handshape distributions of the new SC (Ministry of Education 2008) with TSL (with a two-way chi-squared test) in terms of marked feature distribution, I also try to seek other possible sources of difficulties of learning SC signs. Specifically, handshape patterns in handshape change and two-handed signs are all subject to phonotactic constraints. How well TSL and SC signs follow these constraints might shed some light on their differences in handshape patterns.

#### 6.1.3.1 Comparison of TSL and SC Marked Feature Distribution

The distribution pattern of marked features in TSL and SC handshapes is summarized in Table 11. As described in section 6.1.1 and 6.1.2, both hands show similar patterns in TSL. As for SC, the dominant hand shows a different pattern. Specifically, handshapes with one marked feature are adopted on the dominant hand more than handshapes with no marked feature.

Table 11. *Handshape Distribution Pattern in TSL and SC*

| MF | TSL | | SC | |
|---|---|---|---|---|
| | DH | NH | DH | NH |
| 0 | 634 (47%) | 535 (63%) | 236 (38.2%) | 278 (55.5%) |
| 1 | 440 (33%) | 222 (26%) | 275 (44.5%) | 167 (33.3%) |
| 2 | 275 (20%) | 96 (11%) | 107 (17.3%) | 56 (11.2%) |

*Note*. MF = Marked Feature; DH = Dominant Hand; NH = Nondominant Hand

First, a two-way chi-squared test comparing marked feature distribution on the dominant hand between TSL and SC was performed to see whether their distribution patterns are significantly different. A significant result ($\chi^2$ (2) = 26.0, $p$ < .001, $n$ = 1967) was found, suggesting that the dominant hand of SC shows significantly different patterns from that of TSL.

Second, a two-way chi-squared test comparing marked feature distribution on the nondominant hand between TSL and SC was performed to see whether their distribution patterns are significantly different. A significant result ($\chi^2$ (2) = 8.6, $p$ < .05, $n$ = 1354) was found, suggesting that the nondominant hand of SC shows significantly different patterns from that of TSL.

Finally, since there is no chi-squared test for analyzing a three-way interaction, a Poisson regression analysis was performed using R (R Core Team 2016) to investigate whether lexicon (TSL/SC), handedness (dominant/nondominant hand) and markedness (0/1/2 marked features) are correlated with counts of signs. The results are reported in Table 12. The significant lexicon effect merely tells us that TSL has more signs than SC in this survey (i.e., 1349 vs. 618). There was a main effect of markedness, suggesting that, on the whole, handshapes with more marked features were rarer in signs. The main effect of handedness was not significant, suggesting that both hands have a similar amount of signs. There was a significant interaction between lexicon and handedness. As shown in Figure 52, the handedness counts differ across SC vs. TSL. Specifically, the handedness effect was stronger in TSL. That is, the number of TSL signs that are signed using the dominant hand is bigger than the number of TSL signs that are signed using the nondominant hand (and the dominant hand, i.e., two-handed signs). For SC, such handedness effect was weaker, suggesting that the proportion of two-handed signs in SC is larger than that of TSL. The interaction between handedness and markedness was also significant, suggesting that,

overall, both hands show different markedness effects. Specifically, as shown in Figure 52, the nondominant hand has stronger markedness effects than the dominant hand. Importantly, there was a significant interaction between lexicon and markedness, suggesting that TSL and SC show different markedness effects. The significant Lexicon × Markedness interaction is shown in Figure 53. We can see from Figure 53 that the markedness effect is stronger in TSL than in SC. However, the lexicon × handedness × marked interaction was not significant, suggesting that the handedness × markedness effect was not significantly different across SC vs. TSL. As shown in Figure 52, the lack of a three-way interaction is visible from the fact that the slope difference for the two lines on the left is similar to the slope difference for the two lines on the right.

Table 12. *Poisson Regression Model for Lexicon × Handedness × Markedness*

| Effect | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 6.00712 | 0.02443 | 245.897 | < .0001* |
| Lexicon | -0.36446 | 0.02443 | -14.919 | < .0001* |
| Hand | 0.03097 | 0.02443 | 1.268 | 0.2049 |
| Markedness | -0.57857 | 0.02509 | -23.058 | < .0001* |
| Lexicon:Hand | -0.06090 | 0.02443 | -2.493 | 0.0127* |
| Lexicon:Markedness | 0.05899 | 0.02509 | 2.351 | 0.0187* |
| Hand:Markedness | 0.21424 | 0.02509 | 8.538 | < .0001* |
| Lexicon:Hand:Markedness | -0.01303 | 0.02509 | -0.519 | 0.6036 |

*Note*. The asterisks indicate significant effects ($p < .05$).

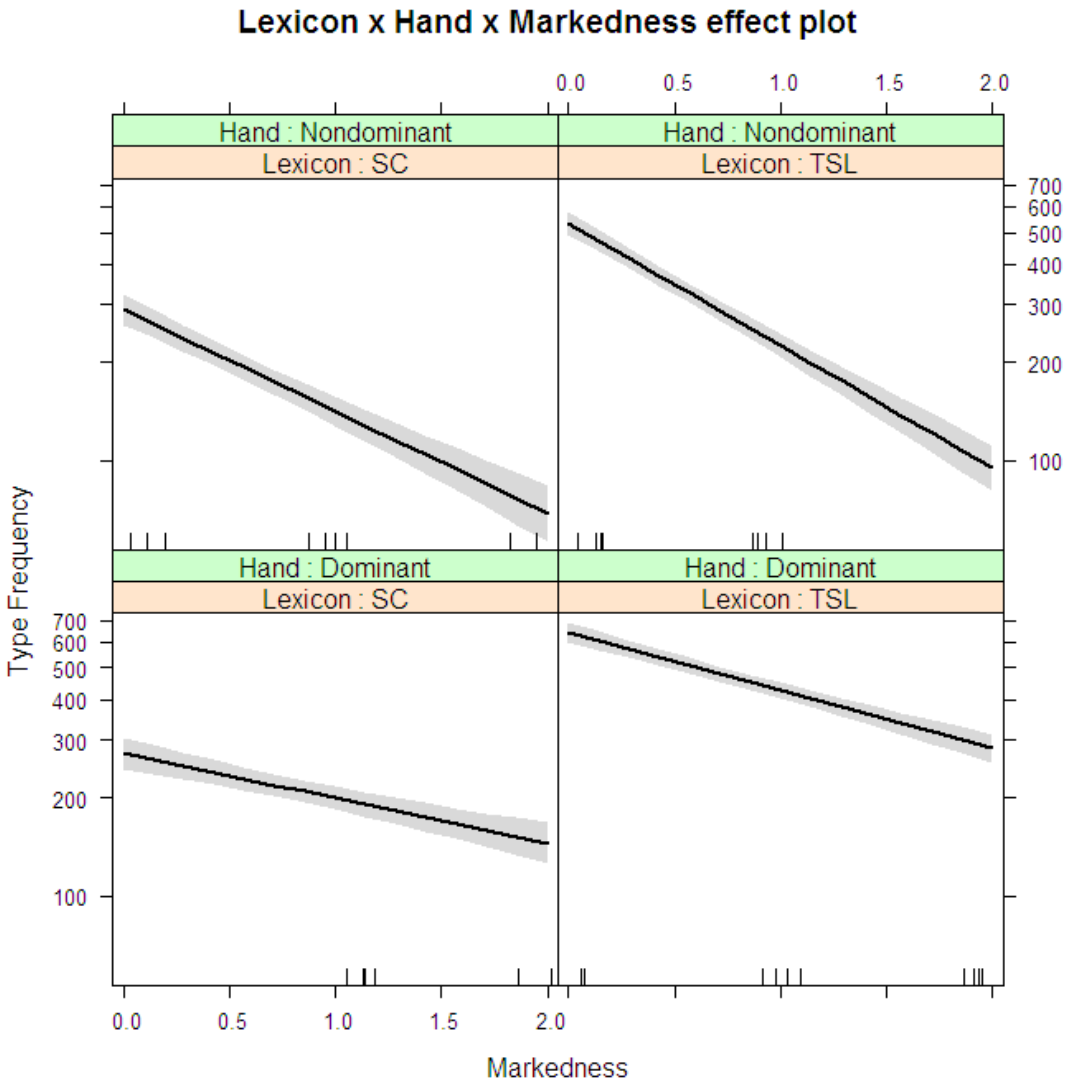



Figure 52. Effect plot for Lexicon × Hand × Markedness interaction

Figure 53. Lexicon × Markedness interaction plot

The results above suggest that one possible source of difficulty in learning SC signs is the fact that SC signs use marked handshapes more often than TSL.

### 6.1.3.2 Comparison of TSL and SC Handshape Changes

In this section, distribution patterns of handshape changes in TSL and SC were first compared to see if there is any difference. I then compared whether the Selected Finger Constraint is equally obeyed by SC and TSL. If SC handshape changes do not obey the Selected Finger Constraint as much as TSL, then we may identify SC's

violations of this constraint as another possible source of learning difficulty.

Following Lee (2003, 2008), in addition to handshape contour and handshape contrast, handshape trilled movement is also included in the handshape change analyses. In the surveyed 1349 TSL signs and 618 SC signs, 283 and 114 signs, respectively, are articulated with some kind of handshape change. The distribution pattern of handshape changes in TSL and SC signs is shown in Table 13. Both sign systems articulate handshape changes as handshape contour most frequently, and handshape trilled movement is the second most common type. Handshape contrast is rarely used in either sign system. A two-way chi-squared test comparing handshape change patterns between SC and TSL was performed to see whether they show different patterns. No significant result was found ($\chi^2$ (2) = 1.9, $p > .05$, $n$ = 397), suggesting that handshape change patterns are not significantly different across SC and TSL.

Table 13. *Frequencies of Handshape Changes in TSL and SC*

| Handshape Change | TSL | SC |
|---|---|---|
| Handshape contour | 179 (63.3%) | 79 (69.3%) |
| Trilled movement | 99 (35%) | 32 (28.1%) |
| Handshape contrast | 5 (1.8%) | 3 (2.6%) |

Next, I compare how well TSL and SC obey the Selected Finger Constraint. Table 14 shows the number of signs that obey/violate this constraint in TSL and SC. We can see that there is a trend that SC (13.2%) seems to violate the Selected Finger Constraint more often than TSL (7.4%). A two-way chi-squared test comparing phonological patterns regarding to the Selected Finger Constraint was performed to see whether SC shows a different pattern from TSL. No significant result was found

($\chi^2$ (1) = 2.6, $p$ > .05, $n$ = 397), suggesting that SC does not violate the Selected Finger Constraint significantly more often than TSL. However, as we can see from Figure 54, there is still a trend for TSL to obey the Selected Finger Constraint more.

Table 14. *Signs that Obey/Violate the Selected Finger Constraint*

| Selected Finger Constraint | TSL | SC |
|---|---|---|
| Obey | 262 (92.6%) | 99 (86.8%) |
| Violate | 21 (7.4%) | 15 (13.2%) |

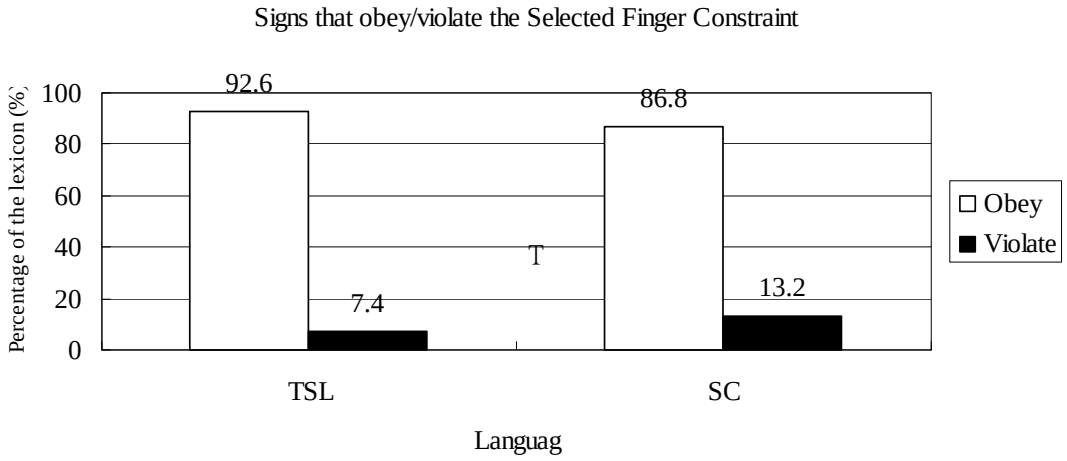



Figure 54. Signs that obey/violate the Selected Finger Constraint

### 6.1.3.3 Comparison of TSL and SC Two-handed Signs

In this section, I investigate how well TSL and SC two-handed signs obey the Revised Symmetry Condition and Revised Dominance Condition. If SC signs do not obey these constraints as much as TSL, then we may identify SC's violations of these constraints as possible sources of learning difficulties. In the surveyed 1349 TSL signs and 618 SC signs, 853 and 501 signs are two-handed, respectively.

Note that some character signs in SC are marked relative to TSL in forcing the non-dominant hand to articulate movements, as in character signs like '企' (shown in

Figure 55). In this case, not only are four hand movements required, but those movements must be articulated by the nondominant hand. This type of character sign violates the Revised Dominance Condition that constrains movement in the nondominant hand. This is like forcing right-handers to write or draw something using their left hand. This kind of character sign is an extremely difficult motor task for producers to do.

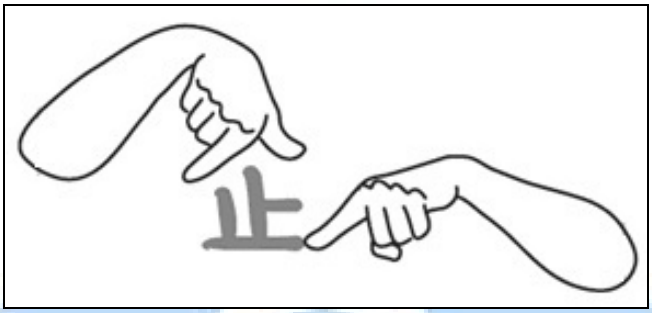


Figure 55. SC character sign 'ENTERPRISE' (Ministry of Education 2008, p.64)

Table 15 shows the number of signs that obey/violate the Revised Symmetry Condition in TSL and SC. A two-way chi-squared test comparing phonological patterns regarding the Revised Symmetry Condition was performed to compare SC with TSL. No significant result was found ($\chi^2$ (1) = 0.26, $p > .05$, $n = 1354$), suggesting that SC does not violate the Revised Symmetry Condition significantly more often than TSL.

Table 15. *Signs that Obey/Violate the Revised Symmetry Condition*

| Revised Symmetry Condition | TSL | SC |
|---|---|---|
| Obey | 842 (98.7%) | 492 (98.2%) |
| Violate | 11 (1.3%) | 9 (1.8%) |

Table 16 shows the number of signs that obey/violate the Revised Dominance Condition in TSL and SC. We can see there is a trend in that SC (28.5%) seems to violate the Revised Dominance Condition more often than TSL (11.3%). A two-way chi-squared test comparing phonological patterns regarding to this constraint was performed to compare SC with TSL. A significant result was found ($\chi^2$ (1) = 63.7, $p$ < .001, $n$ = 1354), suggesting that SC does violate the Revised Dominance Condition significantly more often than TSL. As shown in Figure 56, TSL signs clearly tend to obey the Revised Dominance Condition more often than SC signs.

Table 16. *Signs that Obey/Violate the Revised Dominance Condition*

| Revised Dominance Condition | TSL | SC |
|---|---|---|
| Obey | 757 (88.7%) | 358 (71.5%) |
| Violate | 96 (11.3%) | 143 (28.5%) |

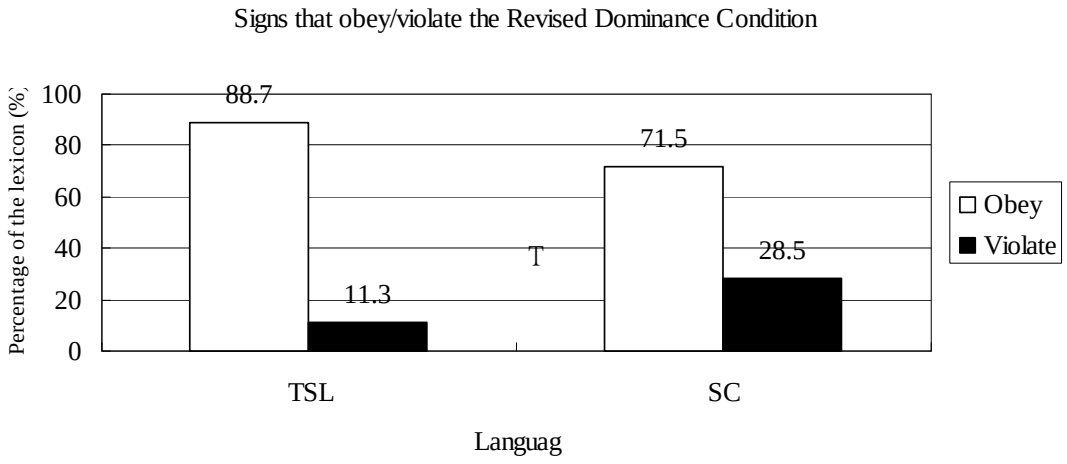



Figure 56. Signs that obey/violate the Revised Dominance Condition

Looking more closely into these violations, we found that, in the SC data, 26 SC character signs violate the Revised Dominance Condition due to the use of the nondominant hand for articulating movements. By contrast, only one TSL character

sign ‘區’ (‘DISTRICT’, shown in Figure 57a) violates this constraint due to the use of the nondominant hand for making movements. Note that this sign violates not only the Revised Dominance Condition, but also violates the Simple Sequence Constraint (due to the three movements) and the Narrator Perspective Principle. However, I have never seen deaf signers articulate the sign in this way. Instead, they still sign it from the narrator’s perspective and use the dominant for making hand movements, just as the original text below this illustration describes. Specifically, the texts instruct learners use their right hand (i.e., the dominant hand for most right-handers) to articulate the three hand movements. The mismatch between description texts and illustrated picture suggests that it is quite possible that this illustrated picture is just an error. In fact, signers most often adopt another simpler form of this character sign (as shown in Figure 57b). This simpler form depicts the simplified version (i.e., ‘区’) of the Chinese character ‘區’ and is frequently used by signers to express institution or place names, such as ‘**區**公所’ (‘DISTRICT OFFICE’) or ‘大安**區**’ (‘DAAN DISTRICT’). For this simpler form of character sign, the Revised Dominance Condition is still violated (due to its overall marked features), but both the Simple Sequence Constraint and the Narrator Perspective Principle are obeyed.

(a) TSL ‘區’ (Smith and Ting 1979, p. 201)  (b) ‘區’ (Chao 1998, p. 137)

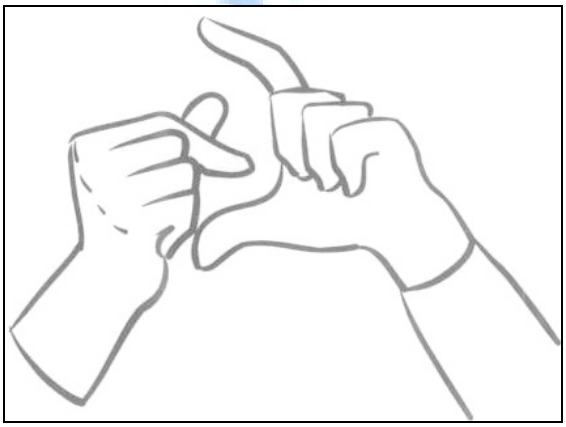


Figure 57. TSL character sign ‘區’

Although SC violates the Revised Dominance Condition significantly more often than TSL, we should note that 96 TSL signs (11%) were found to violate this constraint. Many TSL signs violate the Revised Dominance Condition due to the number of marked features across both hands exceeding two (e.g., TSL 'BANANA', shown in Figure 58a), and/or the number of marked features on the nondominant hand exceeding one (e.g., TSL 'YEAR', shown in Figure 58b). For example, in TSL 'BANANA', the dominant hand has two marked features (due to its marked finger selection and joint configuration) and the nondominant hand has one marked feature (due to its marked finger selection). Thus, this sign has three marked features and violates the Revised Dominance Condition, which allows a maximum of two marked features. In TSL 'YEAR', the dominant hand has no marked feature, but and the nondominant hand has two marked features (due to its marked finger selection and joint configuration). Although this sign has only two marked features, these marked features were all found on the nondominant hand. This sign thus violates the Revised Dominance Condition, which allows only one marked feature to be on the nondominant hand. Violations of the Revised Dominance Condition by TSL and SC signs suggest that handshapes across both hands might be more complicated than was regulated by Eccarius and Brentari's featural model.

(a) (b)

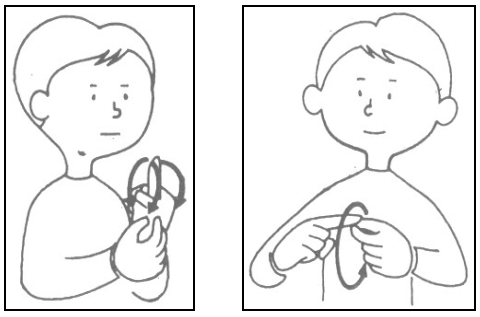


Figure 58. TSL 'BANANA' and 'YEAR' (from Smith and Ting 1979)

We should note that although signs might violate the Revised Dominance Condition due to their overall marked features, phonology alone does not decide their acceptability or learnability. Specifically, iconicity is prevalent in sign language lexicon[16] (Mandel 1977; Taub 2001; Su 2004; Su and Tai 2009). The perceived resemblance between the sign and its referent can be observed in some TSL signs that violate the Revised Dominance Condition. For example, the TSL sign 'BANANA' (Figure 58a) I just described above is a very iconic sign that mimics how one would peel a banana. Similar iconic relation between form and meaning can also be observed in TSL signs like 'RICE TAMALE' and 'PEEL' (as shown in Figure 59), even though they violate the Revised Dominance Condition.

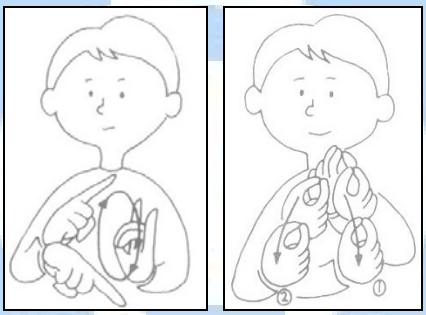


Figure 59. TSL 'RICE TAMALE' and 'PEEL' (from Smith and Ting 1984)

### 6.1.4 Interim Summary

We can see from section 6.1.1 that, in TSL, handshapes with the fewest marked features are used most in signs and handshapes with the most marked features are least used in signs, for both hands. The nondominant hand of SC signs shows the same pattern, but a different pattern was found for the dominant hand of SC signs. Specifically, it adopts handshapes with one marked feature in more signs than handshapes with zero marked feature. Although both TSL and SC show a significantly

[16] But see Lee (2003) for examples of abstract phonology overriding iconicity.

stronger markedness effect on the nondominant hand (i.e., handshapes with more marked features were less used in signs), we found a significant lexicon × markedness interaction, suggesting that the markedness effect was stronger in TSL than in SC. Thus, SC signs might use handshapes with more marked features than TSL signs. It is quite possible that SC inventors did not realize that some handshapes are more difficult than other handshapes when they invented these new signs.

