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Cognitive and Neural Foundations of Chinese Reading

From Learning to Advanced Processing and Beyond

Chapter 3
A Visual Approach to the Acquisition of Chinese Characters by the Deaf in Taiwan

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Abstract A visual approach to the acquisition of Chinese characters is proposed to account for the fact some of the Deaf in Taiwan manage to overcome the cumbersome Chinese characters, thereby to read Chinese with a high level of proficiency. This approach is built up three hitherto little explored threads of thought. Frist, the Chinese characters have a grammar which shares structural principles with signed and spoken languages. Second, both external and internal iconicity in Taiwan Sign Language can be applied to Chinese characters. Third, the Deaf employ visual awareness, rather than phonological awareness, to learn Chinese characters. In conclusion, additional hurdles for the Deaf to read Chinese are briefly sketched in hopes of unraveling the reading ability of Chinese by the Deaf in Taiwan.

Keywords Deaf · Chinese character · Sign language · Iconicity

3.1 Introduction

It has been observed that the reading ability of the Deaf universally lags far behind their hearing peers. The Deaf (with a capital D) refers to the deaf people who use sign language for communication. They generally cannot go beyond the level of the 4th graders in reading comprehension of alphabetic languages such as English (e.g. Quigley & Paul, 1986; Trybus & Karchmer, 1977) and logographic languages such as Chinese (Lin & Li, 1987; Chang, 1987; Tzeng 1996, 1998, 2000). The lack of phonological input and awareness for the Deaf has been identified as the major culprit in causing the problem.

It has been generally assumed that phonological input and awareness are required to decode words in alphabetic languages as well as Chinese characters for the meaning to be incorporated into compounds, phrases, and sentences in reading comprehension. On this assumption, the Chinese logographic writing system would be much harder

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for the deaf to learn to recognize Chinese characters and to read Chinese texts than alphabetic languages. However, we have noticed that a small proportion of the Deaf population in Taiwan are able to reach the proficiency level to read and write in Chinese.

Unlike the phonological decoding in alphabetical languages, the decoding of Chinese characters is mainly visually oriented. Furthermore, the grammar of Taiwan Sign Language is drastically different from that of Chinese. Therefore, for the Deaf in Taiwan, learning to read Chinese amounts to learning to read a second language without the help of spoken Chinese, as in the case of their hearing peers.

The purpose of this paper is to propose a visual approach to the acquisition of Chinese characters by the Deaf in Taiwan. Our central inquiry is how some of the Deaf manage to overcome the hurdles in learning to read Chinese. This inquiry consists of two parts: recognition of Chinese characters (識字 *shìzì*) and reading Chinese texts (閱讀 *yuèdú*). This paper focusses only on the recognition of Chinese characters by the Deaf in Taiwan, leaving the complicated process of reading Chinese texts for future research.

Regarding the recognition of Chinese characters, three basic theoretical foundations are adopted for this inquiry. First, the Chinese characters have a grammar that shares structural principles with both signed and spoken languages (Myers, 2019). Second, despite the abundance of phonetic radicals, Chinese characters are full of iconic motivations. These motivations are similar to the iconic motivations in sign languages and can be applied to the acquisition the Chinese characters by the Deaf. Third, the Deaf use visual awareness, rather than phonological awareness, to process Chinese characters.

3.2 The Nature of Chinese Characters

3.2.1 Iconicity in Chinese Characters

The first systematic study of Chinese characters appeared in 說文解字 *shuōwénjiězì* 'explaining graphs and analyzing characters' compiled by 許慎 *xǔshèn* around 100 AD. The 文 wén refers to simple non-composite characters, and the 字 *zì* to composite characters. This dictionary contains more than 9,000 Chinese characters in the seal script 篆文 *zhuànwén* to be analyzed with respect to their meaning, composition, pronunciation, and etymology. 許慎 *xǔshèn* did not have the knowledge of the scripts inscribed on the oracle bones and tortoise shells in the late Shang dynasty (fourteenth–eleventh centuries BC), known as 「甲骨文」 *jiǎgǔwén*, which were only discovered around the end of nineteenth century. Besides, his analysis and interpretation were also largely influenced by the cosmological view of his time. He proposed six categories of Chinese characters, referred to as 「六書」 *liùshū* 'six writings'. Although later scholars have proposed different categorizations, the six categories have, nonetheless, guided analysis of Chinese characters for two millennia in the

tradition of Chinese philology (cf. Qiu, 2000). Therefore, a few words of explanation of the six categories are desirable and necessary for the purpose of this paper.