Analyses of handshape change patterns suggest that TSL and SC show similar patterns, since they equally obey the Selected Finger Constraint, though TSL signs tend to obey it more. Thus, SC signs also do not change selected fingers when articulating a handshape change, like TSL.

Analyses of two-handed signs suggest that TSL and SC show similar patterns regarding the Revised Symmetry Condition. Thus, when both hands move independently, two-handed SC signs are also symmetrical in their movement and handshapes. However, we found that SC signs violate the Revised Dominance Condition significantly more often than TSL. Specifically, when SC depicts Chinese characters, it always adopts the nondominant hand for making movements.

Our analyses thus show that SC signs might use marked handshapes more often than TSL. In addition, SC signs also tend to use the nondominant hand for making hand movements, which is difficult or disfavored.

### 6.2 Comparison of TSL and SC Locations

This section investigates the location parameter in TSL and SC. Type frequencies of different major areas for each sign system are first listed. How well the One Major Area Constraint is obeyed by TSL and SC is analyzed by a two-way chi-squared test.

### 6.2.1 Type Frequencies of Locations in TSL and SC

Table 17 shows the type frequencies of major body areas in TSL and SC. We can see that the trunk and head areas are the two most frequent locations. However, we can also see that in both sign systems, a few signs are articulated in more than one major area, which violates the One Major Area Constraint.

Table 17. *Location Patterns in TSL and SC*

| Location | TSL | SC |
|---|---|---|
| Trunk | 681 (50.5%) | 380 (61.5%) |
| Head | 363 (26.9%) | 142 (23.0%) |
| Nondominant hand | 261 (19.4%) | 81 (13.1%) |
| Arm | 31 (2.3%) | 9 (1.4%) |
| Head + Trunk | 6 (0.4%) | 5 (0.8%) |
| Head + nondominant hand | 7 (0.5%) | 1 (0.2%) |

### 6.2.2 Comparison

Next, I test whether the One Major Area Constraint is equally obeyed by SC and TSL. If SC signs do not obey the One Major Area Constraint as much as TSL, then we may identify SC's violations of this constraint as another possible source of learning difficulty. Table 18 shows the number of signs that obey/violate the One Major Area Constraint in TSL and SC. Based on Table 18, a two-way chi-squared test comparing phonological patterns regarding to this constraint was performed to compare SC with TSL. No significant result was found ($\chi^2$ (1) = 0.05, $p > .05$, $n$ = 1967), suggesting that SC does not violate the One Major Area Constraint significantly more often than TSL. Since the One Major Area Constraint is equally obeyed by TSL and SC, it might not be the source of difficulty for learning SC signs.

Table 18. *Signs that obey/violate the One Major Area Constraint*

| One Major Area Constraint | TSL | SC |
|---|---|---|
| Obey | 1336 (99%) | 612 (99%) |
| Violate | 13 (1%) | 6 (1%) |

### 6.3 Comparison of TSL and SC Movements

This section investigates the movement parameter in TSL and SC. Type frequencies of different types of movements for each sign system will be listed. In addition, each item will also be transcribed for the number of movements to see whether it is constrained by the Simple Sequence Constraint observed for ASL.

#### 6.3.1 Frequencies of Movements and the Number of Movements in TSL

Table 19 shows the type frequencies of movements in TSL. We can see that path movement is the most frequent type of movement. Like ASL, local movement and trilled movement can co-occur with path movement (coded as Path/Local and Path/Trilled in Table 19, respectively). In addition, many signs that are articulated without any movement (coded as None in Table 19) are also found. These signs include number signs (e.g., '五十' ('FIFTY'), as shown in Figure 60a), some character signs (e.g., '王' ('WANG'), as shown in Figure 60b) and many other stationary signs (e.g., '鹿' ('DEER') and '三角' ('TRIANGLE'), as shown in Figure 60c and 59d). Although as mentioned before, some character signs are actually articulated with some sort of movement, to be faithful to the original dictionary data, signs that are not illustrated (by an arrow, a circle, or a double-headed arrow) or described (in the text below the illustrated picture) with any movement were still transcribed as None in this thesis. Whether these signs with no movement violate syllable requirements of a well-formed sign (Brentari 1998) is outside the scope of

this study, and we will leave this issue for future research.

Table 19. *Frequencies of Movements in TSL*

| Types | Frequency |
|---|---|
| Path | 806 (59.8%) |
| Local | 95 (7%) |
| Trilled | 124 (9.2%) |
| None | 121 (9%) |
| Path/Local | 165 (12.2%) |
| Path/Trilled | 38 (2.8%) |

*Note*. Path/Local: a local movement cooccurs with a path movement; Path/Trilled: a trilled movement cooccurs with a path movement

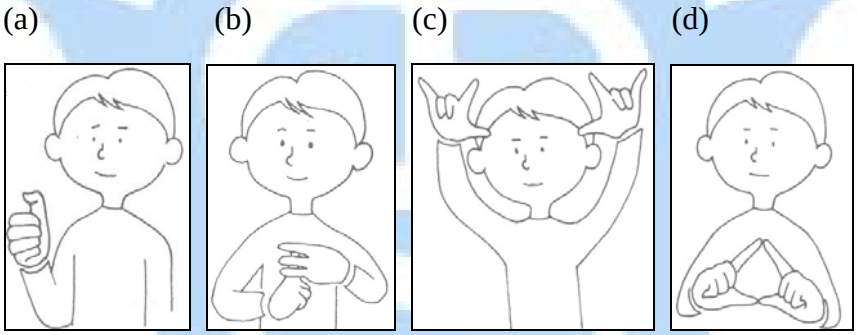



Figure 60. TSL signs without any movement (Smith and Ting 1979)

Table 20 shows the type frequencies of the number of movements in TSL. We can see that most TSL signs are articulated with one movement only, and many signs are articulated with two movements. Only one character sign (as shown in Figure 61) is articulated with more than two movements, which violates the Simple Sequence Constraint. Thus, the upper limit of the number of movements in TSL is also two, except for the character sign '區', which is not actually signed this way and has often

been replaced by a simpler form (as shown before in Figure 57b).

Table 20. *Frequencies of the Number of Movements in TSL*

| Number of movements | Frequency |
|---|---|
| 0 | 121 (9%) |
| 1 | 956 (70.8%) |
| 2 | 271 (20.1%) |
| 3 | 1 (0.1%) |

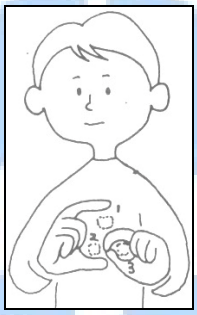


Figure 61. TSL character sign '區' (Smith and Ting 1979, p. 201)

### 6.3.2 Frequencies of Movements and the Number of Movements in SC

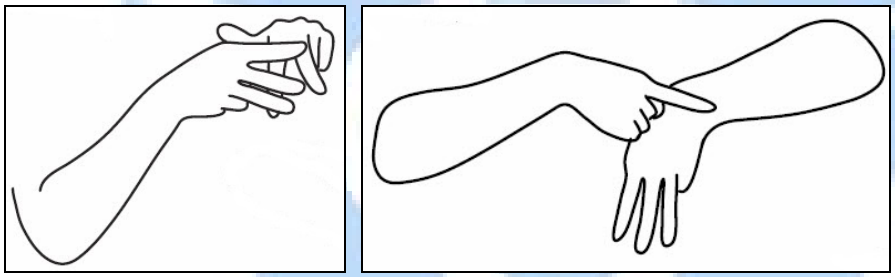
Table 21 shows the type frequencies of movements in SC. We can see that path movement is also the most frequent type of movement. Local movement and trilled movement can also co-occur with path movement (coded as Path/Local and Path/Trilled in Table 21, respectively). Like TSL, many signs that are articulated without any movement (coded as None in Table 21) are also found. These signs include many character signs (as shown in Figure 62a and 61b) and many other stationary signs (as shown in Figure 62c and 61d).

Table 21. *Frequencies of Movements in SC*

| Types | Frequency |
|---|---|
| Path | 376 (60.9%) |
| Local | 31 (5%) |
| Trilled | 31 (5%) |
| None | 84 (13.6%) |
| Path/Local | 70 (11.3%) |
| Path/Trilled | 26 (4.2%) |

*Note*. Path/Local: a local movement co-occurs with a path movement; Path/Trilled: a trilled movement co-occurs with a path movement

(a) '全' (p. 149) (b) '系' (p. 888)



(c) '犀牛' (p. 961) (d) '資' (p. 460)

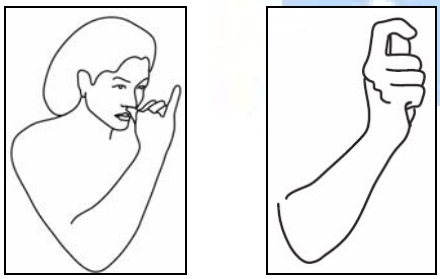


Figure 62. SC signs without any movement (Ministry of Education 2008)

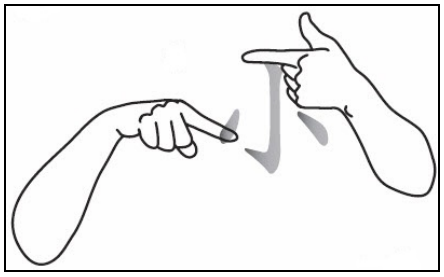
Table 22 shows the type frequencies of the number of movements in SC. We can see that most SC signs are articulated with one movement only, and many signs are articulated with two movements. However, 15 signs are articulated with more than

two movements, 8 of them are character signs. Figure 63 shows example signs with three (as shown in Figure 63a), four (as shown in Figure 63b) and five movements (as shown in Figure 63c), respectively. Some signs are intrinsically complex in terms of movements. For example, SC '八卦' ('THE EIGHT TRIGRAMS', shown in Figure 63d) and '菠菜' ('SPINACH', shown in Figure 63e) both have three lexical movements.

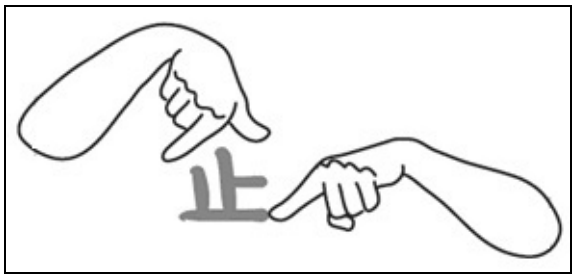
Table 22. *Frequencies of the Number of Movements in SC*

| Number of movements | Frequency |
|---|---|
| 0 | 84 (13.6%) |
| 1 | 426 (69%) |
| 2 | 93 (15%) |
| 3 | 7 (1.1%) |
| 4 | 6 (1%) |
| 5 | 2 (0.3%) |

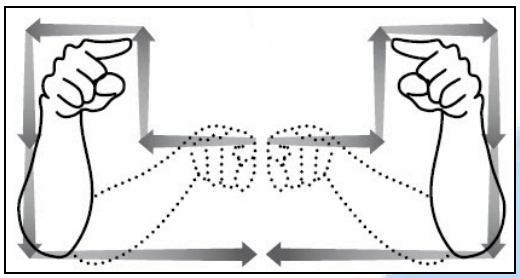
(a) ‘爾’ (p. 1386)



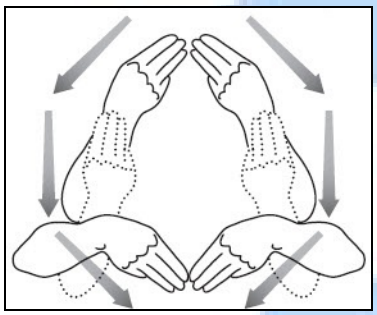
(b) ‘企’ (p. 64)



(c) ‘凹’ ( p. 170)



(d) ‘八卦’ (p.151)



(e) ‘菠菜’ (p. 1265)

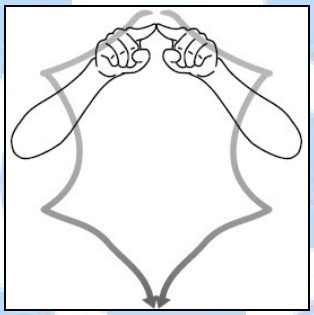


Figure 63. SC signs with multiple movements (Ministry of Education 2008)

### 6.3.3 Comparison

Now we test whether the Simple Sequence Constraint is obeyed to the same degree by SC and TSL signs. If SC signs do not obey the Simple Sequence Constraint as much as TSL, then we may identify SC’s violations of this constraint as another possible source of learning difficulty. Table 23 shows the number of signs that obey/violate the Simple Sequence Constraint in TSL and SC. A two-way chi-squared test comparing phonological patterns regarding to the Simple Sequence Constraint was performed to compare SC with TSL. A significant result was found ($\chi^2$ (1) = 26.2,

$p < .001$, $n = 1967$), suggesting that SC violates the Simple Sequence Constraint more often than TSL. Nevertheless, we should note that fewer than 3% of SC signs violate the Simple Sequence Constraint. Thus, it is questionable whether this tiny difference between SC and TSL can cause difficulties in learning or processing.

Table 23. *Signs that Obey/Violate the Simple Sequence Constraint*

| Simple Sequence Constraint | TSL | SC |
|---|---|---|
| Obey | 1348 (99.9%) | 603 (97.6%) |
| Violate | 1 (0.1%) | 15 (2.4%) |

### 6.4 Character Signs in TSL and SC

From previous sections, we can see that character signs in SC often violate the Revised Dominance Condition and Simple Sequence Constraint. This section investigates character signs in TSL and SC regarding the Narrator Perspective Principle. Character signs are further examined in terms of their signing perspective to see whether they also follow the Narrator Perspective Principle for describing spatial scenes at the sentence level. Articulation differences of character signs between TSL and SC are discussed in section 6.4.1. In section 6.4.2, I argue that TSL character signs violate the No Left/Right Specificity principle, but consistently follow the Narrator Perspective Principle.

#### 6.4.1 Articulation Differences in Character Signs

Character signs are designed to depict the shape of the source Chinese characters. However, character signs are articulated differently in TSL and SC. In SC, it seems that almost all character signs are designed to match the shape of the source character from the viewers' perspective. When character signs are adopted into TSL, however,

they are signed so that the signer can easily see his or her own signing character, just as signers do when describing spatial scenes (i.e., obeying the Narrator Perspective Principle), which might reverse the character for the viewer. For instance, in both systems the character sign '人' ('PERSON', shown in Figure 64a and Figure 64b) is signed using two index fingers contacting each other to mimic the shape of this character. TSL uses the tip of right-hand index finger to contact the first knuckle joint of the left-hand index finger so that the viewer might need to perform a 180° mental rotation to correctly recognize this Chinese character (though in this case, since '人' is a commonly used lexical item in TSL, signers might just memorize its appearance without rotating). By contrast, in Signed Chinese, the tip of the left-hand index finger contacts the first knuckle joint of the right-hand index finger so that the viewer can easily recognize this Chinese character without any mental rotation.

(a) (b)

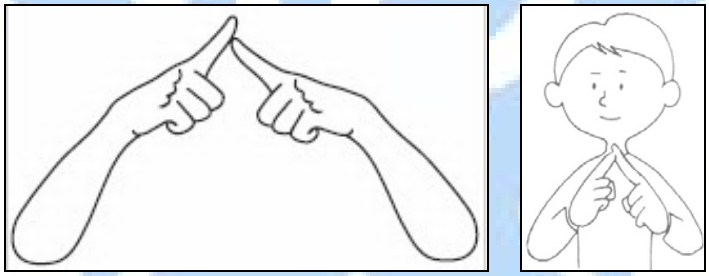


Figure 64. '人' in SC and TSL

The pattern of TSL for conveying character signs from the signer's perspective is also evidenced in Chang's (2011a, 2011b) survey of TSL place names and family names. Character signs have commonly been adopted by TSL signers to express place names and family names. We can see from the character sign '仁' ('KINDNESS', shown in Figure 65) that the deaf signer chooses to express this character from his own perspective, whereas SC adopts the viewer perspective.

(a) (b)

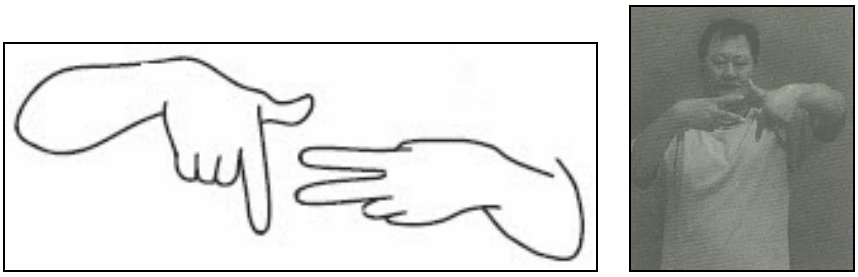


Figure 65. ‘仁’ in SC and TSL

In order to depict Chinese characters from the signer’s perspective, both hands must be positioned in a certain way to mimic a Chinese character. Taking the Chinese character ‘仁’ for example, the signer in Figure 64b has chosen the left hand to depict the ‘亻’ radical and the right hand to depict the ‘二’ radical. The pattern for choosing the narrator’s perspective when signing character signs obviously violates the No Left/Right Specificity principle for regular lexical signs. Specifically, for one-handed native signs, signs can be articulated with either the signer’s right hand or left hand, without affecting its well-formedness. Likewise, for two-handed native signs where only one hand moves, although signers always use their dominant hand for articulating the movement, they can also reverse the choice of hands without affecting the signs’ well-formedness. Thus, right-handed and left-handed signers have no problem understanding each other, because no lexical contrast is neutralized.

### 6.4.2 Revisiting Ann’s Study

The observation that character signs must be signed in a certain way by both right-handed and left-handed signers seems to be challenged by Ann (1998). Ann did a survey on handedness choice for character signs from two right-handed signers and one left-handed signer (p. 77), based on her collection of a dozen character signs (p. 79-81). She claimed that signers always use their dominant hand as the active hand

for depicting character signs (i.e., following No Left/Right Specificity). Note, however, that as Ann herself pointed out, the shape of most character signs she analyzed are 'symmetrical' (p. 83) (e.g., '工', '中', '小', '介' and '个', as shown in Figure 66). We can see that in such character signs, the hand choice does not really affect how the character sign would look like from the signer's (or viewer's) perspective. Based on how signers sign two-handed signs where one hand (i.e., dominant hand) moves, it is thus reasonable to expect that a left-handed signer would choose to use his/her left hand for making that movement, even for a 'symmetrical' character sign.

(a) (b) (c) (d) (e)

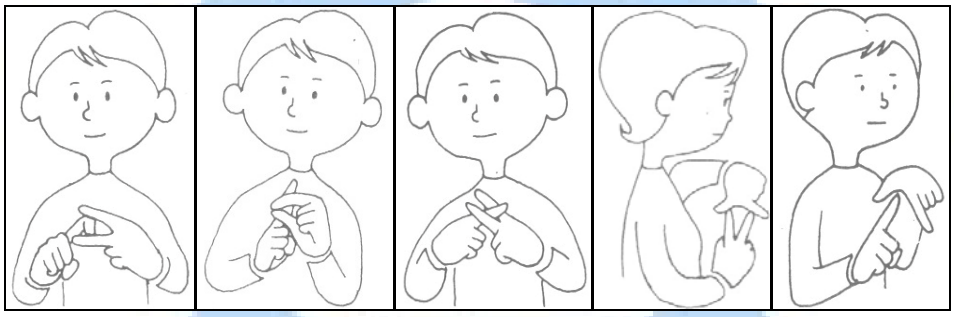


Figure 66. Character Signs for '工', '中', '小', '介' and '个' (Smith and Ting 1979)

As noted by Ann herself, the only exceptions to her claim are the two character signs '人' and '血'. In these signs, both right-handed and left-handed signers position their hands in the same way, so that the Chinese characters are depicted from the signer's perspective. Due to the limitation of Ann's data source, a lot of asymmetrical character signs (e.g., '仁', '明', '司') were not investigated. Overall, Ann's findings suggest that for characters that are symmetrical in shape, the handedness does not matter (i.e., even when obeying the No Left/Right Specificity constraint, signers can still choose to use their dominant hand for articulation), whereas for characters that are asymmetrical in shape, the hands must be positioned in a certain way for depicting

Chinese characters (i.e., violating the No Left/Right Specificity constraint even if signers might be forced to ignore their hand dominance).

For symmetrical characters that are not discussed in Ann (1998), I predict that signers may freely choose to use their dominant hand for articulation without affecting the appearance of character signs. For those unstudied asymmetrical character signs, if the signer perspective was taken, I predict that a left-handed signer would have to ignore his/her own hand dominance for signing and adjust himself/herself to cope with Chinese orthography. These predictions are confirmed in the survey of place names and family names by Chang (2011a, 2011b). I tracked examples signed by one of his consultants (whose name is Jun-ming Yu 于俊明) who I know is a left-handed signer. For symmetrical characters like '吉' ('LUCKY'), the signer locates his left hand on the nose (as shown in Figure 67) to represent the '士' component (with the mouth representing the '口' component). For asymmetrical characters, he consistently articulates them from his perspective and matches the orthography by ignoring his hand preference when depicting these Chinese characters (as shown in Figure 68 and Figure 69).

Figure 67. '吉' by a left-handed signer (Chang 2011a, p. 174)

(a) ‘少’ (b) ‘仁’ (c) ‘明’

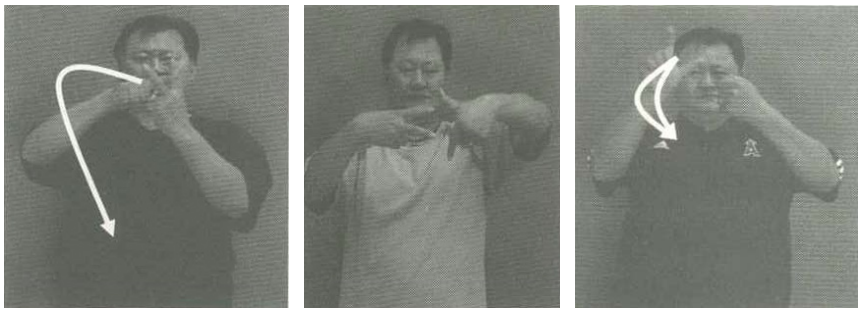


Figure 68. Signs from Chang (2011a) by a left-handed signer

(a) ‘朱’ (b) ‘司’ (c) ‘宇’ (d) ‘俟’

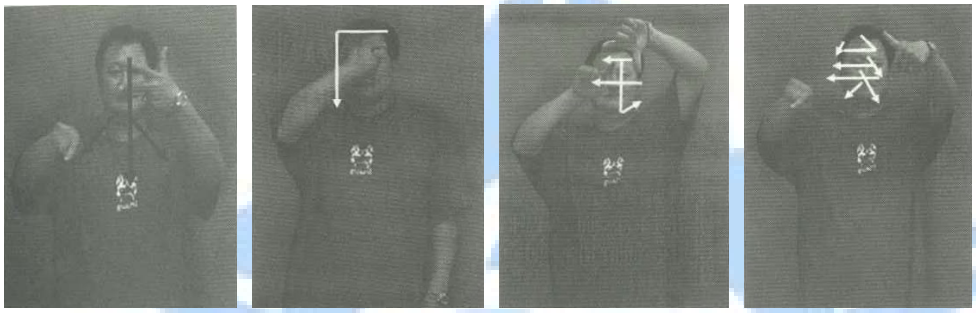


Figure 69. Signs from Chang (2011b) by a left-handed signer

Ann’s generalization is probably biased by her limited data (i.e., only a dozen character signs, most of them ‘symmetrical’), and her conclusion that handedness does not matter for character signs is problematic, at least for asymmetrical Chinese characters. Therefore, I would still assume that signers, be they right-handed or left-handed, prefer to depict Chinese characters from their own perspective since this is a natural way of signing at the sentence level as well. Therefore, for the character ‘仁’ (‘KINDNESS’), both right-handers and left-handers should use their left hand for depicting ‘亻’ and use their right hand for depicting ‘二’, to match the exact orthography of ‘仁’ from the signer’s perspective.

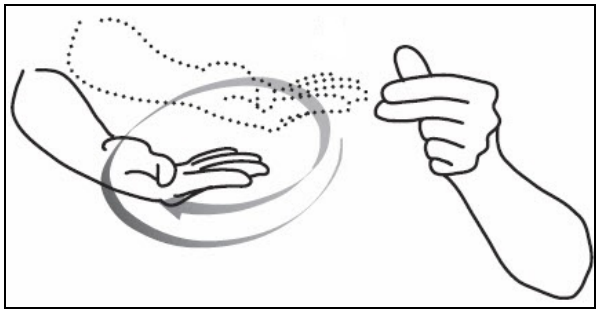
In the 1349 surveyed TSL signs, 50 (3.7%) of them are character signs. Only one character sign ‘區’ violates the Narrator Perspective Principle (as shown before in

Figure 52). In the 618 surveyed SC signs, 80 (12.9%) of them are character signs, and 38 (47.5%) character signs violate the Narrator Perspective Principle. Table 24 shows the number of character signs that obey/violate the Narrator Perspective Principle in TSL and SC. Note that the 42 SC signs that obey the Narrator Perspective Principle include signs that actually obey the principle (i.e., asymmetrical characters, as shown in Figure 70) as well as signs that only vacuously obey it (i.e., symmetrical characters, as shown in Figure 71). For example, the '土' radical of '塘' ('POND') and the '才' radical of '财' ('FINANCE') are represented by the left hand and the right hand respectively, following the Narrator Perspective Principle. Symmetrical character signs can only vacuously obey this principle since the characters and signs themselves are symmetrical in form, without taking specific perspective for signing. It seems that SC character signs do not behave consistently; they are sometimes signed from the narrator's perspective and sometimes signed from the viewer's perspective.

Table 24. *Character Signs that Obey/Violate the Narrator Perspective Principle*

| Narrator Perspective Principle | TSL | SC |
|---|---|---|
| Obey | 49 (99.9%) | 42 (52.5%) |
| Violate | 1 (0.1%) | 38 (47.5%) |

(a) '塘' (p. 870)



(b) '财' (p. 1412)

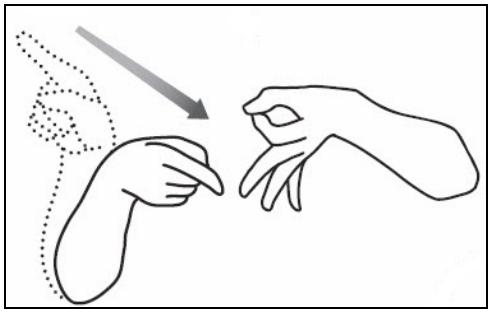


Figure 70. SC '塘' and '财' from Ministry of Education (2008)

(a) ‘器’ (p. 823)　　(b) ‘格’ (p. 53)

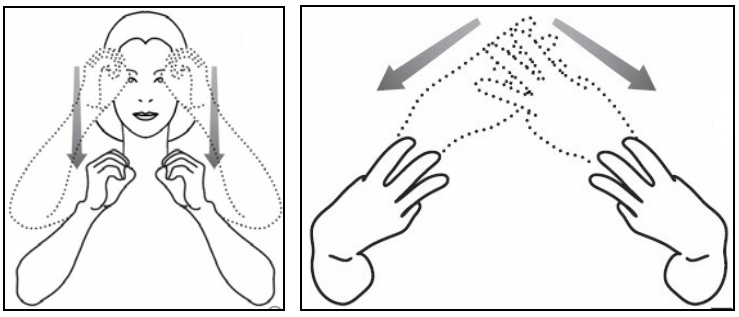


Figure 71. SC ‘器’ and ‘格’ from Ministry of Education (2008)

A two-way chi-squared test comparing the phonological patterns of character signs between SC and TSL suggests that character signs in SC show a quite different pattern from that of TSL ($\chi^2$ (1) = 28.2, $p < .001$, $n = 130$). As we can see from Figure 72, nearly half of the SC character signs violate the Narrator Perspective Principle, whereas TSL obey this principle almost completely. Clearly, TSL always adopts the narrator’s perspective when signing character signs, whereas SC often depicts Chinese characters adopting the viewer’s perspective. We can thus see that character signs in both TSL and SC go against the No Left/Right Specificity principle. However, only in TSL do character signs consistently obey the Narrator Perspective Principle, whereas character signs in SC do not behave consistently regarding the signing perspective.

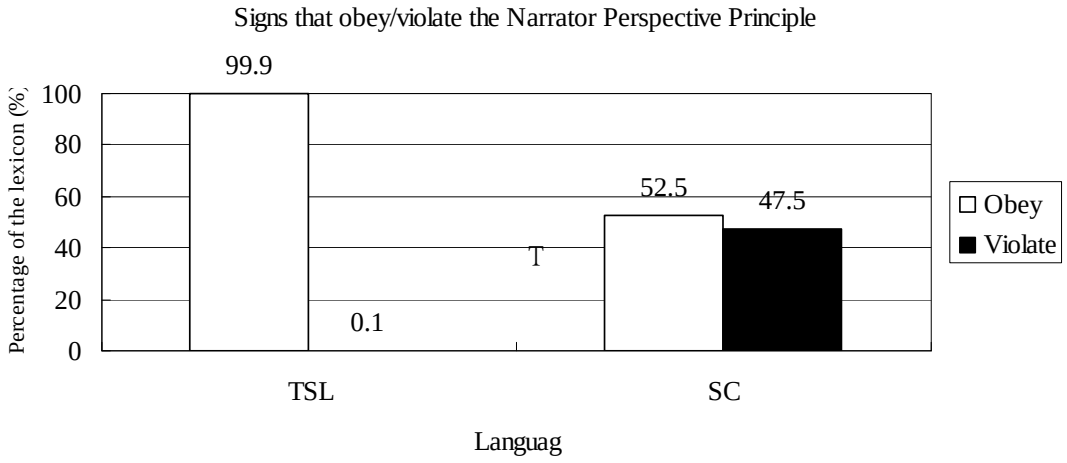



Figure 72. Character signs that obey/violate the Narrator Perspective Principle

From the discussions above, we can see that although character signs in TSL violate the No Left/Right Specificity Principle, they still consistently follow the Narrator Perspective Principle. By contrast, character signs in SC violate not only the No Left/Right Specificity principle, but they also inconsistently obey the Narrator Perspective Principle, potentially making SC character signs even more difficult to learn.

### 6.5 Summary

As we have seen, SC shows some different sign-internal patterns and violates some phonotactic constraints that hold true for natural sign systems, thus potentially causing learning or processing difficulties for deaf learners.

First, for the first time, a significant difference was found between SC and TSL handshape patterns. Specifically, handshapes with no marked feature are used most frequently in TSL signs on both hands, but SC shows a different pattern by using handshapes with one marked feature more often than handshapes with zero marked feature on the dominant hand. More importantly, we found that the markedness effect

is stronger in TSL than in SC. Thus, TSL signs show a stronger tendency to use unmarked handshapes in most signs and also avoid marked handshapes when articulating signs. As a whole, SC signs use marked handshapes more often than TSL signs and also use unmarked handshapes less often than TSL signs. In addition, SC signs also have more two-handed signs than TSL. Since marked handshapes of two-handed signs tend to be recognized more slowly than unmarked handshapes by both deaf signers and hearing nonsigners (Grosvald, Lachaud and Corina 2012), the fact that SC signs have more two-handed signs and tend to use marked handshapes for articulating signs might be a source for learning difficulty.

Second, SC signs violate the Revised Dominance Condition significantly more often than TSL signs. Sources of this difference include overall marked features across both hands in SC and SC's tendency to produce character signs by using the nondominant hand ( i.e., left hand) for making movements, which is difficult for most right-handers. By contrast, TSL signs always use the dominant hand for making hand movements. This difference between SC and TSL signs could be another source for learning difficulty.

Third, SC signs also violate the Simple Sequence Constraint significantly more often than TSL, though the difference lies in less than 3% of SC signs. It seems that SC signs have no clear restriction on how many hand movements one sign can make. In my survey, some SC signs can contain up to five hand movements. However, since only less than 3% of SC signs violates this constraint, it is uncertain whether this tiny difference could cause learning difficulties.

Fourth, character signs are signed differently in TSL and SC. Specifically, character signs in TSL consistently obey the Narrator Perspective Principle and depict Chinese characters from the narrator's perspective, as they would do when describing spatial scenes. By contrast, character signs in SC do not behave consistently regarding

this constraint, and often produce character signs from the viewer's perspective, suggesting that its way of signing character signs is not consistent with deaf signers' preferences. This difference between SC and TSL signs could also be another source for learning difficulty.

Despite the differences between SC and TSL, SC signs are also constrained by some phonotactic constraints that are followed by TSL. Specifically, the Selected Finger Constraint for handshape changes, the Revised Symmetry Condition for two-handed signs, and the One Major Area Constraint for signing locations are also obeyed by SC signs.

Our comparisons between SC and TSL show that although SC signs obey some phonological constraints for natural signs, but they clearly violate certain constraints more severely than TSL signs. These differences might also help to explain why SC signs cannot be well learned by deaf children, in addition to teachers' poor input and the linearly affixed morphological structure of SC signs.

# Chapter 7 Testing the Learnability of Signs

Results from comparisons between SC and TSL signs in Chapter 6 suggest that some structural properties of SC signs are different from TSL. Specifically, SC signs tend to use more marked handshapes than TSL signs, and marked handshapes had been shown to be disadvantageous to both deaf signers and hearing nonsigners (Grosvald, Lachaud and Corina 2012). In addition, SC signs violate the Revised Dominance Condition, the Simple Sequence Constraint, and the Narrator Perspective Principle significantly more often than TSL. These SC structural properties might also cause difficulties for learners. It is common to find SC signs in which the nondominant hand is the active hand, whereas the dominant hand is held still (i.e., they violate the Revised Dominance Condition). We also found that some SC signs require more than two hand movements (i.e., they violate the Simple Sequence Constraint), thus increase the difficulty of articulating these signs. In addition, based on how TSL borrows character signs, deaf signers prefer to convey character signs from the signer's perspective following the Narrator Perspective Principle, just as they do when describing spatial scenes, whereas SC overly adopts the viewer's perspective (i.e., violating the Narrator Perspective Principle).

Since less than 3% of SC signs violate the Simple Sequence Constraint, its effect is questionable. In this chapter, I focus on effects of the Dominance Condition and the Narrator Perspective Principle on learning difficulties. These two differences between TSL and SC signs were manipulated and tested in two experiments to see whether signs that violate these structural constraints are disadvantageous to learners.

In each experiment, a difficulty judgment task was used to test whether signs that violate the Dominance Condition or the Narrator Perspective Principle would be

judged as harder and responded to more slowly. A memory task followed to test whether signs that violate these constraints are harder to remember correctly, thus causing higher error rates.

It would be ideal to find participants who are proficient in Signed Chinese and test their online processing of signs to see whether signs with certain structural properties are difficult for processing. However, this kind of participant would be difficult to find. First, teachers at deaf schools are not necessarily proficient in Signed Chinese since they are not required to possess any level of SC skills (Hsing 2003). Studies have also shown that hearing teachers themselves are not good SC models for deaf learners to learn from because of the teachers' incomplete and inconsistent SC signing (Hsing 2000, 2003). Second, the facts that deaf learners do not learn SC very well (Lin, Huang and Hsing 2001) and also cannot comprehend SC words very well (Liu and Tseng 2007) suggest that deaf students' proficiency in SC is also questionable. Given that teachers may know nothing about signing and that even if they do sign their signing is always incomplete, it is not odd to find that deaf children's learning outcome of SC is poor. Third, SC is an artificial system that is mainly used at deaf schools and no one seems to acquire this system naturally and use it on a daily basis. Native users of SC would be difficult if not impossible to find. In order to test whether certain SC structures that are different from TSL are intrinsically difficult for novice learners to learn, I choose hearing non-signers as participants. Since hearing non-signers have no experience with any form of signing, we can test them with signs that either obey natural phonotactic constraints or do not obey these constraints, by using signs or fake signs coined obeying or violating these natural constraints. Another obvious advantage is that hearing non-signing participants are easy to find. Participants for my experiments were recruited from friends, family members, and colleagues who have no prior knowledge on TSL or SC.

Many SC character signs simultaneously violate both the Dominance Condition and the Narrator Perspective Principle due to the use of the nondominant hand for articulating movement. In order to test the effect of the Dominance Condition and the Narrator Perspective Principle separately, two kinds of signs were chosen for difficulty judgment tasks. First, type 3 non-signs (i.e., where the dominant hand moves while the nondominant hand holds still) that were not character signs were invented as the raw materials to create test materials for the difficulty judgment task for the Dominance Condition. Since the Narrator Perspective Principle is only violated by character signs, choosing non-character signs should be able to avoid this confounding factor. Second, character signs where both hands hold still were chosen as the raw materials to create test materials for the difficulty judgment task for the Narrator Perspective Principle. This type of sign always violates the Dominance Condition due to the lack of an active-passive movement pattern. Signs differ by either signed from the narrator perspective or from the viewer perspective.

Due to the nature of the visual-gestural modality of sign languages, iconicity (i.e., the visual resemblance between linguistic form and meaning) plays an important role in a wide range of linguistic behaviors, such as pronominal reference, human action representation, object representation, size and shape representation, metaphoric representation, and novel sign formation (Taub 2001; Tai 2005). Although both experiments in this section do not specifically investigate the role of iconicity for sign processing and only require participants to make responses regarding articulatory ease, the stimuli shown to participants were all visual-gestural actions, thus making the results prone to be affected by the iconicity of these visual gestures. However, while there is growing evidence showing that iconicity may also affect sign language processing (Thompson, Vinson, and Vigliocco 2009; Thompson, Vinson, and Vigliocco 2010; Baus, Carreiras and Emmorey 2013; Vinson, Thompson, Skinner, and

Vigliocco 2015), the effects of iconicity on sign processing seem to be task-specific and also participant-dependent. Specifically, facilitatory effects of iconicity were found in sign-picture matching (for deaf signers, Thompson, Vinson, and Vigliocco 2009), movement decision, picture-naming (for deaf signers, Vinson, Thompson, Skinner, and Vigliocco 2015), and translation (for hearing non-signers, Baus, Carreiras and Emmorey 2013)., but inhibitory effects of iconicity were observed for handshape decision (for deaf signers, Thompson, Vinson, and Vigliocco 2010) and translation (for deaf signers, Baus, Carreiras and Emmorey 2013), and null effects were found in lexical decision (Bosworth and Emmorey 2010).

Emmorey (2014) argued that iconicity could be viewed as a structured mapping relation between two mental representations (i.e., phonological representation and semantic representation) and effects of iconicity may only be observed when the task specifically taps into such structured mappings. Thus, the null effect of iconicity in lexical decision (Bosworth and Emmorey 2010) can be explained because lexical decision can be made on the basis of form or meaning alone without tapping the structured mapping between the sign and its semantic representation. In addition, the inhibitory effect on handshape decision (Thompson, Vinson, and Vigliocco 2010) and the facilitatory effect on movement decision (Vinson, Thompson, Skinner, and Vigliocco 2015) can also be explained. In Thompson et al. (2010), deaf signers were required to decide whether iconic and non-iconic British Sign Language (BSL) signs were produced with straight or curved handshape (a form based decision). Since the handshapes of signs do not always match curved or straight elements of the referent object or shape specification in the semantic representation, it is the inconsistent mappings between the handshape and the object's semantic representation slow the responses. In Vinson et al. (2015), deaf signers were required to decide whether iconic and non-iconic BSL signs contained an upward or downward movement (also a form

based decision). Following the definitions of Emmorey (2014), the direction of movement should be either not aligned at all (for non-iconic signs) or it should be consistently aligned with movement properties of a referent. For instance, the upward movement of the hand in the BSL sign AIRPLANE aligns with the upward motion of a plane taking off. It is the aligned structural mappings between hand movement and the referent (or its movement specification in the semantic representation) that facilitate movement direction decisions.

Emmorey's view of iconicity as structure mapping also helps to explain why effects of iconicity on sign processing were found most often for deaf signers, but not for hearing non-signers. Within a structure mapping framework of iconicity, for deaf signers who use sign language on a daily basis, the cognitive ability and relevant conceptual knowledge required to compare structural similarities between sign forms and semantic representations are readily available for them, whereas for hearing non-signers, such a cognitive ability and the relevant conceptual knowledge are not necessarily available for them. In addition, this view also helps to explain why iconicity could help adult second language learners to learn iconic signs better than non-iconic signs (Baus, Carreiras and Emmorey 2013), but the iconicity is not necessarily helpful for young children if they have not yet developed the necessary conceptual knowledge for making such iconic mappings between signs and meaning. Adult learners can make such iconic structure mappings more easily and take advantage of iconicity when learning new signs. As for children, it has been shown that iconic signs are not learned first and are not over-represented in the early vocabularies of ASL-learning children (Anderson and Reilly 2002) and young children have difficulties in recognizing iconic gestures derived from actions (Namy 2008).

Although this section focuses on the effects of the Dominance Condition and the

Narrator Perspective Principle, we need to be careful when interpreting the results, since iconicity is pervasive in natural sign languages and has been shown to have effects on sign processing. This section is organized as follows. Section 7.1 describes Experiment 1, which includes a difficulty judgment task and a memory task to test for the preference for articulating movements using the dominant hand, as constrained by the Dominance Condition. Section 7.2 describes Experiment 2, which also includes a difficulty judgment task and a memory task to test for the preference for articulating character signs from the narrators' perspective, as required by the Narrator Perspective Principle. Experimental results and possible confounds from sign iconicity are discussed in section 7.3.

## 7.1 Experiment 1: Tests for the Dominance Condition

Experiment 1 included two tasks. A difficulty judgment task was conducted first, followed by a memory task. Both tasks were designed to investigate whether violating the Dominance Condition would cause learning difficulties.

### 7.1.1 Experiment 1A: Difficulty Judgment Task for the Dominance Condition

In this task, invented two-handed non-signs were manipulated in terms of the choice of hand to move. The goal of this task was to test for a signing pattern that favors using the dominant hand (i.e., following the Dominance Condition) over using the nondominant hand in hand movements. The prediction was that signs violating the Dominance Condition should be judged as harder than those obeying the Dominance Condition. In addition, signs violating the Dominance Condition should also take longer to respond to.

Based on Emmorey's (2014) structure mapping view of iconicity, results of Experiment 1A should be unaffected by iconicity, since all test items were non-signs

without any specific meaning (i.e., iconic mappings are unavailable or impossible), and participants were asked to make judgments regarding articulatory ease based on form only.

#### 7.1.1.1 Materials and Design

Thirty two-handed fake signs where one hand moves while the other hand holds still were created to form two types of test items (i.e., Obey and Violate items, as shown in Appendix 3) and form two lists (i.e., List A and List B) of randomly ordered test items. Within each list, half of the items obey the Dominance Condition (i.e., where the dominant hand moves, as shown in Figure 73a) and the other half of the items violate it (i.e., where the nondominant hand moves, as shown in Figure 73b)[17]. Test items are counterbalanced so that items that obey the Dominance Condition for List A would violate this constraint for List B, and items that violate the Dominance Condition for List A would obey this constraint for List B.

(a) 'Obey' item (b) 'Violate' item

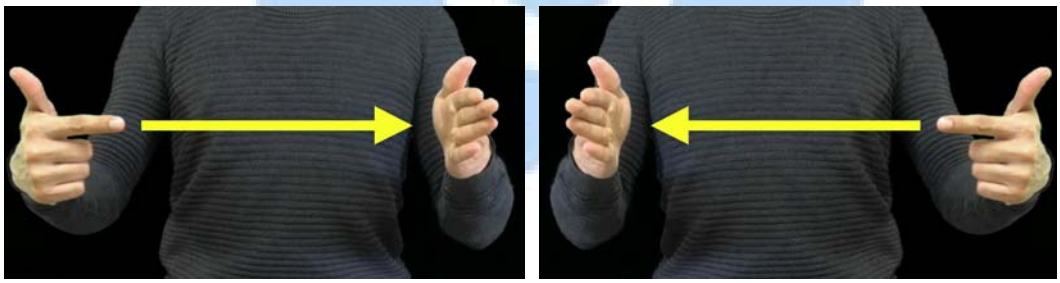


Figure 73. Sample test items

To avoid the possibility that some participants might somehow know TSL or SC signs, all test items were specifically designed so that all of them were fake signs. In addition, all test items were constructed with different handshape combinations across

[17] Note that for left-handers, Figure 70a is the Violate item and Figure 70b is the Obey item.

both hands, and the hand movements made by the active hand were all simple path movements (i.e., a straight movement, an arc movement or a circle movement).

Test items that obey the Dominance Condition (i.e., the Obey items) were performed by myself and recorded with a Sony HDR-CX700 camcorder and then edited as video clips in the mp4 format. The mean duration of all video stimuli is 2117.1 milliseconds. Since I am a right-hander, movements articulated by my nondominant hand might be slower or less smooth than my dominant hand. To avoid this problem, test items that violate the Dominance Condition (i.e., the Violate items) were created by editing their corresponding 'Obey' version into the 'Violate' version ones (by creating mirror image of the video) so that the movements in both versions would be identical except for apparent different hand choices for making movements.

In addition, as shown in Figure 72, all test videos only present the trunk area (i.e., below the neck) of my signing space. Participants can only see (or focus on) hand movements of the signs, but they cannot see my face in the videos. In so doing, we can avoid the possibility that participants might presume items that use the nondominant hand for making movement (i.e., the Violate items) as unnatural or fake, if the participants know me personally and know that I am a right-hander.

Participants were randomly divided into Group A and Group B. List A items were shown to Group A participants and List B items were shown to Group B participants. Group A had thirty participants and Group B had twenty-seven participants. Every participant saw all test signs and an equal number of obeying and violating items.

All participants were run remotely on their own computers. The task was run using Worldlikeness[18] (Chen and Myers 2016), a Web-based experiment tool that allows experimenters to design their judgment experiments and collect data like

[18] http://lngproc-4083.nitrouspro.com:3000

responses and response times. Participants can easily participate in experiments on Worldlikeness, as long as they are connected to the internet and visit experimental links on Worldlikeness. The number of Web-based experiments conducted is increasing exponentially (Birnbaum 2004; Reips 2002, 2007; Reips and Krantz 2010). The advantages of Web-based experiments include: (a) testing a large number of demographically and culturally diverse participants quickly; (b) cost savings of laboratory space, time, and administration; (c) ease of access for participants; (d) better generalizability of findings (e.g., through diverse samples with a wider distribution of demographic characteristics). Although there were concerns about data reliability due to lack of control of participants (e.g., participants' lack of focus or motivation, and reduced interaction with participants, if instructions are misunderstood), some studies have revealed that Web-based methods are qualitatively comparable to traditional methods (Krantz and Dalal 2000; Germine, Nakayama, Duchaine, Chabris, Chatterjee, and Wilmer 2012).