Of the six categories, four are concerned with the formation of characters. The first two categories 象形 *xiàngxíng* 'resemble form (of objects)' and 指事 *zhǐshì* 'indicate matters' are about non-composite characters. The former category is exemplified by 日 *rì* 'sun' and 月 yuè 'moon' in 說文解字 *shuōwénjiězì*, and the latter, exemplified by 上 *shàng* 'above' and *xià* 'below'. The third category 會意 *huìyì* 'conjoining meanings' and the fourth category 形聲 *xíngshēng* 'form and meaning' are about composite characters. 說文解字 *shuōwénjiězì* exemplifies the third category with 武 *wǔ* 'martial' and 信 *xìn* 'trust', the fourth category with 江 *jiāng* 'river' and 河 *hé* 'river'. The fourth category contains 'semantic-phonetic' composite characters of which the semantic component provides semantic clues, and the phonetic component, phonological cues. This category is by far the largest as well as the most productive category in the developmental course of Chinese characters, covering more than 90 percent of contemporary Chinese characters in use.

The fifth category is 假借 *jiǎjiè* 'loan-borrowing', which is basically a rebus principle as in Sumerian inscription. Instead of listing the original opaque examples given in 說文解字 *shuōwénjiězì*, we illustrate the principle with the character 能 *néng*. The character is originally a pictographic sketch of a bear. Later, it is borrowed to represent the abstract concept 能 *néng* 'to be able to' through the rebus principle. Then, the character 熊 *xióng* 'bear' is created to represent bears by adding four legs to the bottom of 能 *néng*. Interestingly, 熊 *xióng* is borrowed one more time for the onomatopoeia sound '*xióng*' of burning fire in the expression 熊熊烈火 *xióngxióng lièhuǒ* 'raging flames'.

As a matter of fact, most of the characters in the 形聲 *xióngshēng* category were derived from the 假借 *jiǎjiè* in order to overcome the overwhelmingly large number of homographs. The last of the six categories is 轉注 *zhuǎnzhù*, which is concerned with the extended use of a character in meaning through metonymical or metaphorical uses.

Iconicity plays a key role in both the lexicon and syntax of sign languages (Klima & Bellugi, 1979; Liddell, 2003; Mandel, 1977; Sandler & Lillo-Martin, 2006). Taiwan Sign Language, the native language of the Deaf in Taiwan, is no exception (Myers & Tai, 2005). It is significant to find out to what extent the iconicity in Chinese characters can be of help to the recognition of Chinese characters by the Deaf signers.

Heuristically, we can start with Peirce's three kinds of signs in semiotics, namely, iconic, indexical, and symbolic signs. Iconic signs bear some resemblance to their referents. Indexical signs point to the referents by partial or indirect association. Symbolic signs bear an arbitrary relationship to their referents. While spoken languages, being linear in one dimension, are largely symbolic and arbitrary, thus, the well-known Saussure's arbitrary principle of language. Although it has been convincingly pointed out by Haiman (1980, 1983, 1985) and others that iconicity is pervasive in spoken languages, iconicity in general is not acknowledged in spoken languages as it is in sign languages.

The simple non-composite characters of the first category 象形 *xiàngxíng* 'resemble form (of objects)' are iconic signs and pictorial in origin. Even though

their conventionalized contemporary forms are not pictorial anymore, their iconic motivations are easier to interpret and perceive, as in the case of 日 *rì* 'sun' and 月 *yuè* 'moon'. The compound character 明 *míng* 'bright' belongs to the third category 會意 *huìyì*, and the 'conjoining meaning' is transparent and mnemonic to learn. Many characters for animals are of the first category, for instance, 象 *xiàng* 'elephant' and 馬 *mǎ* 'horse'. The character 象 *xiàng* was later borrowed through the rebus principle to mean 'resemble' as in 象形 *xiàngxíng* as well as to be used as the phonetic component of the semantic-phonetic character 像 *xiàng* 'portrait'. In the same vein, perhaps, in different diachronic sequences, the character 馬 *mǎ* was adopted as the phonetic component for the character 媽 *mā* 'mother', and as a loan in the expression of 馬馬虎虎 *mǎmǎhūhū*, which does not mean many horses and tigers, but simply mean 'careless'. Reduplication of nouns has an iconic motivation for plurals in Chinese, as in 家家戶戶 *jiājiāhùhù* 'every household'. For the Deaf, the idiom 家家戶戶 *jiājiāhùhù* is easier to grasp than the idiom 馬馬虎虎 *mǎmǎhūhū*. Because the former is semantic-based, but the latter is sound-based, to which the Deaf have no access through spoken Chinese as their hearing peers.