#### 7.1.1.2 Participants

Fifty-seven persons participated in this task. Participants ranged in age from 23 to 49 ($M$ = 36.8, $SD$ = 5.2). All participants had normal or corrected-to-normal vision and normal hearing. All but one participants are right-handers according to the handedness test[19]. Participants were unpaid volunteers, recruited from friends, family members, and colleagues who do not have any prior knowledge about TSL or SC.

#### 7.1.1.3 Procedure

Participants were first provided with a link to an illustration webpage describing specific requirements for running experiments on their computers, how the

[19] However, this left-hander did not have different response patterns from other participants.

experiments would be done, and providing with links to the tasks (as shown in Appendix 4). There are two versions of the demonstration webpages. Group A participants were provided with the A version of webpage (http://www.ccunix.ccu.edu.tw/~d96130001/listA.html) and Group B participants were provided with the B version of illustration webpage (http://www.ccunix.ccu.edu.tw/~d96130001/listB.html). Participants were instructed to sign test items themselves before making judgments. Specifically, the hand (including handshape) for making movements should exactly match the hand in the shown test items. As shown in Figure 74, the handshape and movement of the right hand of the participant should be the same as those of the right hand of the test item, which is on the left-hand side of the video (from participants' viewing perspective).

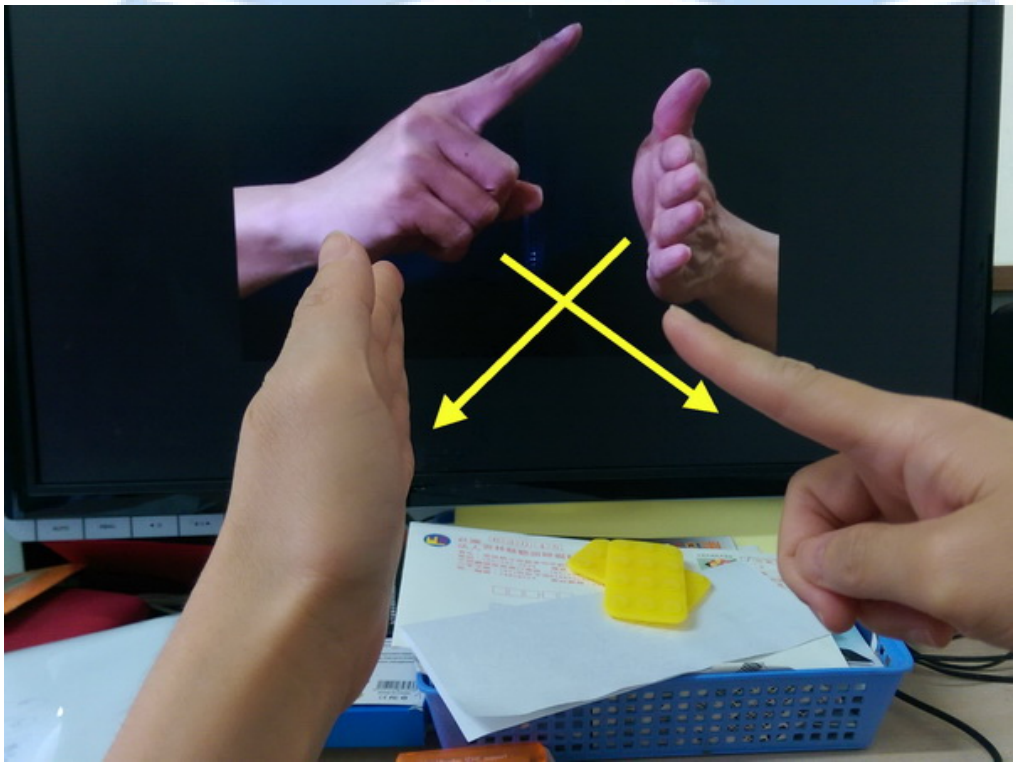


Figure 74. Picture illustrating how participants should sign

In the illustration webpage, the experimental instructions were the same, but the

page was either linked to List A items or to List B items, depending on the participant group. Before actually participating in tasks, participants were asked to do an online handedness test[20] based on Oldfield (1971) to decide their dominant hand. If the handness score is greater than zero, the dominant hand is the right hand; if the handness score is less than zero, the dominant hand is the left hand. Participants were then directed to experimental tasks that were designed on the Worldlikeness webpage.

When connecting to the task webpage on Worldlikeness, test materials for the task were preloaded on participants' computers, they would then see a webpage describing the informed consent. If they agreed to participate, they also need to decide either they want to share their response results publicly (with other researchers) or only with the experimenter. Next, they were shown a page for them to fill in some basic information like age, gender, and handedness (i.e., right-hander or left-hander). An instruction page regarding to the task was then shown to the participants. If they understood the instructions, they had to click to move on to the actual experimental task page.

In each experimental trial, participants were shown a video showing the test item, and had to repeat that sign themselves and then decide as quickly as possible whether they think this test item is easy or difficult to articulate by pressing keys on their keyboard. If they thought the test item is easy to sign, they have to press the 'L' key to respond, and if they thought the item is difficult to sign, they have to press the 'S' key to respond. Participants' responses (1 vs. 0, where 1 = easy, 0 = difficult) and reaction times (measured from the onset of the video) were recorded through Worldlikeness. Participants took approximately 2-4 minutes to complete the task.

[20] http://signer.er-webs.com/handnesstest.html

#### 7.1.1.4 Results

5 participants from Group A and 5 participants from Group B were excluded from the analyses due to their overall odd responses (either they responded before the stimulus ended or they did not respond even after the stimulus had ended for 10 s, for over half of their responses). The dropped responses occupied 25.6% of the total responses. The remaining 74.4% of response choices and log reaction times were analyzed with mixed-effects logistic regression and mixed-effects linear regression respectively in R (R Core Team 2016), with item type in effect coding (-1 vs. 1, where 1 = Obey, -1 = Violate). Mixed-effects models containing both fixed effects and random effects were built using the lme4 package (Bates, Maechler, Bolker and Walker 2015) in R. Log reaction times were rescaled into z scores if R reported a convergence problem (i.e., the estimation algorithm stopped looping before finding the best model). Likelihood ratio tests for comparing goodness of fit of two models were used to compute the *p* values for mixed-effects linear regression.

For the analysis of response choices, since the dependent variable is binary judgment (i.e., easy or difficult), a logistic regression model for analyzing binary dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 25 reports the results of a mixed-effects logistic regression model with Item Type as a fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of response choices showed that difficulty judgment was affected by Item Type ($B$ = 0.35, $SE$ = 0.15, $z$ = 2.25, $p < .05$). Specifically, signs violating the Dominance Condition were judged as harder than those obeying the Dominance Condition (as shown in Figure 75).

Table 25. *Mixed-effects Logistic Regression Model for Item Type*

| Effect | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 2.1644 | 0.2828 | 7.652 | < .0001* |
| Item Type | 0.3475 | 0.1544 | 2.250 | 0.0244 * |

*Note*. The asterisk indicates a significant effect ($p < .05$).

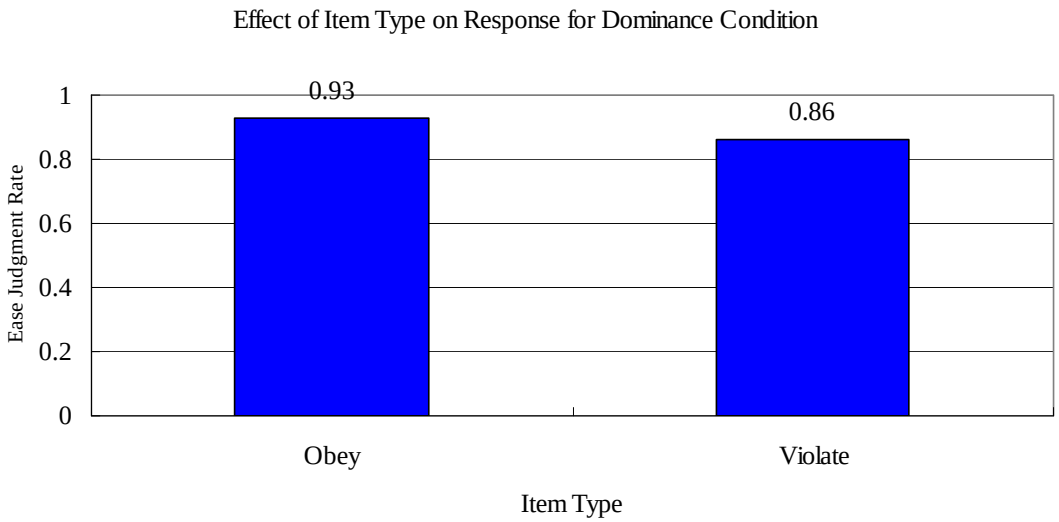



Figure 75. Effect of Item Type on Response for Dominance Condition

For the analysis of reaction times, since the dependent variable is continuous values, a linear regression model for analyzing continuous dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 26 reports the results of a mixed-effects linear regression model with Item Type as a fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of log reaction times showed that the time needed to respond was also affected by Item Type ($B$ = -0.02, $SE$ = 0.01, $t$ = -2.13, $p$ < .05). As we can see from Figure 76, signs violating the Dominance Condition were responded to more slowly than those obeying the Dominance Condition.

Table 26. *Mixed-effects Linear Regression Model for Item Type*

| Effect | *Coefficient* | *SE* | *t* | *p* |
|---|---|---|---|---|
| (Intercept) | 8.48247 | 0.03460 | 245.13 | |
| Item Type | -0.02086 | 0.00981 | -2.13 | 0.0366 * |

*Note*. The asterisk indicates a significant effect ($p < .05$). The *p* value for Item Type was computed using a likelihood ratio test.

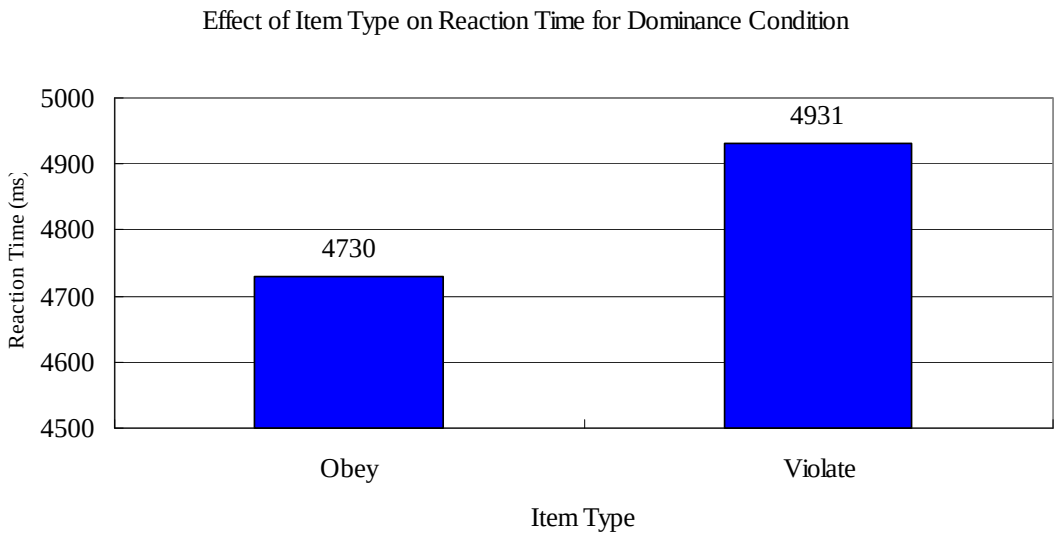



Figure 76. Effect of Item Type on Reaction Time for Dominance Condition

A mixed-effects logistic regression analysis was run with Item Type, log RT and the Item Type × log RT interaction as fixed effects and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts) to see if there is a significant interaction between Item Type and log RT. Results were reported in Table 27[21]. No interaction between Item Type and log RT was found, suggesting that participants did not differ when responding to Obey items or Violate items.

[21] Log RTs were rescaled into z scores so that the convergence problem (i.e., the coefficients are not meaningful since the estimation algorithm stopped looping before finding the best model) could be avoid.

Table 27. *Mixed-effects Logistic Regression Model for Item Type× log RT interaction*

| *N* = 1272 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 2.3360 | 0.2848 | 8.202 | < .0001* |
| Item Type | 0.3294 | 0.1670 | 1.972 | 0.0486 * |
| log RT | -0.8859 | 0.1201 | -7.377 | < .0001* |
| ItemType:logRT | 0.0305 | 0.1134 | 0.269 | 0.7880 |

*Note*. The asterisk indicates significant effects ($p < .05$).

Results from this task thus show that using the nondominant hand for making hand movements (thus violating the Dominance Condition) is disfavored, and it would thus probably cause difficulties in learning and processing.

### 7.1.2 Experiment 1B: Memory Task for the Dominance Condition

Participants from the difficulty judgment task were asked to immediately take part in the memory task. The purpose of this task was to test whether signs violating the Dominance Condition would also be harder to remember correctly. The prediction was that signs violating the Dominance Condition should be harder to remember correctly, thus causing more error responses.

Like Experiment 1A, results of Experiment 1B should be unaffected by iconicity, since all test items are also non-signs without any specific meaning (i.e., iconic mappings are unavailable), and participants were asked to make recalls based on form only.

#### 7.1.2.1 Materials and Design

In this task, 20 test items were chosen from signs used in the previous difficulty judgment task. 10 items (5 Obey items and 5 Violate items) from List A and 10 items

(5 Obey items and 5 Violate items) from List B were chosen to form a list of 20 test items for the memory task. Test items were randomly shown to participants.

#### 7.1.2.2 Participants

Some participants failed to link to the memory task page on Worldlikeness when trying to participate in the task for unknown technical reasons. A total of forty-seven participants (including the ten participants that were excluded for further analyses in section 7.1.1.4, as long as their response patterns were not odd in the memory task) from the previous difficulty judgment task participated in the memory task. All but one participant are right-handers according to the handedness test. Participants ranged in age from 23 to 44 ($M$ = 36.7, $SD$ = 5.1).

#### 7.1.2.3 Procedure

The task was run using Worldlikeness. After reading the informed consent and filling in some basic personal information, participants were shown an instruction page regarding the memory task and then began the memory task. In each experimental trial, participants were shown a video of the test item, and had to decide as quickly as possible whether they had seen the test item in the previous judgment task by pressing keys on their keyboard. If they thought they saw the same sign from the previous difficulty judgment task, they had to press the 'L' key to respond, and if they thought they never saw the sign from the previous difficulty judgment task, they had to press the 'S' key to respond. Participants' responses were recorded through Worldlikeness. Participants took approximately 1-2 minutes to complete the task.

#### 7.1.2.4 Results

Since this task only required participants to judge whether they saw the test items

from the previous difficulty judgment task, it is possible to respond before the test item video ends (since sign recognition could occur rather quickly, long before they saw the whole sign (Emmorey and Corina 1990)). Thus, only responses that took longer than 10 s (1.81% of all responses) were excluded from the analyses. Response choices were analyzed with a mixed-effects logistic regression in R.

For the analysis of response choices, since the dependent variable is binary data (i.e., correct or incorrect), a logistic regression model for analyzing binary dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 28 reports the results of a mixed-effects logistic regression model with Item Type as a fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of response choices showed that memory accuracy was not affected by Item Type ($B$ = 0.01, $SE$ = 0.14, $z$ = 0.08, $p$ > .05), suggesting that signs violating the Dominance Condition were not harder to remember than those obeying the Dominance Condition. In fact, the average accuracy rate for both types of item is about 52% (as shown in Figure 77), which is very close to the chance level. Participants might be just randomly guessing by chance in the memory task. It seems that participants have trouble in remembering the specific dominant/nondominant distinction within such a short period of time.

Table 28. *Mixed-effects Logistic Regression Model for Item Type*

| $N$ = 923 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 0.05877 | 0.10462 | 0.562 | 0.574 |
| Item Type | 0.01079 | 0.13954 | 0.077 | 0.938 |

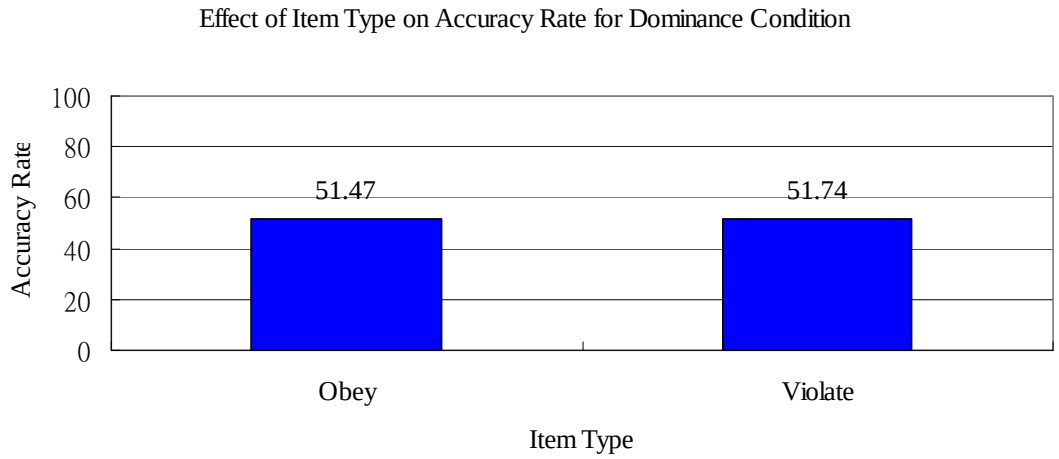



Figure 77. Effect of Item Type on Accuracy Rate for Dominance Condition

However, since I did not include control items or filler items that were not in either List A or List B to see if participants remember (any) learned items, the interpretation of the recall accuracy results might be questionable. One possibility is that participants did remember the old items, and they might have been more accurate in accepting old items as familiar than they were in rejecting new items as unfamiliar. In addition, participants might be more accurate in accepting Obey items as familiar than they might be in rejecting Violate items as unfamiliar only for old items, but showed no such difference for new items. Another mixed-effects logistic regression analysis was run with Item Type, Newness (effect coding: -1 vs. 1, where 1 = New, -1 = Old) and the Item Type × Newness interaction as fixed effects and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts) to see if there is a significant interaction between Item Type and Newness. Results were reported in Table 29. However, only a main effect of Newness was found ($B$ = -0.78, $SE$ = 0.07, $t$ = -10.59, $p$ < .0001). In general, participants were more accurate in accepting Old items as familiar than they were in rejecting New items as unfamiliar. However, as shown in Figure 77, for both Old and New items, participants' accuracy rates were not different between Obey items and Violate items, suggesting that

participants did not differ when responding to Obey items or Violate items.

Table 29. *Mixed-effects Logistic Regression Model for Item Type×Newness interaction*

| *N* = 923 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 0.069900 | 0.089045 | 0.785 | 0.432 |
| Item Type | -0.006353 | 0.086988 | -0.073 | 0.942 |
| Newness | -0.777534 | 0.073406 | -10.592 | < .0001* |
| Item Type:Newness | 0.091557 | 0.072895 | 1.256 | 0.209 |

*Note*. The asterisk indicates a significant effect ($p < .05$).

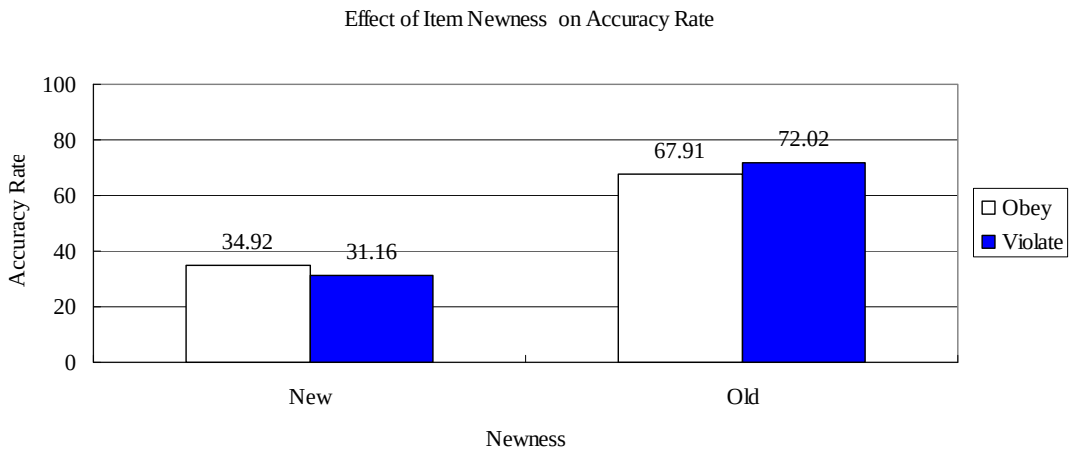



Figure 78. Effect of Newness on Accuracy Rate for Dominance Condition

Results from the judgment task show that signs that violate the Dominance Condition were judged as harder to articulate than signs that obey the Dominance Condition. In addition, participants were also slower to respond to signs that violate the Dominance Condition than signs that obey the Dominance Condition. Although results from the memory task show that participants were more accurate in accepting Old items as familiar than they were in rejecting New items as unfamiliar, there was no significant difference in participants' recall accuracy between Obey items and

Violate items (for both new and old items). In sum, our results from the judgment task still provide some evidence that it is articulatorily difficult to use the nondominant hand for making hand movements in a two-handed sign.

## 7.2 Experiment 2: Tests for the Narrator Perspective Principle

Experiment 2 also included two tasks. A difficulty judgment task was conducted first, followed by a memory task. Both tasks were designed to investigate whether violating the Narrator Perspective Principle would cause learning difficulties.

### 7.2.1 Experiment 2A: Difficulty Judgment Task for the Narrator Perspective Principle

In this task, character signs were manipulated in terms of the perspective of signing. The goal of this task was to test for a signing pattern that favors choosing the producer's perspective over the viewer's perspective to represent character signs. Participants were told that the signs represent Chinese characters. The prediction was that, if the Narrator Perspective Principle is a natural constraint not just for signing at the sentence level, signs that violate Narrator Perspective Principle should be rated as harder than those obeying it. In addition, signs violating the Narrator Perspective Principle should also take longer to respond to.

Based on Emmorey's (2014) structure mapping view of iconicity, results of Experiment 2A might be affected by iconicity, since all test items are character signs that configure the handshapes to mimic the shape of Chinese characters as iconic as possible (i.e., iconic mappings are possible).

#### 7.2.1.1 Materials and Design

28 Chinese characters were chosen for this task. The corresponding 28 two-handed character signs (15 real character signs and 13 invented character signs,

as shown in Appendix 5) where both hands hold still were chosen or invented to form two types of test items and form two lists (i.e., List A and List B) of randomly ordered test items. Within each list, half of the items obey the Narrator Perspective Principle (as shown in Figure 79a) and the other half of the items violate it (as shown in Figure 79b). Test items were counterbalanced so that items that obey the Narrator Perspective Principle for List A would violate this principle for List B, and items that violate the Narrator Perspective Principle for List A would obey this principle for List B.

(a) 'Obey' item (b) 'Violate' item

Figure 79. Sample test item '仙'

Test items that obey the Narrator Perspective Principle (i.e., the Obey items) were performed by myself and recorded with a Sony HDR-CX700 camcorder and then edited as video clips in the mp4 format. Each video clip shows a Chinese character for two seconds and then shows a still picture of a character sign for another two seconds. The total duration of each video clip for this task was thus 4 s. Test items that violate the Narrator Perspective Principle were created by editing their corresponding 'Obey' version of videos into the 'Violate' version (by creating mirror image of the video), so that the character signs in both versions would be identical except for different perspective choices for depicting character signs.

In addition, as shown in Figure 78, all test videos only present the trunk area (i.e.,

below the neck) of my signing space. Participants could only see (or focus on) my hands, but they could not see my face in the videos. In so doing, we can avoid the possibility that participants might presume that items that adopt the viewer perspective for depicting Chinese characters (i.e., the Violate items) as unnatural, if the participants know me personally and know that I am a right-hander.

Participants were randomly divided into Group A and Group B. List A items were randomly shown to Group A participants and List B items were randomly shown to Group B participants. Group A had twenty-two participants and Group B had twenty-one participants. Every participant saw all test signs and an equal number of obeying and violating items.

#### 7.2.1.2 Participants

Participants from Experiment 1 were also invited to participate in Experiment 2. However, due to unknown technical reasons, some participants failed to participate in this experiment. A total of forty-three persons participated in this task. Participants ranged in age from 23 to 49 ($M$ = 36.8, $SD$ = 5.7). All participants had normal or corrected-to-normal vision and normal hearing. All but one participants are right-handers according to the handedness test. Participants were unpaid volunteers, recruited from friends, family members, and colleagues who do not have any prior knowledge about TSL or SC.

#### 7.2.1.3 Procedure

The task was run using Worldlikeness. In each experimental trial, participants were first shown a video showing a Chinese character for 2 seconds first, followed by a video showing the still image of the character sign for 2 seconds, and they had to repeat that character sign themselves and decide as quickly as possible whether they

think this test item is easy or difficult to articulate by pressing keys on their keyboard. If they thought the test item is easy to sign, they had to press the 'L' key to respond, and if they thought the item is difficult, they had to press the 'S' key to respond. Participants' responses and reaction times (measured from the onset of the video) were recorded through Worldlikeness. Participants took approximately 3-5 minutes to complete the task.

#### 7.2.1.4 Results

Responses that were too fast (i.e., respond before the stimulus ends) or too slow (i.e., no response even after the stimulus has ended for 10 s) were excluded from the analyses. The dropped responses consisted 10% of the total responses. The remaining 90% of response choices and log reaction times were analyzed with mixed-effects logistic regression and mixed-effects linear regression respectively, with item type in effect coding (-1 vs. 1, where 1 = Obey, -1 = Violate). Log reaction times were rescaled into z scores if R reported a convergence problem.

For the binary judgment (i.e., easy or difficult) data, a logistic regression model for analyzing binary dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 30 reports the results of a mixed-effects logistic regression model with Item Type as a fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of response choices showed that difficulty judgment was not affected by Item Type ($B$ = 0.15, $SE$ = 0.13, $z$ = 1.21, $p > .05$), suggesting that character signs violating the Narrator Perspective Principle were not judged to be harder to articulate than those obeying it (as shown in Figure 80). Thus, participants seemed to accept both types of character signs equally, and neither of them was thought to be harder to articulate.

Table 30. *Mixed-effects Logistic Regression Model for Item Type*

| *N* = 1161 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 1.9725 | 0.2758 | 7.151 | < .0001* |
| Item Type | 0.1508 | 0.1252 | 1.205 | 0.228 |

*Note*. The asterisk indicates a significant effect ($p < .05$).

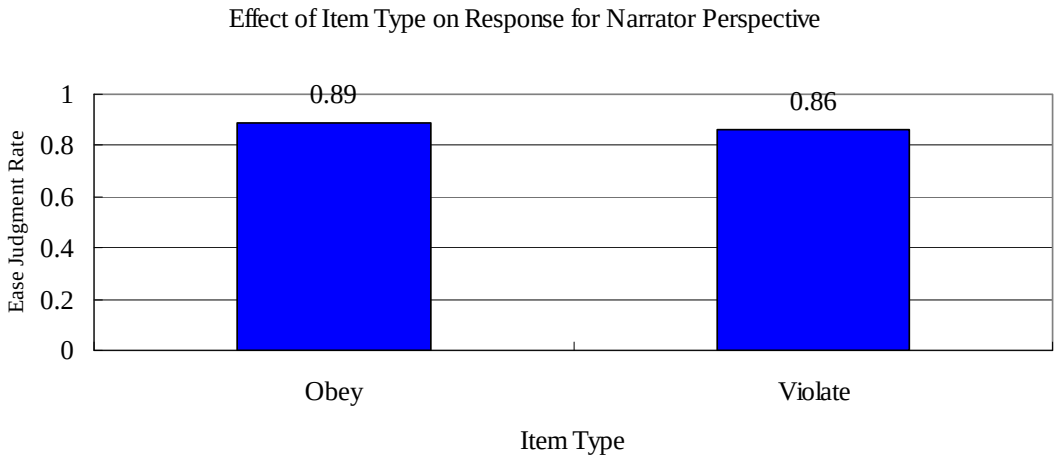



Figure 80. Effect of Item Type on Response for Narrator Perspective Principle

Results from the judgment task suggest that participants thought that both types of character signs are equally fine, but did they respond to them equally fast? For the analysis of reaction times, a linear regression model for analyzing continuous dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 31 reports the results of a mixed-effects linear regression model with Item Type as fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of log reaction times showed that the time needed to respond was affected by Item Type ($B = 0.02$, $SE = 0.01$, $t = 2.25$, $p < .05$). Nevertheless, the pattern is contrary to our prediction. Specifically, character signs violating the Narrator Perspective Principle were responded more quickly than those obeying it (292 ms faster, as shown in Figure 81).

Thus, participants were faster to make responses to character signs that are signed from the viewer perspective.

Table 31. *Mixed-effects Linear Regression Model for Item Type*

| *N* = 1161 | *Coefficient* | *SE* | *t* | *p* |
|---|---|---|---|---|
| (Intercept) | 8.856913 | 0.035872 | 246.90 | |
| Item Type | 0.019723 | 0.008777 | 2.25 | 0.02531 * |

*Note*. The asterisk indicates a significant effect ($p < .05$). The *p* value for Item Type was computed using a likelihood ratio test.

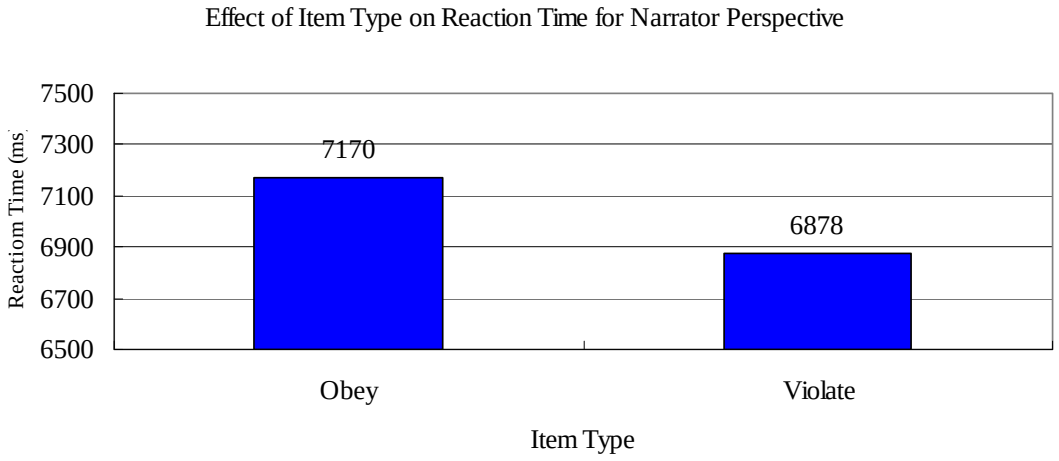



Figure 81. Effect of Item Type on Reaction Time for Narrator Perspective Principle

Another mixed-effects logistic regression analysis was run with Item Type, log RT and the Item Type × log RT interaction as fixed effects and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts) to see if there is any interaction between Item Type and log RT. Results were reported in Table 32[22]. Only a marginally significant Item Type × log

[22] Log RTs were rescaled into z scores so that the convergence problem (i.e., the estimation algorithm stopped looping before finding the best model) could be avoided.

RT interaction was found ($B$ = -0.19, $SE$ = 0.10, z = -1.9, $p$ = 0.057, > .05). As we can see from Figure 82, it seems that faster responses show stronger pro-narrator perspective and slower responses show stronger pro-viewer perspective (though not significant).

Table 32. *Mixed-effects Logistic Regression Model for Item Type× log RT interaction*

| *N* = 1161 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 2.1057 | 0.3121 | 6.746 | < .0001* |
| Item Type | 0.2445 | 0.1360 | 1.797 | 0.0723 |
| log RT | -0.6441 | 0.1196 | -5.385 | < .0001* |
| Item Type:log RT | -0.1956 | 0.1022 | -1.914 | 0.0557 |

*Note*. The asterisk indicates a significant effect ($p$ < .05).

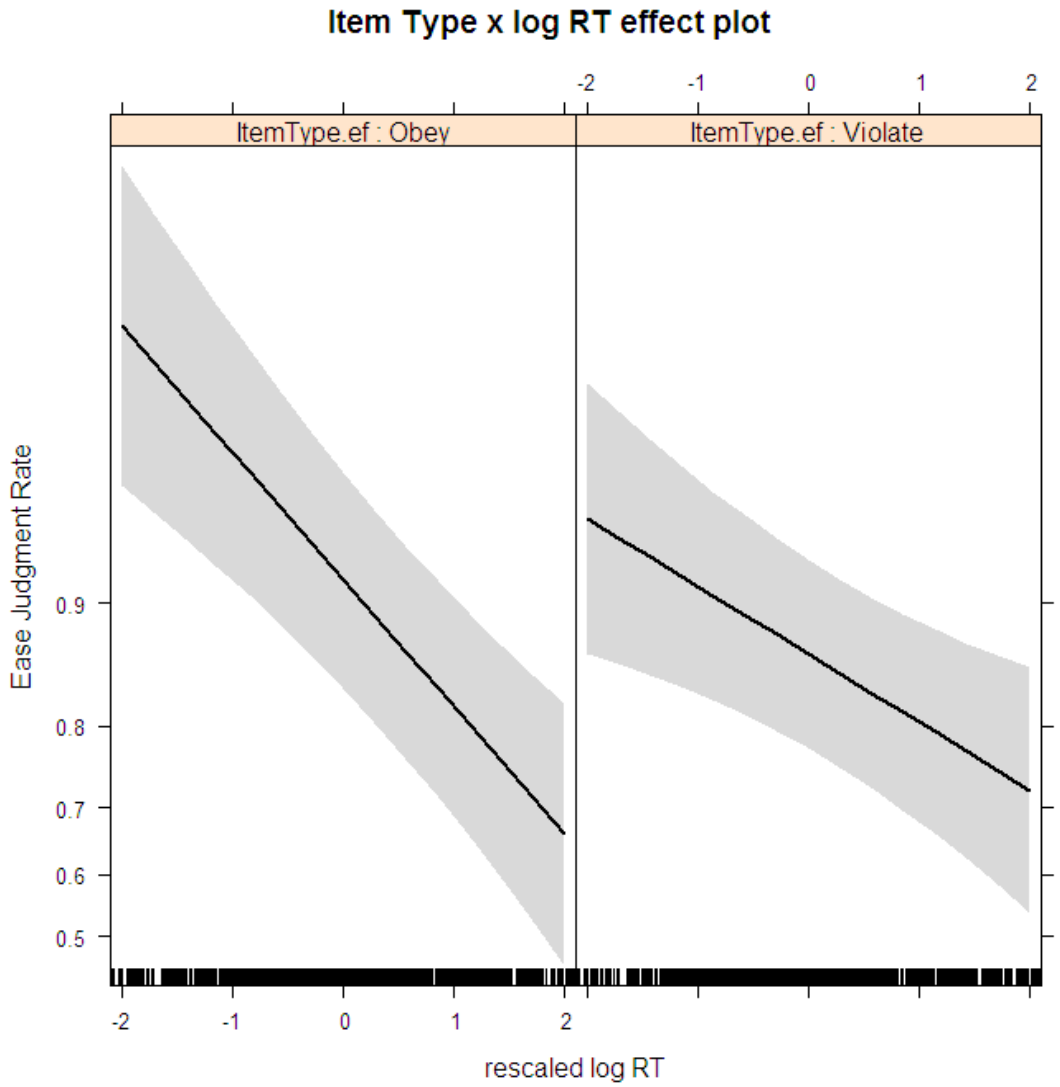



Figure 82. Effect plot for Item Type × log RT interaction

Results from this task suggest that representing a character sign from the narrator's perspective is not necessarily the more natural or easier way of doing it. Instead, participants were quicker to respond when items were shown to them from the viewer's perspective. In this case, participants respond as if they are looking at Chinese characters (in a signed form).

### 7.2.2 Experiment 2B: Memory Task for the Narrator Perspective Principle

Participants from the difficulty judgment task were asked to immediately take

part in the memory task. The purpose of this task was to test whether signs violating the Narrator Perspective Principle would be harder to remember correctly. The prediction was that signs violating the Narrator Perspective Principle should be harder to remember correctly, thus causing more error responses.

Like Experiment 2A, results of Experiment 2B might be affected by iconicity, since all test items are character signs with iconic mapping relation to Chinese characters (i.e., iconic mappings are possible).

#### 7.2.2.1 Materials and Design

In this task, 20 test items were chosen from test items that are used in the difficulty judgment task of Experiment 2. Specifically, 10 items (5 Obey items and 5 Violate items) from List A and 10 items (5 Obey items and 5 Violate items) from List B were chosen to form a list of 20 test items for the memory task. These test items were randomly shown to participants.

#### 7.2.2.2 Participants

Forty participants from the difficulty judgment task participated in the memory task (three participants failed to link to the memory task page). All but one participants are right-handers. Participants ranged in age from 23 to 44 ($M$ = 36.7, $SD$ = 5.5).

#### 7.2.2.3 Procedure

The procedure was the same as earlier memory task in section 7.1.2. Participants' responses were recorded through Worldlikeness. Participants took approximately 1-2 minutes to complete the task.

#### 7.2.2.4 Results

Responses that took longer than 10 seconds (2.25% of the total responses) were excluded from the analyses. Response choices were analyzed with a mixed-effects logistic regression, with item type in effect coding.

For the analysis of binary data (i.e., correct or incorrect), a logistic regression model for analyzing binary dependent variables is chosen for modeling (Baayen 2008; Gries 2013). Table 33 reports the results of a mixed-effects logistic regression model with Item Type as fixed effect and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts). An analysis of response choices showed that memory accuracy was not affected by Item Type ($B$ = -0.09, $SE$ = 0.07, $z$ = -1.29, $p$ > .05), suggesting that signs violating the Narrator Perspective Principle were not harder to remember than those obeying the Narrator Perspective Principle. As shown in Figure 83, the average accuracy rate for Obey items is 49.9% and the average accuracy rate for Violate items is 54.5%. Thus, the accuracy rates for both types of item are also about 50%. Participants seemed to be guessing again in the memory task. We can see that participants also have trouble in remembering the specific narrator/viewer distinction within such a short period of time.

Table 33. *Mixed-effects Logistic Regression Model for Item Type*

| $N$ = 782 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 0.08720 | 0.07166 | 1.217 | 0.224 |
| Item Type | -0.09231 | 0.07166 | -1.288 | 0.198 |

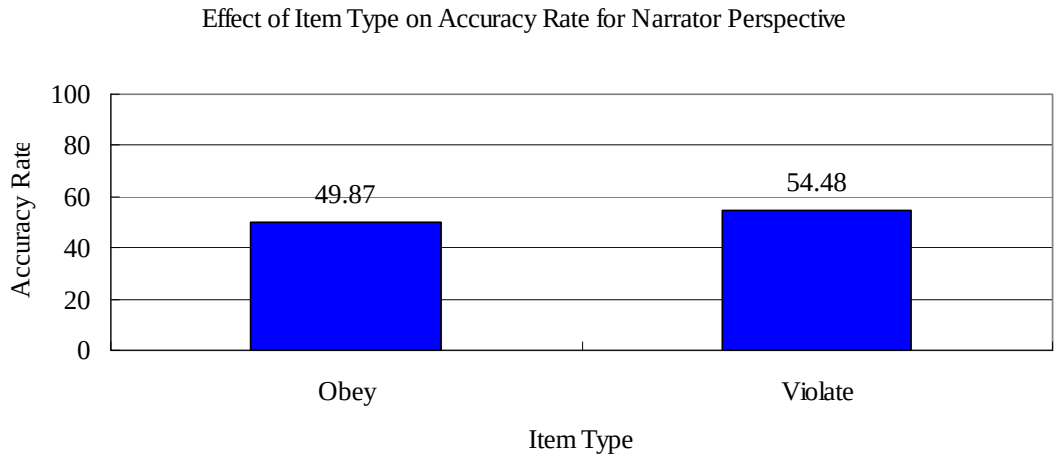



Figure 83. Effect of Item Type on Accuracy Rate for Narrator Perspective Principle

However, as in Experiment 1B, since I did not include control items that were not in either List A or List B to see if participants remember (any) learned items, the interpretation of the recall accuracy results is also questionable. Thus, as in Experiment 1B, participants might be more accurate in accepting old items as familiar than they might be in rejecting new items as unfamiliar. In addition, participants might be more accurate in accepting Obey items as familiar than they might be in rejecting Violate items as unfamiliar only for old items, but showed no such difference for new items. Another mixed-effects logistic regression analysis was run with Item Type, Newness (effect coding: -1 vs. 1, where 1 = New, -1 = Old) and the Item Type × Newness interaction as fixed effects and Participant and Item as random effects (by-participant random slopes and random intercepts and by-item random intercepts) to see if there is a significant interaction between Item Type and Newness. Results were reported in Table 34. Only a main effect of Newness was found ($B$ = -1.12, $SE$ = 0.08, $z$ = -13.46, $p$ < .0001), participants were more accurate in accepting Old items as familiar than they were in rejecting New items as unfamiliar. However, as shown in Figure 82, for both old and new items, participants' recall accuracy rates were not different between Obey

items and Violate items, suggesting that participants did not differ when responding to Obey items or Violate items.

Table 34. *Mixed-effects Logistic Regression Model for Item Type×Newness interaction*

| *N* = 782 | *Coefficient* | *SE* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 0.11486 | 0.08351 | 1.375 | 0.169 |
| Item Type | -0.12561 | 0.08351 | -1.504 | 0.133 |
| Newness | -1.12373 | 0.08351 | -13.457 | < .0001* |
| Item Type:Newness | -0.04082 | 0.08351 | -0.489 | 0.625 |

*Note*. The asterisk indicates a significant effect ($p < .05$).

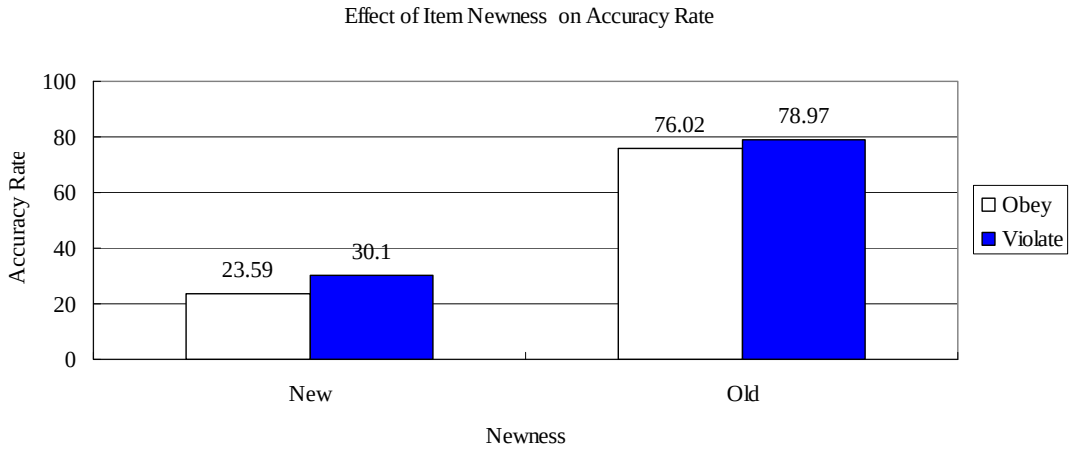



Figure 84. Effect of Newness on Accuracy Rate for Narrator Perspective Principle

Results from the judgment task show that signs that violate the Narrator Perspective Principle were not judged as harder to articulate than signs that obey the Narrator Perspective Principle. In addition, participants were slower to respond to signs that obey the Narrator Perspective Principle than signs that violate the Narrator Perspective Principle. However, the unexpected results might not be the effect of

signing perspective per se. Instead, the highly iconic relation between character signs (when presented from the viewer's perspective) and Chinese characters might be a confounding factor influencing participants' processing of character signs. Results from the memory task also show that participants' recall accuracy between Obey items and Violate items were not significantly different (for both new and old items), even though they were more accurate in accepting Old items as familiar than they were in rejecting New items as unfamiliar. On the whole, results from Experiment 2 suggest that signing character signs from the narrator's perspective might not necessarily be a more natural or preferred way of signing Chinese characters.

### 7.3 Discussion

The results from Experiment 1 provide some evidence that for two-handed signs with an active-passive pattern, it is indeed a natural tendency to use the dominant hand for making hand movements (Battison 1978). Specifically, signs that violate the Dominance Condition were judged as harder to articulate than signs that obey the Dominance Condition. Participants were also slower to respond to signs that violate this constraint. Moreover, results from Experiment 1 should be unaffected by iconicity, since signs used for this experiment are all non-signs without any meaning or referent, thus iconic mappings between signs and meaning (or referent) would be impossible. Therefore, the results we found here should be an indication that signs violating the Dominance Condition are articulatorily difficult for learners. If SC signs often violate this natural tendency for signing, deaf learners might find SC signs difficult to learn and use.

However, we cannot find a difference in learners' preference regarding how Chinese characters should be signed in Experiment 2. Moreover, hearing nonsigners were quicker to respond when they saw a character sign articulated from their viewing

perspective, as if they were reading Chinese characters. One possible reason for why this was the case is that iconicity comes into play when participants tried to learn character signs that are signed from the viewer perspective. Specifically, since hearing participants are already quite familiar with Chinese characters, and thus when the form of a character sign matches closely to the Chinese character they usually saw (i.e., signed from the viewer perspective, as shown in Figure 85), they can learn or recognize the character sign more quickly and then proceed to imitate the sign themselves, as required by the task. Since character signs articulated from the viewer perspective are very iconic to the Chinese characters they represented, the iconic mappings between signs and Chinese characters might speed up the process for sign recognition. Thus, the reaction time results might be confounded by the iconicity of character signs.