The simple non-composite Chinese characters of the second category 指事 *zhǐshì* 'indicate matters' as exemplified by 上 *shàng* 'above' and 下 *xià* 'below' can further be understood through 'diagrammatic iconicity' in iconicity theory. As pointed out in Haiman (1980), 'Peirce (1932, pp. 247, 277–282) made a crucial distinction between two types of iconicity, which we may call "imagic" and "diagrammatic". An iconic image is a single sign which resembles its referent with respect to some (not necessarily visual) characteristics, an iconic diagram is a systematic arrangement of signs, none of which necessarily resembles its referent, but whose relationships to each other mirror the relationships of their referents (Haiman ibid., p. 315)'. It can be seen that diagrammatic iconicity has the function of isomorphism in mapping reality to language representation. Chinese characters like 上 *shàng* and 下 *xià* exhibit diagrammatic iconicity. They should be very easy for the Deaf to recognize without the sound input of '*shàng*' and '*xià*', as in the case of hearing Chinese children learning to recognize these two characters in the first year of schooling. It should be noted here that Sutton-Spence and Woll (1999, pp. 129–130) propose a distinction between syntactic and topographic space in sign language. While syntactic space is used to express syntactic relations, topographic space reflects the layout of things in the real world. It stands to reason that the Deaf can simply apply their knowledge of topographic space in signing to the recognition of characters in this category.

Now, the character 上 *shàng* and 下 *xià* can be compounded with simple non-composite characters under the general principle of 會意 *huìyì* 'conjoining meanings' as in 忐 *tǎn* and 忑 *tè* to form the expression 忐忑 *tǎntè* 'mentally disturbed'. The two characters have no sound clues at all. The recognition of this compound word needs no sound input for the Deaf as well as for the hearing learners.

形聲字 *xíngshēngzì* of the fourth category, known as phonetic compounds, are treated by Chinese linguists as representing phonological values without iconicity involved. However, the semantic radicals (語意偏旁 *yǔyìpiānpáng*) of these characters are able to provide semantic values. For instance, the semantic radical 扌 is derived from 手 *shǒu* 'hand' and the characters with this radical on the left in general

indicate actions with hands, as in 抓 *zhuā* 'to grab' and 扭 *niǔ* 'to twist'. Similarly, the characters with semantic radical 足 *zú* 'foot' have to do with actions with feet, as in 跑 *pǎo* 'to run' and 跳 *tiào* 'to jump'. Therefore, characters in this category are not purely phonological. The semantic radicals in Chinese serve to indicate general semantic meaning, akin to prefixes like 'pre-' and 're-' in English (Myers, 2019).

Some of the semantic radicals not only provide semantic categories, but also diagrammatic iconicity. The semantic radical 囗 *wéi*, which means 'to circumscribe' or 'to surround', is also diagrammatically iconic to the visual relationship, as can be seen in characters such as 園 *yuán* 'garden', 圃 *pǔ* 'a vegetable garden'; 圈 *quān* 'circle' and *juàn* 圈 'pen of domestic animals'; qiú 囚 'prisoner' and 困 *kùn* 'to trap'.

Some composite characters can be diagrammatically iconic, too. For example, the character 盥 *guàn* 'to wash hand or face', which is diagrammatic iconic in each of the four components, correspond to two hand holding the water above the water container. Another example can be seen in the contrast between 裹 *guǒ* 'to wrap' and 裸 *luǒ* 'naked'. The two characters share the same semantic radical 衣 *yī* 'clothes' and phonetic (presumably) component 果 *guǒ* 'fruit'. Note that the semantic radical 衣 *yī* is transformed to 衤 in 裸 *luǒ* as a prefix, but as a split circumfix in 裹 *guǒ*. It appears that diagrammatic iconicity is involved here. While 裹 *guǒ* symbolizes that the body is inside the clothes, 裸 *luǒ* symbolizes that the body is not covered by the clothes.