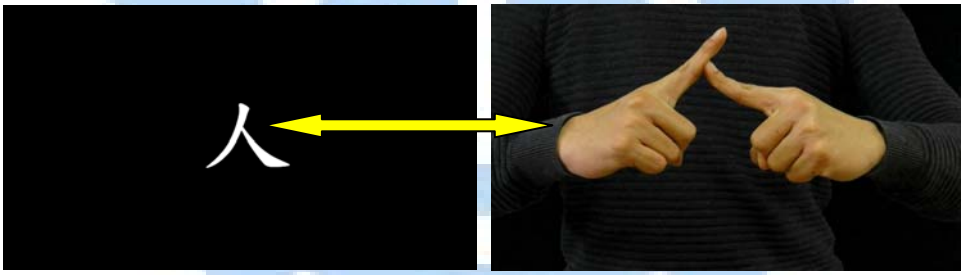



Figure 85. Iconic mappings between Chinese character and character sign (viewer's perspective)

However, character signs in natural TSL are also iconic from the signer's viewing perspective (but shown from the viewer's viewing perspective in the books). Note that the Chinese Sign Language dictionary shows '人' iconically from the signer's viewing perspective (Figure 43b). A future experiment manipulating the signing perspective (i.e., signed from the signer's perspective or from the viewer's perspective) and shown perspective (i.e., shown from the signer's viewing perspective

or from the viewer's viewing perspective) in the stimuli might help to clarify how the iconic relation between characters and signs affects learning or processing.

The lack of a preference for how to represent Chinese characters manually might be due to the hearing nonsigners' lack of experience in signing. The need to configure the fingers of both hands in a certain way to represent a Chinese character, either from the narrator's perspective or from the viewer's perspective, could be equally difficult for nonsigners. TSL signers' strong preference in signing character signs from the narrator's perspective might be influenced by their signing experience when describing spatial scenes. The difference in preferences between deaf and hearing nonsigners suggests that the Narrator Perspective Principle might not be as natural a constraint as the other phonotactic constraints we discussed in Chapter 5, or that it only applies to spatial descriptions at the sentence level, as originally shown by Emmorey et al. (1998). Since participants in our study were all nonsigners who had no experience in signing at all, it is thus questionable whether they would also prefer signing from the narrator perspective. On the whole, this experiment showed that the tendency to describe spatial scenes from the narrator's perspective was not also adopted by nonsigners to articulate character signs.

As for the memory tasks for both constraints, although participants were more accurate in accepting Old items as familiar than they were in rejecting New items as unfamiliar, their recall accuracy for Obey items was not higher than that for Violate items, suggesting that remembering detailed specifications about which hand should move or how hands should be positioned to represent Chinese characters might be too difficult for novice learners, or that these specifications are phonotactic constraints for sign production only, but are not necessary for sign recognition due to the No Left/Right Specificity principle. Another reason might be that since half of the test items obey the constraint and the other half violate the constraint, participants become

confused when trying to memorize signs they just learned.

The experiments reported in this chapter tested two phonotactic constraints that are violated significantly more often by SC signs. Results from Experiment 1 show that it is better to sign two-handed signs using the dominant hand for making hand movement, since this way of signing is not only consistently attested in the TSL lexicon (as shown in section 6.1.3), but also preferred and processed faster by hearing nonsigners (as proven in Experiment 1), suggesting that using the dominant hand for making movements is a natural way of signing two-handed signs. This might help to explain why certain SC signs are difficult for deaf learners. Although we did not find evidence to support that character signs are better signed from the narrator perspective, we should note that character signs in SC do not just violate the Narrator Perspective Principle alone. Specifically, character signs in SC often simultaneously violate the Dominance Condition (in addition to the Narrator Perspective Principle), since SC character signs often use the nondominant hand for making movements, which is proven to be difficult for novice learners. For instance, the character sign '企' ('ENTERPRISE', shown in Figure 86) is not only signed from the viewer perspective, but it also uses the nondominant hand to depict the four strokes of the '止' radical. Thus, SC character signs are still articulatorily difficult for novice learners, at least due to the use of the nondominant hand for tracing Chinese characters.

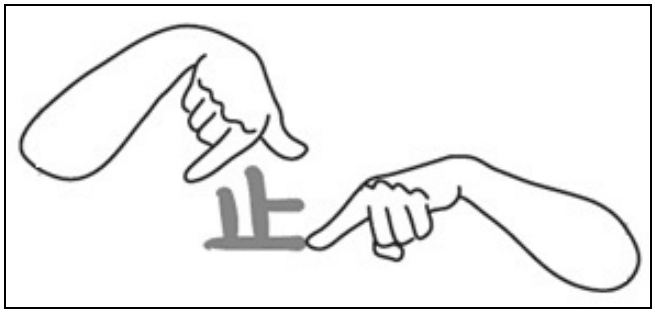



Figure 86. SC character sign 'ENTERPRISE' that violates both Narrator Perspective

and Dominance Condition (Ministry of Education, p. 64)

Finally, since all tasks were run remotely using Worldlikeness, this study demonstrates that it is possible to collect judgment data on well-formedness of signs online, though some participants were excluded from analyses because they did not completely follow our instructions or did not respond fast enough.

# Chapter 8 Conclusions

This chapter summarizes findings of this thesis in section 8.1, and provides some suggestions for improving learnability and acceptability of the SC lexicon in section 8.2. Implications for deaf education are discussed in section 8.3.

## 8.1 Summary of Findings

My analyses of the devising principles of the 2008 SC dictionary (Ministry of Education 2008) showed that only about 35% of its lexical items was directly adopted from TSL. Most SC signs were constructed by either concatenating two or more TSL signs following Chinese morphology (e.g., the SC sign for '蛋糕' ('CAKE'), as shown before in Figure 13), or by inventing new signs that are different from TSL (e.g., the SC sign for '了解' ('UNDERSTAND'), as shown before in Figure 19b). Thus, SC signs are not as 'natural' as the Ministry of Education claims.

Comparisons of handshape, location and movement patterns between SC and TSL signs suggest that SC signs are phonologically different from TSL signs not only in their handshape distribution but also in how well SC signs follow the Revised Dominance Condition, Simple Sequence Constraint and the Narrator Perspective Principle that hold for TSL signs. First, by adopting Eccarius and Brentari's (2007) featural model, I showed that SC signs use marked handshapes more often than TSL signs. Since marked handshapes are structurally more complex (Brentari 1998), physiologically more difficult to articulate (Ann 1993, 1996, 2005, 2006), and also more difficult for processing (Grosvald, Lachaud and Corina 2012), the fact that SC signs tend to use marked handshapes might make them difficult for learners.

Second, two-handed SC signs violate the Revised Dominance Condition

(Eccarius and Brentari 2007) more frequently than TSL. One major source of these violations is character signs in SC, which often use the nondominant hand for making movements. Results of Experiment 1 confirmed that the Dominance Condition is a natural constraint that should be followed, even for non-signers, since it is more natural and easier to use the dominant hand for making hand movements. This is evidenced by participants' positive and faster judgments for signs that use the dominant hand for articulating hand movements. The fact that SC signs often adopt the nondominant hand for making hand movements could certainly make learners find them difficult to learn and sign.

Third, SC signs do not seem to have an upper limit on how many hand movements a sign can contain. Almost all TSL signs are constrained to have a maximum of two hand movements, and thus obey the Simple Sequence Constraint. I found that some SC signs can contain up to five hand movements (e.g., the SC sign '凹' ('CONCAVE'), as shown before in Figure 62c). Since signs are articulated more slowly than spoken utterances (Bellugi and Fischer 1972), linear sequences of multiple movements are not favored by deaf signers (Supalla 1990). Signing with multiple movements is certainly more laborious than signing with simple movements.

Fourth, SC also differs from TSL in how it constructs a character sign. Specifically, SC not only uses character signs more often than TSL, but its construction of character signs always violates the Narrator Perspective Principle. The representation of character signs in SC might impose a higher articulatory demand due to its marked use of the nondominant hand. In SC signs, the nondominant hand is often required to depict portions of Chinese characters and to make multiple hand movements. Nevertheless, the Narrator Perspective Principle might not be as natural a constraint as other phonotactic constraints. Judgment results from Experiment 2 showed that novice learners do not prefer character signs obeying the Narrator

Perspective Principle over those violating the Narrator Perspective Principle. In addition, learners were quicker to respond when the test item is signed from the viewer's perspective (though this facilitatory effect might be confounded by the iconic mappings between Chinese characters and character signs). Participants' quicker responses might be attributed to their daily experience of reading Chinese characters and their lack of signing experience.

Finally, although SC signs are artificially designed, they are still constrained by many phonological constraints that are obeyed by natural signs. Specifically, the Selected Finger Constraint, the Symmetry Condition, and the One Major Area Constraint are equally obeyed by SC and TSL signs, suggesting that these constraints might be universal (possibly due to articulatory ease) and are obeyed even by SC invertors who are unaware of these natural constraints.

In sum, this thesis provide some evidence showing that SC signs are designed in a way that violates certain natural phonological constraints for signing and thus might be difficult for learners to learn or process due to phonological complexities.

### 8.2 Suggestions for SC Designers

As described in Chapter 3, SC borrows increasingly more TSL signs into its lexicon, but why not just take TSL as the major metalanguage for teaching deaf students Chinese? Studies have shown that deaf children's English ability can benefit from their ASL fluency (Strong and Prinz 1997; Hrastinski and Wilbur 2016). Although most deaf children in Taiwan are not exposed to TSL before schooling, they seem to pick up this natural language quite easily from their peers. Liu et al. (2006) have shown that students can understand TSL better than Signed Chinese. More importantly, Chapter 4 has shown that teaching in SC does not succeed in improving Chinese literacy. The assumption of the proponents of SC is that by signing words in a

way that conforms to Chinese grammar, deaf children would be able to pick up Chinese grammar from manually coded Chinese. However, as pointed out by Chang (2014), it is questionable that we can improve our English ability by producing Chinese words following the grammar of English (i.e., an artificial Chinese that is expressed following English word order). If we do not believe or think that artificial Chinese is beneficial for learning English, why should we believe that Signed Chinese can help improving deaf children's Chinese literacy, especially when no evidence supports this assumption?

The failure of SC in improving Chinese literacy can be attributed to several factors. First, good SC language models for deaf children to learn this system are hard to find. In addition, teachers often do not use SC signs to match their spoken utterances perfectly, leaving out many important messages in their signing at the sentence level. Second, at the morphological level, the one character per sign strategy slows down the speed of signing (Myers, Tsay and Su 2011), and has been proven to be disadvantageous to the processing of concatenated words (Liu and Tseng 2007; Liu, Tseng and Liu 2009). Third, at the phonological level, this thesis showed that the sign-internal phonological patterns of SC signs violate some phonotactic constraints that hold true for TSL and are thus difficult for signers to process and learn. This study informs us not only about SC's phonological patterns but also about how well it follows phonotactic constraints. If SC signs are not designed following these constraints, signers might find the SC lexicon difficult (i.e., unnatural) to learn.

From the discussions above, though we can see that SC cannot function as an entirely learnable sign system, it has nevertheless helped TSL users to expand their signing lexicon by adopting some invented SC signs into TSL (Chao 1998). So Signed Chinese is not completely useless for TSL signers.

Several suggestions are offered below for SC inventors and proponents to

improve the acceptability and learnability of the SC lexicon.

First, SC inventors should study and collect TSL signs first, and adopt as much TSL as possible in the SC dictionary. Our survey showed that 35% of SC signs was directly borrowed from TSL signs, but why not accept all TSL signs and only invent new signs when there is no TSL equivalent sign for that term?

Second, if a new sign is needed, it should be designed in a way that conforms to TSL grammar and phonological constraints that are obeyed by natural signs. In so doing, newly invented signs would be more acceptable and also easier for learners to learn. For instance, the SC sign for the character '巨' ('GIANT', as shown in Figure 87a) is signed from the viewer's perspective, but I observed that this sign has been adopted by many TSL signers who sign it from the narrator's perspective (as shown in Figure 87b). In another case, the character sign '價' ('PRICE') is not only signed from the viewer's perspective, but it also uses the nondominant hand for hand movements (i.e., it violates the Dominance Condition, as shown in Figure 88a). Many TSL signers have already adopted this sign, but they have modified it to use the dominant hand for hand movements, thus conforming to the Dominance Condition (as shown in Figure 88b).

(a) SC form (b) adopted form

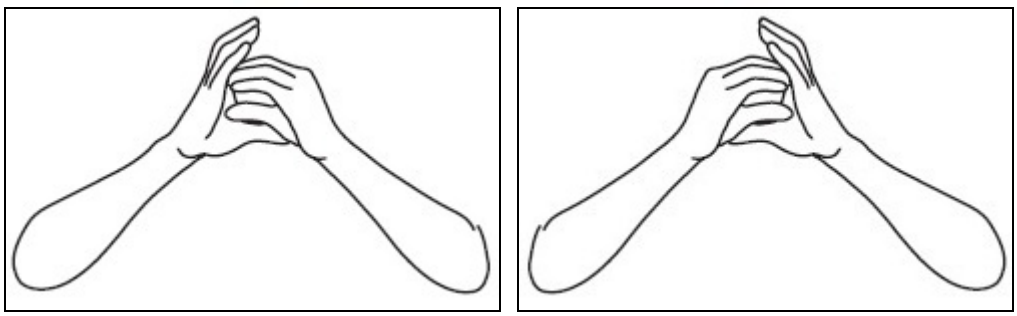


Figure 87. SC form (from Ministry of Education 2008, p. 452) and deaf signers' adopted form for character '巨'

(a) SC form (b) adopted form

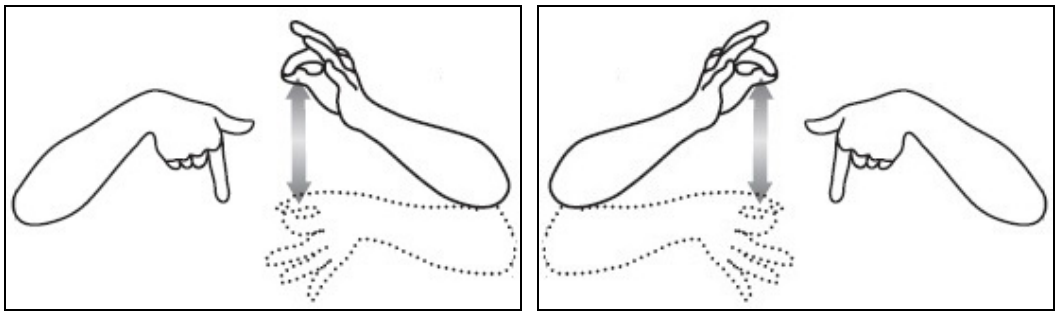


Figure 88. SC form (from Ministry of Education 2008, p. 457) and deaf signers' adopted form for character '價'

Third, there is no need to invent new handshapes for SC. TSL already has plenty of handshapes (Tai and Tsay 2015) for SC inventors to use to construct new signs. Most of the newly invented handshapes in the 2008 SC dictionary are used in a very small number of SC signs (as shown in section 6.1.2), but why not just adopt TSL handshapes for creating new signs?

Fourth, the SC dictionary should provide detailed glosses for each lexical item. Since SC was invented for novice learners, it should offer as much information as possible. It should also clearly specify which grammar (i.e., TSL or Chinese) was adopted for conveying lexical items. Some signs are signed following TSL grammar and some are signed following Chinese grammar, but novice learners might not know that there are two different systems within the SC dictionary.

### 8.3 Implications

SC was invented with the goal of improving deaf children's Chinese literacy, but studies have shown that it has failed to achieve this goal (e.g., Lin, Huang and Hsing 2001). Most deaf children came to deaf schools without true fluency in any language, they have to learn signing and Chinese (spoken or written, depending on their residual

hearing) at the same time. Myers, Tsay and Su (2011) suggested that teachers in Taiwan should instruct deaf children in TSL, since signing SC is not only more laborious, but also more time-consuming for teachers. In addition, Liu, Tseng and Chang (2006) showed that deaf children can understand TSL better than written Chinese and SC. This thesis showed that some phonological patterns of SC signs might be difficult for novice learners to learn. How can deaf children utilize SC as a tool to learn Chinese if they have difficulties in learning SC signs in the first place? Despite the fact that SC cannot help improve Chinese literacy, it is still adopted by the Ministry of Education to teach deaf children.

Studies have shown that deaf children's English literacy is positively correlated with their ASL proficiency (Strong and Prinz 1997; Hrastinski and Wilbur 2016). Thus, mastering a sign language well also helps to learn a second language. However, because many specialists on deaf education still believe that learning TSL might impede the learning of Chinese (e.g., Lin 2015a), the role of TSL in Taiwan's deaf education is minimized. In addition, in order for young children to acquire a full language, it is important to expose young children to a language as early as possible. However, current early intervention policy for preschool deaf children still puts much emphasis on oral training, even at deaf schools. Learning a spoken language through very limited residual hearing (especially for those who have severe or profound hearing loss) cannot guarantee a successful result due to their physical limitations on hearing. Deaf children's poor literacy might partly originate from their lack of early mastery of a full language. Since TSL is a naturally developed language, its signs mostly obey natural constraints for signing (as described in Chapter 6) and thus deaf children could easily acquire this language if they were exposed to it early enough. In addition, Marschark (2007) pointed out that "having a mother who is a good signer appears to be more important than whether she is deaf or hearing or the precise age at

which a child learns to sign, as long as it is early" (p. 171). Thus, teachers for the deaf and parents should learn and master TSL, and use TSL as a metalanguage to teach and interact with young deaf children. Sign language can provide young deaf children access to messages that are difficult for them to fully comprehend through audio channel and function as an effective means of teacher-child and parent-child communication (Marschark 2007). Huang (2014) showed that TSL can be used as a metalanguage to help deaf children comprehend and retell stories. The fact that TSL is phonologically easier for deaf children to learn and its possible benefits (e.g., for learning a second language like Chinese and for parent-child communication) should be promoted to the public, so that parents, educators, and medical professionals know more about this language and its importance and benefits to deaf children (see also Chang 2014).

Learning to read single words is an important foundation of becoming a skilled reader. Many studies have shown that a natural sign system can be used as a bridge to help improve deaf children's literacy. Haptonstall-Nykaza and Schick (2007) showed that ASL fingerspelling can serve as a visual phonological bridge as an aid to decode English orthography. Mounty, Pucci, and Harmon (2014) found that early access to fingerspelling can provide a foundation for literacy in English. The closest parallel to ASL fingerspelling in Taiwan is signs invented for expressing *zhuyin fuhao* (注音符號). However, this sign system is not widely adopted by deaf schools and most deaf people are not familiar with this system. Moreover, it cannot help improving Chinese literacy (Lin 2006). Chang (2014) also claimed that the benefit of learning Chinese words through *zhuyin* or *pinyin* (拼音) might be quite limited for deaf children. Instead, deaf children should learn Chinese words via the visual channel and focus on

reading and writing[23] (see Zhang and Liu 2014, Liu and Liu 2015 for the benefits of reading picture books for improving young deaf children's literacy). Due to the differences between English and Chinese orthography, it is still unclear how TSL can function as a bridge to help improving deaf children's decoding of Chinese characters/words. One possible option might be to take advantage of character signs that configure handshapes of both hands to represent radicals and thus closely match the form of Chinese characters, since TSL character signs have already established some consistently used handshapes for certain subcharacter radicals. This may help TSL signers improve their Chinese reading skills, since studies have shown that reading a Chinese character involves the processing of its subcharacter radicals (Taft and Zhu 1997; Hsu, Tsai, Lee and Tzeng 2009). Although Chinese characters are diverse and complicated in form, and character signs are not common in native TSL lexicon (i.e., less than 4%), Chang (2011a, 2011b) showed that TSL has a great potential to use a wide range of TSL handshapes for representing a variety of subcharacter radicals when there is a need to express Chinese place names and family names. The fact that TSL could use different handshapes for representing a variety of subcharacter radicals suggests that deaf readers have the potential to use TSL handshapes as a means of decoding Chinese characters. Further researches would be needed to investigate how TSL can be utilized to provide such sign-to-character mappings and help improving Chinese literacy.

[23] See Chang (2014) for more suggestions on how to learn Chinese words, syntax and pragmatics.

## References


Allen, Thomas. 1986. Patterns of academic achievement among hearing impaired students: 1974 and 1983. *Deaf Children in America*, ed. by Arthur Schildroth & Michael Karchmer, 161–206. San Diego, CA: College-Hill Press.

Anderson, Diane, & Judy Reilly. 2002. The MacArthur communicative development inventory: normative data for American Sign Language. *Journal of Deaf Studies and Deaf Education* 7.2: 83-106.

Ann, Jean. 1993. *A Linguistic Investigation of the Relationship Between Physiology and Handshape*. University of Arizona dissertation.

Ann, Jean. 1996. On the relation between ease of articulation and frequency of occurrence of handshapes in two sign languages. *Lingua* 98: 19-41.

Ann, Jean. 1998. Contact between a sign language and a written language: character signs in Taiwan Sign Language. *Pinky Extension and Eye Gaze*, ed. by Ceil Lucas, 59-99. Washington, D.C.: Gallaudet University Press.

Ann, Jean. 2001. Bilingualism and language contact. *The Sociolinguistics of Sign Languages*, ed. by Ceil Lucas, 33-60. Washington, D.C.: Gallaudet University Press.

Ann, Jean. 2005. A functional explanation of Taiwan Sign Language handshape frequency. *Language and Linguistics* 6.2: 217-246.

Ann, Jean. 2006. *Frequency of Occurrence and Ease of Articulation of Sign Language Handshapes: The Taiwanese Example*. Washington, D.C.: Gallaudet University Press.

Anthony, David. 1966. *Seeing Essential English*. Master thesis. Eastern Michigan University.

Baayen, Harald. 2008. *Analyzing Linguistic Data: A Practical Introduction to*

*Statistics Using R.* New York: Cambridge University Press.

Bates, Douglas, Martin Maechler, Ben Bolker & Steve Walker. 2015. Fitting Linear Mixed-Effects Models using lme4. *Journal of Statistical Software* 67.1: 1-48.

Battison, Robbin. 1978. *Lexical Borrowing in American Sign Language*. Silver Spring: Linstok Press.

Baus, Cristina, Manuel Carreiras & Karen Emmorey. 2013. When does iconicity in sign language matter? *Language and Cognitive Processes* 28.3: 261-271.

Bellugi, Ursula, & Susan Fischer. 1972. A comparison of sign language and spoken language. *Cognition* 1: 173-200.

Birnbaum, Michael. 2004. Human research and data collection via the internet. *Annual Review of Psychology* 55: 803-832.

Bornstein, Harry. 1990. A manual communication overview. *Manual Communication: Implications for Education*, ed. by Harry Bornstein, 21-44. Washington, DC: Gallaudet University Press.

Bornstein, Harry, Karen Saulnier, & Lillian Hamilton. 1983. *The Comprehensive Signed English Dictionary*. Washington, DC: Gallaudet University Press.

Bosworth, Rain, & Karen Emmorey. 2010. Effects of iconicity and semantic relatedness on lexical access in American Sign Language. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 36: 1573–1581.

Brentari, Diane. 1990. *Theoretical Foundations of American Sign Language Phonology*. University of Chicago dissertation.