There are more cases of diagrammatic iconicity in Chinese characters. However, it is more important to point out here that spoken Chinese is loaded with homophones. For example, the word *lì* can have more than 90 meanings, and the resolution to ambiguity largely depends on different characters, e.g. 力 *lì* 'strength', 立 *lì* 'to erect', 利 *lì* 'benefit', 例 *lì* 'example', 麗 *lì* 'beautiful', and 歷 *lì* 'record', etc. Therefore, Chinese characters play an important role in isomorphism in mapping the signal to meaning. And the function of isomorphism hinges upon diagrammatic iconicity.

In short, the commonly accepted thesis that the system of Chinese characters is based on sound and not on visual graphs must be qualified. Furthermore, diagrammatic iconicity is not limited to the whole or partial isomorphism between the schematized visual world and the linguistic structure. As pointed out by Greenberg (1995), in addition to the above external iconicity, there is also internal iconicity, in which the dominant paradigm of a language can serve as a model for the development of linguistic patterns within the same language. The semantic-phonetic category has indeed become the dominant model for new Chinese characters coined for newly discovered metals and chemicals, as numerous composite characters with semantic radicals, for example, 金 *jīn*, a semantic radical for metals, as in 鉀 *jiǎ* 'potassium', 鉛 *qiān* 'lead', and 鈾 *yòu* 'uranium', etc. Another example is 酉 *yǒu*, a semantic radical for chemicals, as in 酮 *tóng* 'ketone', 酯 *zhǐ* 'ester', and 酶 *méi* 'enzyme', etc.

As a matter of fact, internal iconicity also applies to language contact. A good case in point is the character sign used in Taiwan Sign Language (TSL). Ann (1998) has identified the following methods of constructing character signs in TSL.

1. To imitate the shape of either the whole or a part of a Chinese character by means of handshape: 中，王，田
2. To trace either the whole or a part of a Chinese character in the air:千，就
3. To combine both (1) and (2) methods: 丁，毛，河
4. To use both handshape and the mouth: 中，品
5. To combine a natural sign with tracing: 太

In his study of lexical formation of family names and place names in Taiwan Sign Language, Chang (2011a, pp. 114–142; 2011b, pp. 162–183) has identified more than 300 character signs used in full or partial forms. Chinese character signs are also used in Japan and China, adopting the simplified characters and Japanese characters (Fischer & Gong, 2011). Chinese character signs are on a par with finger spellings of the sign languages based on alphabets, such as in American Sign Language and French Sign Language. While in the sense of 'imitation' or 'modelling', both finger spellings and character signs involve internal iconicity, only character signs can involve both external and internal iconicity, as in the character signs 中 *zhōng* 'middle', 王 *wáng* 'king', and 田 *tián* 'rice field'.

In short, the Chinese character system exhibits both external and internal iconicity. It stands to reason to assume that the Deaf in Taiwan can apply imagic and diagrammatic iconicity in the visual world and sign languages to the learning of Chinese characters.

3.2.2   Grammatical Structures

Chinese characters form a system and are amenable to structural analysis within the framework of modern and contemporary linguistic theory. Wang (1983) and subsequently Myers (2019) have clearly shown that Chinese characters have a rich grammar containing phonetics, phonology, morphology, and syntax akin to natural spoken and signed languages. One of the most fundamental properties of human language is 'duality of patterning', in which the meaningless simplest elements can be put together through 'minimal contrast' to form meaningful words. For example, the meaningless phoneme /o/、/p/、/t/、/s/ can form different words such as 'stop', 'spot', 'tops', 'pots', and 'opts' in English. Similarly, the meaningful Chinese characters can be formed with meaningless simple strokes by means of 'minimal contrast', as illustrated in (1) (Tai, 2021:16 with rearrangements).