Brentari, Diane. 1996. Trilled movement: phonetic realization and formal representation. *Lingua* 98: 43-71.

Brentari, Diane. 1998. *A Prosodic Model of Sign Language Phonology*. Cambridge, Massachusetts: The MIT Press.

Chang, Bey-lih (張蓓莉). 1989. Tingjue zhangai xuesheng zhi yuyan nengli yanjiu

聽覺障礙學生之語言能力研究 [A Study on Language Ability of Hearing-impaired Students]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of Special Education*] 5: 165-204.

Chang, Jung-Hsing (張榮興). 2011a. *Taiwan Shouyu Xingshi Renzhi Yu Zaoci Celue Yanjiu* 台灣手語姓氏認知與造詞策略研究 [*Cognition and Lexical Formation of Family Names in Taiwan Sign Language*]. Taipei: Crane Publishing.

Chang, Jung-Hsing (張榮興). 2011b. *Taiwan Shouyu Diming Zaoci Celue Yanjiu* 台灣手語地名造詞策略研究 [*Lexical Formation of Place Names in Taiwan Sign Language*]. Taipei: Crane Publishing.

Chang, Jung-Hsing (張榮興). 2014. *Longqingmiyi: Wo Suo Kanjian de Longren Jiaoyu* 聾情覓意：我所看見的聾人教育 [*Searching for the Meanings of Deafhood: Deaf Education through My Eyes*]. Taipei: Crane Publishing.

Chang, Xue-Er (張雪莪). 2001. *Tan tingzhang jiaoyu yu shouyu* 談聽障教育與手語 [On Deaf Education and Sign Language]. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 103-117. Taipei: National Taiwan Normal University.

Channon, Rachel. 2002. *Signs are Single Segments: Phonological Representations and Temporal Sequencing in ASL and Other Sign Languages*. University of Maryland dissertation.

Chao, Chien-min (趙建民). 1998. *Lonren Wenhua Gailun* 聾人文化概論 [*An Introduction to Deaf Culture*]. Taipei: 中華民國啟聰協會 [Chinese Deaf Association, R. O. C.].

Chao, Chien-min (趙建民). 2011. *Shouyu Yuyanxue Gailun* 手語語言學概論 [*Introduction to Sign language Linguistics*]. Taipei: 中華民國啟聰協會

[Chinese Deaf Association, R. O. C.].

Chao, Yu-ping (趙玉平). 1998. *Wenzi Shouyu Dian* 文字手語典 [*Character Sign Dictionary*]. Taipei: 現代經典 [Modern Classics].

Chen, Tsung-Ying & James Myers. 2016. Worldlikeness: A web-based tool for typological psycholinguistic research. Poster presented at The 40th Penn Linguistic Conference, Mar 18-20, University of Pennsylvania, Philadelphia, PA, United States.

China Association of the Deaf and Hard of Hearing (中國聾人協會). 2003. 中國手語 [*Chinese Sign Language*]. Beijing: 華夏出版社 [Huaxia Publishing House].

Corina, David. 1993. To branch or not to branch: underspecification in ASL handshape contours. *Current Issues in ASL Phonology*, ed. by Geoffrey Coulter, 63-95. New York: Academic Press.

Crasborn, Onno, & Els van der Kooij. 1997. Relative orientation in sign language phonology. *Linguistics in the Netherlands 1997*, ed. by Jane Coerts & Helen de Hoop, 37-48. Amsterdam: John Benjamins.

Department of Labor of Taipei City Government (台北市政府勞工局). 2010. *Taipei Shi Shouyu Fanyi Peixun Jiaocai Diyi Ce* 台北市手語翻譯培訓教材第一冊 [*Sign Language Interpretation Training Material of Taipei City*, Vol. 1]. Taipei: 台北市勞工局 [Department of Labor of Taipei City Government].

Eccarius, Petra, & Diane Brentari. 2007. Symmetry and dominance: a cross-linguistic study of signs and classifier constructions. *Lingua* 117: 1169-1201.

Emmorey, Karen. 1996. The confluence of space and language in signed languages. *Language and Space*, ed. by Paul Bloom, Mary Peterson, Lynn Nadel & Merrill Garrett, 171–209. Cambridge, MA: MIT Press.

Emmorey, Karen. 2002. *Language, Cognition, and Brain: Insights from Sign*

*Language Research*. Mahwah, NJ: Lawrence Erlbaum Associates.

Emmorey Karen. 2014. Iconicity as structure mapping. *Philosophical Transactions of Royal Society B* 369: 20130301.

Emmorey, Karen, & David Corina. 1990. Lexical recognition in sign language: Effects of phonetic structure and morphology. Perceptual and Motor Skills 71.3:1227-1252.

Emmorey, Karen, Edward Klima, & Gregory Hickok. 1998. Mental rotation within linguistic and nonlinguistic domains in users of American Sign Language. *Cognition* 68.3: 221-246.

Emmorey, Karen, Stephen Kosslyn, & Ursula Bellugi. 1993. Visual imagery and visual-spatial language: enhanced imagery abilities in deaf and hearing ASL signers. *Cognition* 46.2: 139-181.

Fischer, Susan, & Qunhu Gong. 2010. Variation in East Asian sign language structures. *Sign Languages*, ed. by Diane Brentari, 499-518. New York: Cambridge University Press.

Fischer, Susan, & Qunhu Gong. 2011. Marked hand configurations in Asian sign languages. *Formational Units in Sign Languages*, ed. by Rachel Channon & Harry van der Hulst, 19-42. Berlin: De Gruyter.

Freel, Brittany, Diane Clark, Melissa Anderson, Gizelle Gilbert, Millicent Musyoka, & Peter Hauser. 2011. Deaf individuals' bilingual abilities: American Sign Language proficiency, reading Skills, and family characteristics. *Psychology* 2.1: 18-23.

Frishberg, Nancy. 1975. Arbitrariness and iconicity: historical change in American Sign Language. *Language* 51: 696-719.

Frishberg, Nancy. 1993. Dominance Reversal. Paper presented at the University of Amsterdam.

Geraci, Carlo. 2009. Epenthesis in Italian Sign Language. *Sign Language and Linguistics* 12: 3-51.

Germine, Laura, Ken Nakayama, Bradley C. Duchaine, Christopher F. Chabris, Garga Chatterjee, & Jeremy B. Wilmer. 2012. Is the web as good as the lab? comparable performance from web and lab in cognitive/perceptual experiments. *Psychonomic Bulletin and Review* 19.5: 847-857.

Gorce, Nora. 1985. *Everyone Here Spoke Sign Language: Hereditary Deafness on Martha's Vineyard*. Cambridge, MA: Harvard University Press.

Gries, Stefan. 2013. *Statistics for Linguistics with R*: *A Practical Introduction*. Germany: De Gruyter Mouton.

Grosvald, Michael, Christian Lachaud & David Corina. 2012. Handshape monitoring: Evaluation of linguistic and perceptual factors in the processing of American Sign Language. *Language and Cognitive Processes* 27.1: 117-141.

Gustad, Martha, Roland Kelly, John-Allen Payne, & Eugene Lylak. 2002. Deaf and hearing students' morphological knowledge applied to print English. *American Annals of the Deaf* 147: 5-21.

Gustason, Gerilee. 1990. Signing Exact English. *Manual Communication: Implications for Education*, ed. by Harry Bornstein, 108-127. Washington, DC: Gallaudet University Press.

Gustason, Gerilee, Donna Pfetzing, & Esther Zawolkow. 1972. *Signing Exact English*. Silver Spring, MD: National Association of the Deaf.

Haptonstall-Nykaza, Tamara., & Brenda Schick. 2007. The transition from fingerspelling to English print: facilitating English decoding. *Journal of Deaf Studies and Deaf Education* 12.2: 172-183.

Hrastinski, Iva, & Ronnie Wilbur. 2016. Academic achievement of deaf and hard-of-hearing students in an ASL/English bilingual program. *Journal of Deaf*

*Studies and Deaf Education* 21.2: 156–170.

Hulst, Harry van der. 1996. On the other hand. *Lingua* 98, 121-143.

Hsing, Min-Hua (邢敏華). 2000. Qicong xuexiao jiaoshi koushouyu bingyong goutong shi zhi juzi xunxi yu cihui yuyi tezhi fenxi 啟聰學校教師口手語並用溝通時之句子訊息與辭彙語意特質分析 [An Analysis of Deaf-school Teachers' Utterance Message and Morpheme Semantic Features between Spoken and Signed Language Channels]. *Teshu Jiaoyu Yu Fujian Xuebao* 特殊教育與復健學報 [*Journal of Special Education and Rehabilitation*] 8: 27-52.

Hsing, Min-Hua (邢敏華). 2003. Taiwan qicong xuexiao jiaoshi koushouyu bingyong jiaoxue yanjiu 台灣啟聰學校教師口手語並用教學研究 [A Study on Deaf-school Teachers' Simultaneous Communication Instruction in Taiwan]. *Tainan Shiyuan Xuebao* 台南師院學報 [*Journal of National Tainan Teachers College*] 37.2: 23-46.

Hsu, Chun-Hsien, Jie-Li Tsai, Chia-Ying Lee, & Ovid J.-L. Tzeng. 2009. Orthographic combinability and phonological consistency effects in reading Chinese phonograms: An event-related potential study. *Brain and Language* 108.1: 56-66.

Huang, Bo-Long (黃柏龍). 2001. Tan shouyu jiaoxue 談手語教學 [On Sign language Teaching]. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 82-86. Taipei: National Taiwan Normal University.

Huang, Yu-Chi (黃玉枝). 2014. Shuangyu huiben gushi jiaoxue dui tingsun youer gushi lijie nengli zhi xuexi chengxiao 雙語繪本故事教學對聽損幼兒故事理解能力之學習成效 [The Effects of Bilingual Picture Books on Deaf Children's Comprehension]. *Goutong Zhangai Jiaoyu Banniankan* 溝通障礙

教育半年刊 [*Journal of Communication Disorders Biquarterly*] 1.2: 30-46.

Klima, Edward, & Ursula Bellugi (eds.). 1979. *The Signs of Language*. Harvard University Press.

Krantz, John, & Reeshad Dalal. 2000. Validity of web-based psychological research. *Psychological Experiments on the Internet*, ed. by Michael H. Birnbaum, 35-60. Academic Press.

Kuo, Wei-fan (郭為藩). 1985. *Teshu Ertong Xinli Yu Jiaoyu* 特殊兒童心理與教育 [*Psychology and Education of Special Children*]. Taipei: Wen-Join Book Company.

Lee, Hsin-Hsien. 2003. *Analyzing Handshape Changes in Taiwan Sign Language*. National Chung Cheng University MA thesis.

Lee, Hsin-Hsien. 2008. The representation of handshape change in Taiwan Sign Language. *Sign Language and Linguistics* 11.2: 139-183.

Lee, Hsin-Hsien, Tsay, Jane, & James Myers. 2001. Handshape articulation in Taiwan Sign Language and Signed Chinese. Paper presented at the Conference on Sign Linguistics, Deaf Education and Deaf Culture in Asia, Chinese University of Hong Kong.

Li, Junyu (李鈞棫). (ed.). 1978. *Shouyu Huace Diji Ji* 手語畫冊第一輯 [*Sign language album*, Vol. 1]. Taipei: Ministry of Education.

Liddell, Scott, & Robert Johnson. 1986. American Sign Language compound formation processes, lexicalization and phonological remnants. *Natural Language and Linguistic Theory* 4: 445-513.

Liddell, Scott. 1990. Structures for representing handshape and local Movement at the phonemic level, *Theoretical Issues in Sign Language Research*, *Vol. 1: Linguistics*, ed. by Susan Fischer & Patricia Siple, 37-65. Chicago: The University of Chicago Press.

Liddell, Scott, & Robert Johnson. 1989. American Sign Language: the phonological base. *Sign Language Studies* 64: 195-277.

Lin, Bao-Guey (林寶貴). 2001. Shouyu yijian diaocha 手語意見調查 [Survey of Opinions on Sign Language]. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 45-67. Taipei: National Taiwan Normal University.

Lin, Bao-Guey (林寶貴). 2006. *Tingjue Zhangai Jiaoyu Lilun Yu Shiwu* 聽覺障礙教育理論與實務 [*Theory and Practice of Deaf Education*]. Taipei: Wu-Nan Book Company.

Lin, Bao-Guey (林寶貴). 2015a. Xiuding Taiwan changyong shouyu cidian bing jianzhi APP yingyonh chengshi 修訂台灣常用手語辭典並建置APP應用程式 [Revising the Taiwan Sign Language Dictionary and Build an App]. 2015 *Liangan Goutong Zhangai Xueshu Yantaohui Lunwenji* 2015兩岸溝通障礙學術研討會論文集 [*Proceedings of the 2015 Symposium on Communication Disorder*], 155-162. Taipei: National Taiwan Normal University.

Lin, Bao-Guey (林寶貴). 2015b. Taiwan tingzhang jiaoyu de lishi yu fazhan 臺灣聽障教育的歷史與發展 [The History and Development of Taiwan Deaf Education]. 2015 *Liangan Goutong Zhangai Xueshu Yantaohui Lunwenji* 2015 臺灣聽障教育百年國際學術研討會 [*Proceedings of the 2015 Taiwan Deaf Education 100 Years International Conference*], 66-83. Tainan: National Tainan University.

Lin, Bao-Guey (林寶貴), & Yu-Chi Huang (黃玉枝). 1997. Tingzhang xuesheng guoyu nengli ji cuowu leixing zhi fenxi 聽障學生國語文能力及錯誤類型之分析 [An analysis on hearing-impaired students' Chinese language ability and its error patterns]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of*

*Special Education*] 15: 109-129.

Lin, Bao-Guey (林寶貴) & Zhen-Xian Li (李真賢). 1987. Tingzhang xuesheng guoyu nengli zhi yanjiu 聽障學生國語文能力之研究 [A study on deaf students' Chinese literacy]. *Jiaoyu Xueyuan Xuebao* 教育學院學報 12: 1-27.

Lin, Bao-Guey (林寶貴), Huang, Yu-Chi (黃玉枝), & Min-Hua Hsing (邢敏華). 2001. Tingzhang xuesheng xuexi shouyu huace chengxiao ji yinhxiang yinsu zhi yanjiu 聽障學生學習手語畫冊成效及影響因素之研究 [Studies on deaf students' learning outcome of Signed Chinese and affecting factors]. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 118-130. Taipei: National Taiwan Normal University.

Lin, Bao-Guey (林寶貴), Ya-hui Yang, (楊雅惠) & Su-mei Tai (戴素美). 2001. Xiudingban shouyu huace shouyu cihui biaoxian jiangou xiangdu fenxi yuanjiu 「修訂版手語畫冊」手語詞彙表現建構向度分析研究 [A study on the formational properties of 'Revised sign language album']. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 68-81. Taipei: National Taiwan Normal University.

Lin, Fang-yu. (林芳宇) 2007. *Taiwan Shouyu Mingci Fanchouhua - Shangweici de Chengxian* 台灣手語名詞範疇化-上位詞的呈現 [*Noun Categorization in Taiwan Sign Language - The Representation of Superordinate Level*]. National Chung Cheng University MA thesis.

Liu, Chun-Jung (劉俊榮), & Hsiu-Tan Liu (劉秀丹). 2015. Tingsun ertong pinghenq quxiang huiben yuedu jiaoxuefa zhi chengxiao 聽損兒童平衡取向繪本閱讀教學法之成效 [The Efficacy of Reading Instruction with Picture Book for Students with Hard-of-hearing in a Balanced Approach]. *Zhangaizhe Lijie*

*Banniankan* 障礙者理解半年刊 [*Understanding Individuals with Disabilities Biquarterly*] 14.1: 75-94.

Liu, Hsiu-Tan (劉秀丹), & Chin-Hsing Tseng (曾進興). 2007. Wenfa shouyu guoci yu jufa texing dui longsheng ciyi yu juyi lijie de yingxiang 文法手語構詞與句法特性對聾生詞義與句義理解的影響 [The Effect of Morphological and Syntactic Factors on the Word and Sentence Comprehension of Manually Coded Chinese by Deaf Signers]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of Special Education*] 32.1: 77-92.

Liu, Hsiu-Tan (劉秀丹), Chin-Hsing Tseng (曾進興), & Sheng Chang (張勝成). 2006. Qicong xuexiao xuesheng wenfa shouyu ziran shouyu ji shumianyu gushi lijie nengli zhi yanjiu 啟聰學校學生文法手語、自然手語及書面語故事理解能力之研究 [Deaf Students' Story Comprehension Using Manually Coded Chinese, Taiwanese Sign Language and Written Chinese]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of Special Education*] 30: 113-133.

Liu, Hsiu-Tan (劉秀丹), Chin-Hsing Tseng (曾進興), & Chun-Jung Liu (劉俊榮). 2009. Ziran shouyu yu wenfa shouyu de cihui jiyi guangdu bijiao 自然手語與文法手語的詞彙記憶廣度比較 [A Comparison of the Short-Term Memory Span for Words in Taiwan Sign Language and Manually Coded Chinese]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of Special Education*] 34.3: 25-45.

Luetke-Stahlman, Barbara, & Diane Nielsen. 2003. The contribution of phonological awareness, and receptive and expressive English to the reading ability of deaf students exposed to grammatically accurate English. *Journal of Deaf Studies and Deaf Education* 8: 464-484.

Mandel, Mark. 1977. Iconic devices in American Sign Language. *On the Other Hand*, ed. by Lynn A. Friedman, 57-107. London: Academic Press.

Mandel, Alan. 1981. *Phonotactics and Morphophonology in American Sign Language*. Berkeley: University of California dissertation.

Marmor, Gloria, & Laura Petitto. 1979. Simultaneous communication in the classroom: how well is English grammar represented? *Sign Language Studies*, 23: 99-136.

Marschark, Marc. 2007. *Raising and Educating a Deaf Child: A Comprehensive Guide to the Choices, Controversies, and Decisions Faced by Parents and Educators*. 2nd edition. Oxford University Press.

Mayer, Connie, & Tane Akamatsu. 2000. Deaf children creating written texts: contributions of American Sign Language and signed forms of English. *American Annals of the Deaf* 145: 394-403.

McIntire, Marina. 1977. The Acquisition of ASL Hand Configuration. *Sign Language Studies* 16, 247-260.

Ministry of Education. 1987. *Shouyu Huace Dier Ji* 手語畫冊第二輯 [*Sign Language Album*, Vol. 2]. Taipei: Taipei School for the Deaf.

Ministry of Education. 1999. *Xiudingban Shouyu Huace Diyi Ji Dier Ji* 修訂版手語畫冊第一輯、第二輯 [*Revised Sign Language Album*, Vol. 1 and Vol. 2]. Taipei: Ministry of Education.

Ministry of Education. 2000. *Changyong Cihui Shouyu Huace Diyi Ji Dier Ji* 常用詞彙手語畫冊第一輯、第二輯 [*Sign Language Album for Common Chinese Words*, Vol. 1 and Vol. 2]. Taipei: Ministry of Education.

Ministry of Education. 2001. *Changyong Chengyu Shouyu Huace* 常用成語手語畫冊 [*Sign Language Album for Common Chinese Idioms*]. Taipei: Ministry of Education.

Ministry of Education. 2008. *Changyong Shouyu Cidian* 常用手語辭典 [*A sign language dictionary*]. Taipei: Ministry of Education.

Morgan, Hope, & Rachel Mayberry. 2012. Complexity in two-handed signs in Kenyan Sign Language: evidence for sublexical structure in a young sign language. *Sign Language and Linguistics* 15.1: 147-174.

Mounty, Judith, Concetta Pucci, & Kristen Harmon. 2014. How deaf American Sign Language/English bilingual children become proficient readers: an emic perspective. *Journal of Deaf Studies and Deaf Education* 19.3: 333-346.

Myers, James & James H-Y. Tai. (eds.) 2005. Special issue on Taiwan Sign Language. *Language and Linguistics*, 6.2.

Myers, James, Jane S. Tsay, & Shiou-fen Su. 2011. Representation Efficiency and Transmission Efficiency in Sign and Speech. *Language and Cognition: Festschrift in Honor of James H-Y. Tai on His 70th Birthday*, ed. by Junghsing Chang, 171-199. Taipei: Crane Publishing.

Namy, Laura. 2008. Recognition of iconicity doesn't come for free. *Developmental Science* 11.6: 841-846.

National Taiwan Normal University. 2016. *Changyong Shouyu Cidian* 常用手語辭典 *Sign Language Dictionary* [Mobile application software]. Retrieved from https://play.google.com/store/apps/details?id=com.xtremeapp.sld

Nielsen, Diane, Barbara Luetke, & Deborah Stryker. 2011. The importance of morphemic awareness to reading achievement and the potential of signing morphemes to supporting reading achievement. *Journal of Deaf Studies and Deaf Education* 16: 275-288.

Ogata, Hideaki (緒方英秋). 2008. *すぐに使える手話辭典 6000* [*Ready-to-Use Japanese Sign Language Dictionary 6000*]. Tokyo: 日本文藝社.

Padden, Carol, & David Perlmutter. 1987. American Sign Language and the architecture of phonological theory. *Natural Language and Linguistic Theory* 5.3: 335-375.

Paul, Peter. 2001. *Language and Deafness*. San Diego: Singular Thomson Learning.

Perlmutter, David. 1992. Sonority and syllable structure in American Sign Language. *Linguistic Inquiry* 23.3: 407-442.

Pyers, Jennie, Pamela Perniss, & Karen Emmorey. 2008. Viewpoint in the visual-spatial modality. Paper presented at the 30th Annual Convention of the German Society of Linguistics workshop on *Gestures: A comparison of signed and spoken languages*, Bamberg, Germany.

Pyers, Jennie, Pamela Perniss, & Karen Emmorey. 2015. Viewpoint in the visual-spatial modality: The coordination of spatial perspective, *Spatial Cognition and Computation*, 15.3: 143-169.

Qi. Sue, & Ross Mitchell. 2012. Large-scale academic achievement testing of deaf and hard-of-hearing students: past, present, and future. *Journal of Deaf Studies and Deaf Education* 17: 1-18.

Oldfield, R.C. 1971. The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia* 9.1:97-113.

R Core Team. 2016. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. (https://www.R-project.org)

Raffin, Michael. 1976. The acquisition of inflectional morphemes by deaf children using Seeing Essential English. University of Iowa dissertation.

Reips, Ulf-Dietrich. 2002. Standards for internet-based experimenting. *Experimental Psychology* 49.4: 243-256.

Reips, Ulf-Dietrich. 2007. The methodology of internet-based experiments. *The Oxford Handbook of Internet Psychology,* ed. by Adam Joinson, Katelyn McKenna, Tom Postmes & Ulf-Dietrich Reips, 373–390. Oxford University Press.

Reips, Ulf-Dietrich, & John Krantz. 2010. Conducting true experiments on the web.

*Advanced methods for conducting online behavioral research*, ed. by Samuel Gosling, and John Johnson, 193-216. American Psychological Association.

Sandler, Wendy. 1989. *Phonological Representation of the Sign: Linearity and Nonlinearity in American Sign Language*. Dordrecht: Foris.

Sandler, Wendy. 1993. A sonority cycle in American Sign Language. *Phonology* 10.2: 243-279.

Sandler, Wendy, & Diane Lillo-Martin. 2006. *Sign language and Linguistic Universals*. Cambridge University Press.