(1)
a. contrast with the stroke 點 (、) 'dot'
「大/太/犬」；「几/凡」；「王/玉」；「刀/刃」
b. contrast with the stroke 豎 (丨) 'vertical'
「曰/田/由/甲/申」；「爿/片」 (反方向對照)

c. contrast with the stroke 橫 (一) 'horizontal'
「一/十」;「日/旦」;「不/丕」;「口/曰」
d. contrast with the stroke 撇 (丿) 'throw away'
「十/千」;「天/矢/夫/失」;「心/必」;「代/伐」

In signed languages, meaningful signs are composed by meaningless elements such as handshapes, locations, movements, orientations coupled with facial expressions. They can be illustrated by the following minimal pairs in Taiwan Sign Language (TSL) (Tai & Tsay, 2021: 348).

(2)
a. Handshape contrast: handshape L ✍ vs. handshape Open A ✍ (same location: chin)
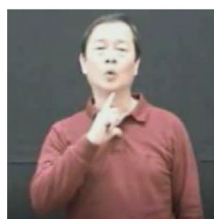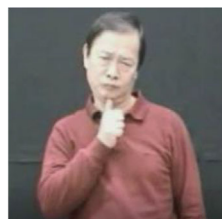
a. RICH   b. POOR

b. Location contrast: chest vs. arm (same handshape: Crossed Thumb-Index ✍)

c. CHRISTIAN   d. NURSE

c. Movement contrast: downward vs. lateral (same handshape and location)

e. BLACK   f. REGRET

d. Orientation contrast: palms down vs. palms facing each other (same handshape and location)

g. NOW   h. PERIOD
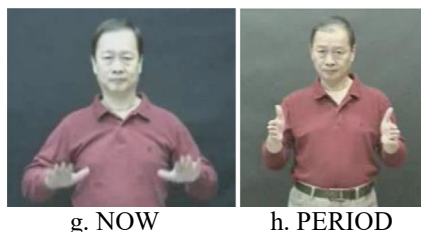
The Deaf signers in Taiwan or elsewhere in the world should be able to apply their knowledge of the minimal contrast principle to the learning of Chinese characters.

Furthermore, the same stroke can vary according to its position in the character. For example, the stroke [丨] 豎 *shù* 'vertical' consistently takes the form of [丿] 彎 *wān* 'bend' on the left side of a character, for example in the characters 「川」 and 「月」. At the same time, the hook stroke [亅] 鉤 *gōu* will appear on the right of the 「月」, as well as in characters 「句」, 「丁」 and 「事」, etc. Variations of a stroke in different positions are akin to the variations (i.e. allophones) of a phoneme in different positions. Take the phoneme /t/ for example, it can have five allophones as [th]op (top), s[t]op (stop), bu[ʔ]on (button), wri[D]er (writer), and cu[t̚] (cut). Therefore, strokes have the status of 'graphemes' with 'allographs' as variants in character compositions. Signs in sign languages naturally adjust their forms in the discourse as the words will adjust their phonemes in the flow of speech. Therefore, the Deaf can transfer this kind of linguistic knowledge to the recognition of Chinese characters.

The grammar of Chinese characters also has a rich component of morphology, in addition to phonetic and phonological components (Myers, 2019). First, affixation constitutes a central part of morphology. Significantly, Chinese characters exhibit a system akin to affixation in spoken and sign languages. Thus, the semantic radicals derived from the full independent characters in (3) can be treated as affixes in Chinese characters. First, they cannot be independent characters (獨體字 *dútǐzì*) and can only be components (部件 *bùjiàn*) of characters. Second, their semantic categorizations are often broader than the original characters from which they are derived.

(3)
人 → 亻;刀 → 刂;水 → 氵;艸 → 艹
手 → 扌;心 → 忄;火 → 灬;衣 → 衤

It is significant to note that while words in spoken language are one-dimensional, characters are two-dimensional with horizontal and vertical axes. On the horizontal axis, some affixes can be placed on the left of a character, as the semantic radical [亻] in 「仁」 and 「他」, thus on a par with a prefix in spoken language. They can also be placed on the right, as the semantical radical [刂], akin to a suffix in spoken languages in 「刺」 and 「刮」 or infixes as [丿] in 「辨」 and [糸] in 「辮」.

On the vertical axis, Chinese characters can also have top-affixes and bottom-affixes. For example, the semantic radical [艹] in 「草」 and 「菜」; and the semantic radical [灬] in 「煎」 and 「煮」. More interestingly, the independent full character 「衣」, in addition to its derived semantic radical [衤] on the left in 「衫」, 「袖」, and others, 「衣」 can be split as in 「衷」、「裹」, akin to merged compound words in spoken and sign languages.