Smith, Wayne & Li-fen Ting. 1979. *Shou Neng Sheng Qiao Diyi Ce* 手能生橋第一冊 [*Your Hands Can Become a Bridge*, Vol. 1]. Taipei: Deaf Sign Language Research Association, ROC.

Smith, Wayne & Li-fen Ting. 1984. *Shou Neng Sheng Qiao Dier Ce* 手能生橋第二冊 [*Your Hands Can Become a Bridge*, Vol. 2]. Taipei: Deaf Sign Language Research Association, ROC.

Smith, Wayne. 1989. *The Morphological Characteristics of Verbs in Taiwan Sign Language*. Indiana University dissertation.

Smith, Wayne. 2005. Taiwan Sign Language research: an historical overview. *Language and Linguistics* 6.2: 187-215.

Stedt, Joseph, & Donald Moores. 1990. Manual codes on English and American Sign Language: historical perspectives and current realities. *Manual Communication: Implications for Education*, ed. by Harry Bornstein, 1-20. Washington, DC: Gallaudet University Press.

Stewart, David. 1983. Bilingual education: teachers' opinions of signs. *Sign Language Studies* 39: 145-167.

Stokoe, William. 1960. Sign language structure: an outline of the visual communication systems of the American deaf. In *Studies in Linguistics:*

*Occasional Papers*. Buffalo: University of Buffalo.

Strong, Michael & Philip Prinz. 1997. A study of the relationship between American Sign Language and English literacy. *Journal of Deaf Studies and Deaf Education* 2.1: 37-46.

Su, Shiou-fen. 2004. *Iconicity in Taiwan Sign Language*. National Chung Cheng University MA thesis.

Su, Shiou-fen & James H-Y. Tai. 2009. Lexical comparison of signs from Taiwan, Chinese, Japanese, and American Sign Languages: Taking iconicity into account. *Taiwan Sign Language and Beyond*, ed. by James H-Y. Tai & Jane Tsay, 149-176. Chia-Yi, Taiwan: The Taiwan Institute for the Humanities, National Chung Cheng University.

Supalla, Samuel. 1990. *Segmentation of Manually Coded English: problems in the mapping of English in the visual/gestural mode*. University of Illinois at Urbana-Champaign dissertation.

Supalla, Samuel. 1991. Manually Coded English: the modality question in signed language development. *Theoretical Issues in Sign Language Research*, Vol 2. *Psychology*, ed. by Patricia Siple & Susan Fisher, 85-109. The University of Chicago Press.

Supalla, Samuel, & Cecile McKee. 2002. The role of Manually Coded English in language development of deaf Children. *Modality and Structure in Signed and Spoken Languages*, ed. by Richard Meier, Kearsy Cormier & David Quinto-Pozos, 143-165. Cambridge University Press.

Swisher, Virginia. 1985. Characteristics of hearing mothers' Manually Coded English. *SLR'83: Proceedings of the Third International Symposium on Sign Language Research*, ed. by Wiliam Stokoe & Virginia Volterra, 38-47. Linstok Press.

Swisher, Virginia. 1991. Conversational interaction between deaf children and their

hearing mother: the role of visual attention. *Theoretical Issues in Sign Language Research*, Vol 2. *Psychology*, ed. by Patricia Siple & Susan Fisher, 111-134. The University of Chicago Press.

Taft, Marcus, & Xiaopin Zhu. 1997. Submorphemic processing in reading Chinese. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23.3: 761-775.

Tai, James H-Y. 2005. Modality Effects: Iconicity in Taiwan Sign Language. *POLA Forever: Festschrift in Honor of Professor William S-Y. Wang on his 70TH Birthday*. ed. by Dah-an Ho & Ovid J. L. Tzeng, 19-36. Taipei: Institute of Linguistics, Academia Sinica.

Tai, James H-Y. & Jane Tsay (eds.). 2009. *Taiwan Sign Language and Beyond*. Chia-Yi, Taiwan: The Taiwan Institute for the Humanities, National Chung Cheng University.

Tai, James H-Y. & Jane Tsay. 2010. Taiwan Sign Language Corpus: digital dictionary and database. *Proceedings* of *2010 TELDAP International Conference*, 41-47. Taipei: Academia Sinica.

Tai, James H.-Y. & Jane Tsay. 2015. Taiwan Sign Language. *Sign Languages of the World*, ed. by Julie Bakken Jepsen, Goedele De Clerck, Sam Lutalo Kiingi & William B. McGregor Germany, 771-809. Germany: De Gruyter Mouton.

Taub, Sarah. 2001. *Language from the body: iconicity and metaphor in ASL*. Cambridge: Cambridge University Press.

Thompson, Robert, Vinson, David, & Gabriella Vigliocco. 2009. The link between form and meaning in American Sign Language: Lexical processing effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 35.2: 550–557.

Thompson, Robert, Vinson, David, & Gabriella Vigliocco. 2010. The link between

form and meaning in British Sign Language: Lexical processing effects in a phonological decision task. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 36.4: 1017–1027.

Tsay, Jane, & James Myers. 2009. The morphology and phonology of Taiwan Sign Language. *Taiwan Sign Language and Beyond*, ed. by James H-Y. Tai & Jane Tsay, 83-129. Chia-Yi, Taiwan: The Taiwan Institute for the Humanities, National Chung Cheng University.

Tsay, Jane (蔡素娟), James H-Y. Tai (戴浩一) & Yijun Chen (陳怡君). 2015. *Taiwan Shouyu Xianshang Cidian DisanBan* 台灣手語線上辭典第三版 [*Taiwan Sign Language Online Dictionary,* 3rd ed.]. 國立中正大學語言學研究所 Institute of Linguistics, National Chung Cheng University. Retrieved from http://140.123.46.77/TSL/

Uyechi, Linda. 1996. *The Geometry of Visual Phonology*. California: CSLI Publications.

Vinson, David, Robin Thompson, Robert Skinner & Gabriella Vigliocco. 2015. A faster path between meaning and form? Iconicity facilitates sign recognition and production in British Sign Language. *Journal of Memory and Language* 82: 56–85.

Wilbur, Ronnie. 2000. The use of ASL to support the development of English and literacy. *Journal of Deaf Studies and Deaf Education* 5.1: 81-104.

Wilbur, Ronnie. 2003. Modality and the structure of language: sign Languages versus signed Systems. *Oxford Handbook of Deaf Studies, Language, and Education*, ed. by Marc Marschark & Patricia Elizabeth Spencer, 332-346. Oxford University Press.

Wilbur, Ronnie. 2011. Sign Syllables. *The Blackwell Companion to Phonology*, Vol 2, ed. by Marc van Oostendorp, Colin Ewen, Elizabeth Hume & Keren Rice,

1309-1334.

Wilbur, Ronnie, & Lesa Petersen. 1998. Modality interactions of speech and signing in simultaneous communication. *Journal of Speech, Language, and Hearing Research* 41.1: 200-212.

Wodlinger-Cohen, Rhonda. 1991. The manual representation of speech by deaf children and their mothers, and their teachers. *Theoretical Issues in Sign Language Research*, Vol 2. *Psychology*, ed. by Patricia Siple & Susan Fisher, 149-169. The University of Chicago Press.

Woodward, James, & Thomas Allen. 1988. Classroom use of artificial sign systems by teachers. *Sign Language Studies* 61: 405-418.

Wu, Rosaling Jane (吳敏而). 2005. Ke yuce duwu: yuedu de qimeng jiaocai 可預測讀物: 閱讀的啟蒙教材 [Predictable books: Enlightened Teaching Material of Reading]. 拉大語文課程的框架-可預測讀物研討會. Paper presented at the Conference on Extend the Frame of Literacy: Predictable Reading Material. Taipei: National Taiwan Normal University.

Yao, Jun-Ying (姚俊英). 2001. Taiwan shouyu yanjin 台灣手語演進 [The Development of Taiwan Sign Language]. *Shouyu Jiaoxue Yu Yingyong Yantaohui Lunwenji* 手語教學與應用研討會論文集 [*Proceedings of the Symposium on Sign Language Teaching and its Application*], 142-147. Taipei: National Taiwan Normal University.

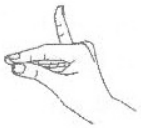
Zhang, Mei-Jun (莊梅君), & Hsiu-Tan Liu (劉秀丹). 2014. Keyucexing huiben jiaoxue fangan dui guoxiao tingjue zhangai xuesheng yuedu lijie de chengxiao 可預測性繪本教學方案對國小聽覺障礙學生閱讀理解的成效 [Effects of Predictable-Pattern-Book Instruction on Reading Comprehension for Second- and Third-Grade Students with Hearing Impairments]. *Teshu Jiaoyu Yanjiu Xuekan* 特殊教育研究學刊 [*Bulletin of Special Education*] 39.3: 27-46.

Appendix 1. *Zhuyin Fuhao* Handshape Chart (from Ministry of Education 2008)

Appendix 2. TSL handshapes (from Tai and Tsay 2015, p. 800-801)

# Appendix I: Handshapes in Taiwan Sign Language

Handshape names adopt the American Sign Language handshape names in English alphabet and numeral digits with necessary variations. In parentheses are the handshapes names in Chinese characters used in the previous studies on TSL. Romanization in Mandarin Pinyin is provided along with the character names.

| | | | | |
|---|---|---|---|---|
| | | | | |
| Open A<br>(男 nan) | Flexed A<br>(副 fu) | B<br>(胡 hu) | Open B<br>(手 shou) | Bent B<br>(九 jiu) |
| | | | | |
| C<br>(方 fang) | Bent C<br>(紳 shen) | F<br>(錢 qian) | Open F<br>(WC) | G<br>(像 xiang) |
| |  | | | |
| I<br>(女 nyu) | Flat I<br>(千 qian) | Curved I<br>(蟲 chong) | K<br>(欠 qian) | Open K<br>(布袋戲 budaixi) |
| | | | | |
| L<br>(六liu) | Bent L<br>(句 ju) | Curved L<br>(爺 ye) | Curved-Baby L<br>(難 nan) | Flexed L<br>(很 hen) |
| | | | | |
| Extended N<br>(鴨 ya) | O<br>(零 ling) | Open O<br>(果guo) | Flat O<br>(萬 wan) | Baby O<br>(呂 lyu) |
| | | | | |
| Bent-Baby O<br>(雞 ji) | R<br>(筆bi) | S<br>(拳 quan) | U<br>(棕zong) | V<br>(二 er) |

Curved V
(二十 ershi)

W
(三san)

Curved W
(三十 sanshi)

Unspread W
(童 tong)

X
(十 shi)

Y
(民 min)

L-I
(守 shou)

X-I
(奶 nainai)

1-I
(語 yu)

Flat 1-I
(龍 long)

1
(一 yi)

3
(七 qi)

Curved 3
(虎 hu)

4
(四 si)

Curved 4
(四十 sishi)

5
(五 wu)

Bent 5
(同 tong)

5-Curved Pinky
(八ba)

Curved 5-Pinky
(八十 bashi)

Piled 5
(蓋 jiang)

8
(併 jie)

Open 8
(菜 cai)

Crossed Thumb-Index
(叟 zhi)

Thumb-Midde-Pinky
(飛機 feiji)

Curved-Index
(鵝 e)

Curved Middle
(博 bo)

Middle
(兄 xiong)

Curved-Index-Middle
(高 gao)

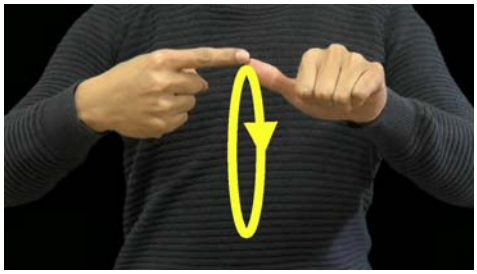
Ring
(姐 jie)

Ring-Pinky
(百 bai)

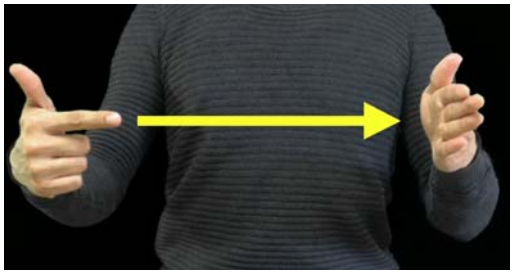
Bent Curved-Index-Middle
(矮 ai)

Thumb-Pinky
(細 xi)

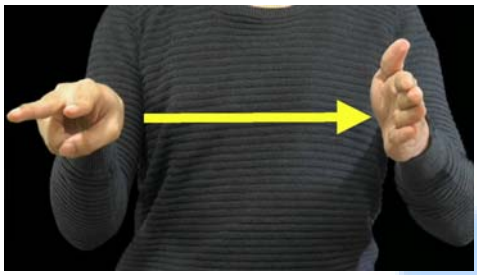
Appendix 3. Fake two-handed signs for testing the Dominance Condition



Item 1

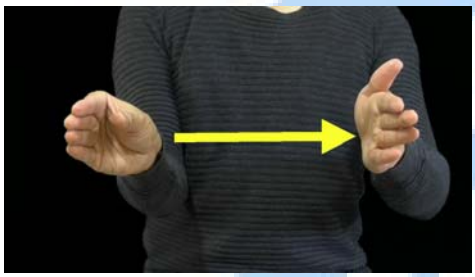


Item 2



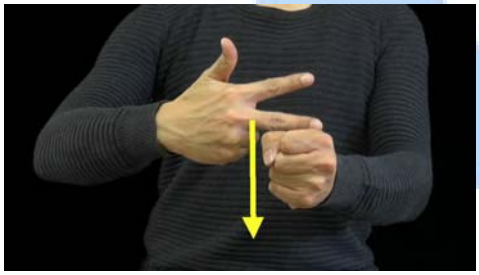
Item 3

Item 4



Item 5

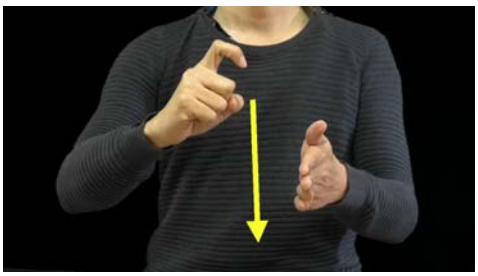
Item 6



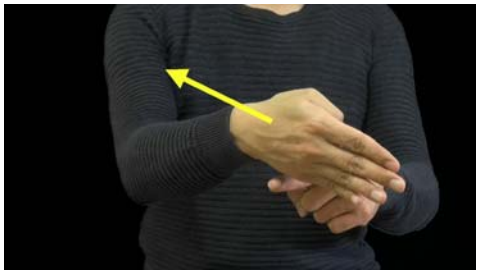
Item 7

Item 8

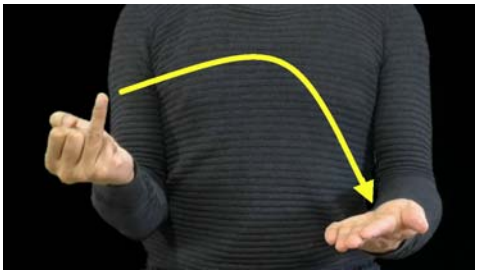
Item 9



Item 10

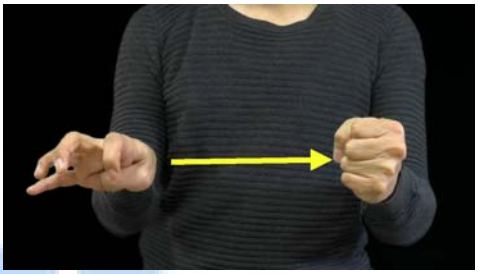


Item 11

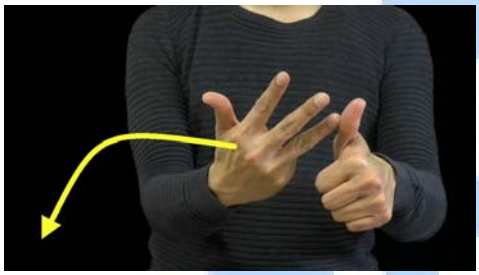


Item 12

Item 13



Item 14

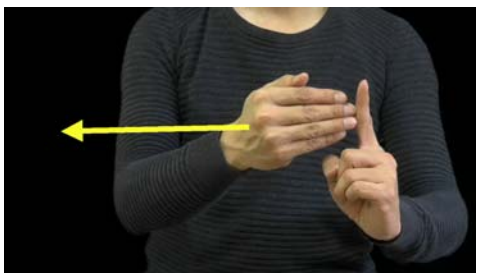


Item 15

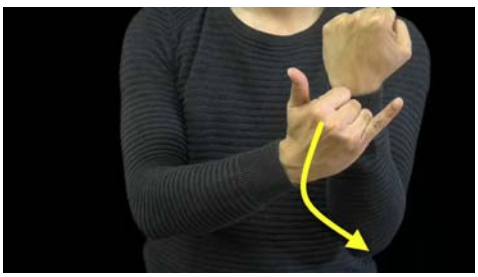
Item 16

Item 17

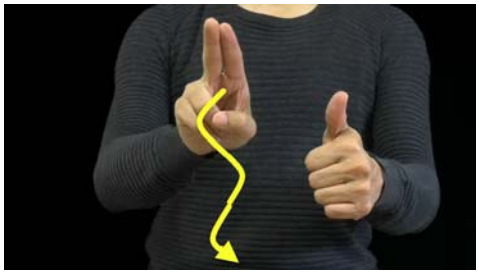
Item 18



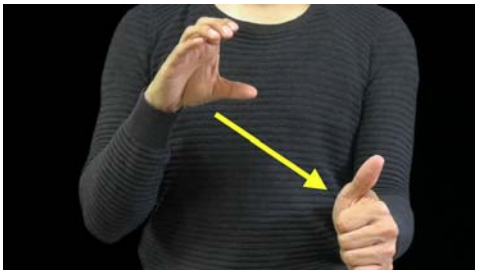
Item 19



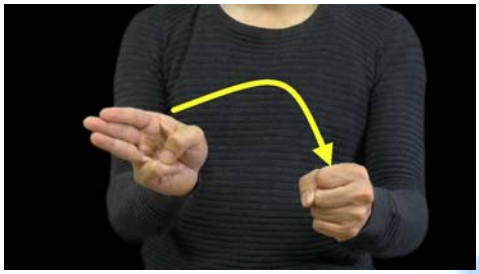
Item 20



Item 21



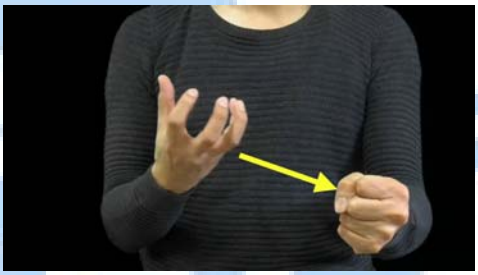
Item 22



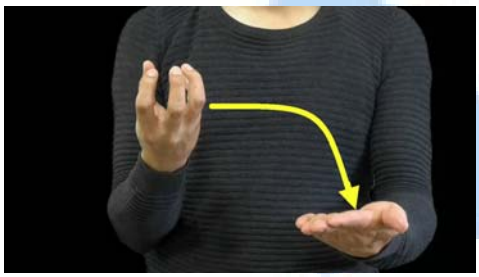
Item 23

Item 24

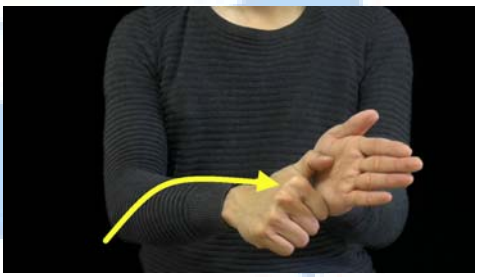
Item 25



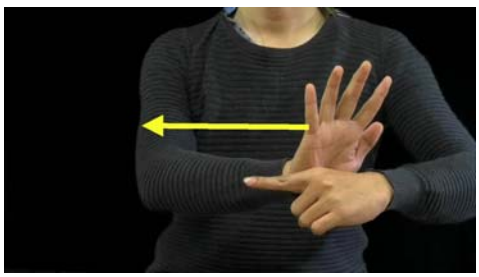
Item 26



Item 27



Item 28



Item 29

Item 30

Appendix 4. Illustration webpage for experiments

# 手語實驗流程說明

1. 請先進行 慣用手測驗，確認你的慣用手爲左手或右手，因爲正式實驗開始時，需要這項基本資料。

2. 本實驗請使用電腦進行，因爲需連到中正大學網站，並按鍵做反應。

3. 建議使用Chrome瀏覽器(會自動更新)、Firefox瀏覽器最新版或Internet Explorer 10以上版本進行實驗。

4. 進行實驗時，請在不被干擾的場所進行，勿中途離開或從事其他行爲。

5. 整個實驗約10分鐘左右可完成。

6. 實驗頁面需載入影片完成才能進行，若一直出現空白頁面，請清除瀏覽器瀏覽資料後再嘗試連線實驗網頁。
(瀏覽器清除資料方法 請參考這裡)

**實驗流程說明：**

本研究目的在於釐清比手語時哪些因素會使得手語較難學習，共包含 2 個實驗，每個實驗包含2個部分。

第1部分，螢幕上會秀出手語，請你重複比一次，接著立即按鍵判斷手語的難易度。

第2部分，你需判斷螢幕中的手語是否和在第1部分中看過的手語完全一樣，並立即按鍵回答。

每一題按鍵回答後會自動跳下一題，直到各實驗結束爲止，並會呈現你的實驗表現。

實驗1的詳細說明　　實驗2的詳細說明

## 對實驗流程都瞭解了嗎？請開始進行實驗吧

1. **慣用手測驗** 請由此進行 並記住你的慣用手是左手或右手。

2. **實驗1-1** 請由此進行 (請等候 預載多媒體檔案 100%完成)，共30題。請立即接著進行 **實驗1-2** (共20題)。

3. **實驗2-1** 請由此進行 (請等候 預載多媒體檔案 100%完成)，共28題。請立即接著進行 **實驗2-2** (共20題)。

注意：**(每個實驗第一部分、第二部分需連續進行。實驗1與實驗2可於不同時間進行，請盡空完成兩個實驗)**

---

研究者

國立中正大學語言學研究所 博士生：李信賢

研究主題：比較台灣手語與中文手語的音韻結構差異

E-mail：

Appendix 5. Character signs for testing the Narrator Perspective Principle. Asterisks indicate invented character signs.

Item 1 ‘仙’

Item 2 ‘戶’

Item 3 ‘汕’*

Item 4 ‘匡’*

Item 5 ‘巨’

Item 6 ‘燃’

Item 7 ‘吹’*

Item 8 ‘己’

Item 9 ‘斤’

Item 10 ‘匀’*

Item 11 ‘區’

Item 12 ‘汤’*

Item 13 ‘灶’*

Item 14 ‘倫’

Item 15 ‘可’*

Item 16 ‘則’

Item 17 ‘訪’*

Item 18 ‘入’

Item 19 ‘仁’

Item 20 ‘句’*

Item 21 ‘圳’*

Item 22 ‘汁’*

Item 23 ‘計’*

Item 24 ‘人’

Item 25 ‘論’

Item 26 ‘彦’*

Item 27 ‘冰’

Item 28 ‘建’