In addition to affixation, compounding is also a productive word formation mechanism in the morphology of spoken and signed languages. Chinese characters are loaded with compound characters as illustrated in (4).

(4)
日 + 月 ➤ 明 (semantic radical: 日)
木 + 才 ➤ 材 (semantic radical: 木)
田 + 力➤男 (semantic radical: 田)
耳 + 心➤恥 (semantic radical: 心)
上 + 心➤志 (semantic radical: 心)
下 + 心➤忑 (semantic radical: 心)

Note that these compound characters cannot be written as two characters with space in between. They must be collapsed into one single square in different ways as illustrated in (4). These examples also illustrate the effect of two-dimensionality of compounding, different from one dimensionality in spoken languages, as 'blue + bird ➤ bluebird', and 'green + house ➤ greenhouse' in English. Otherwise, they are parallel in both meaning change and prosodic adjustment. In the case of Chinese characters, it is the adjustment of the relative proportion of the space in one single square.

Reduplication is another component of morphology. It is very common in both spoken and sign languages to use reduplication to signify plurality, an iconic motivation in both modalities of language. Reduplication with the same motivation can also be illustrated with the familiar example in (5).

(5)
木 + 木 = 林; 木 + 木 + 木 = 森
火 + 火 = 炎; 火 + 火 + 火 = 焱
魚 + 魚 = 鱻; 魚 + 魚 + 魚 = 鱻 (variant character of 「鮮」)

In short, the morphology of Chinese characters is largely similar to that of spoken and sign languages. The profound Deaf can certainly transfer their knowledge of reduplication in sign language to the recognition of Chinese characters.

Myers (2019) has only slightly touched on the syntax of Chinese characters. In this paper, we propose to start with their composition of components within characters, especially the patterns of spatial arrangement of semantic radicals, phonetic radicals, and other kinds of components. The main patterns can be seen in (6).

(6)
1. ⿰ (兩個部件由左至右): 「相」、「肝」、「邦」、「朝」
2. ⿱ (兩個部件由上至下): 「杏」、「吉」、「岩」、「召」

3. ⬓ (三個部件由左至右):「衍」、「班」、「辨」、「瑯」
4. ⬒ (三個部件由上至下):「京」、「岔」、「莫」、「高」
5. ◲ (兩個部件由外而內):「回」、「因」、「國」、「困」
6. ⬓ (三面包圍–下方開口):「凰」、「問」、「周」、「風」
7. ⬒ (三面包圍–上方開口):「凶」、「幽」、「函」、「凼」
8. ◲ (三面包圍–右方開口):「匠」、「區」、「巨」、「匹」
9. ◳ (兩面包圍–由左上至右下):「屠」、「屍」、「屬」
10. ◳ (兩面包圍–由右上至左下):「包」、「病」、「載」
11. ◳ (兩面包圍–由左下至右上):「超」、「過、「建」
12. ◳ (同樣部件的重複):「林」,「森」;「日」、「昌」、　　　　「晶」

The 12 patterns of spatial arrangements listed above are based on Unicode 3.0. Other permissible patterns remain to be uncovered.

Furthermore, in many cases, the same semantic element in a character can be structured either as a semantic radical or as a part of the semantic compound. It can be illustrated with the three most productive semantic elements, 'heart', 'hand', and 'foot' as in (7), (8), and (9).

(7) 心 *xīn* 'heart' as independent characters
1. as semantic radical 「忄 」 on the left (152 characters)

忙、忖、忏、忸、忼、快、忻、忮、松、忱、忡、忤、忼、怖、怕、怦、怛、
恢、怩、怔、怜、怪、恒、怙、怯、怊、怵、作、怡、快、恫、恬、�guī、恑、
恪、恠、恨、恢、恍、恰、恓、恤、恂、恃、悖、悌、悧、惆、悍、悔、悁、
性、悄、悛、悚、悒、悮、悅、悟、惜、倖、惆、惓、悱、悼、惦、惇、惝、
惕、　惟、控、惚、惛、悸、悽、情、悵、惙、悴、悰、惟、惋、惘、愎、惼、
惆、惰、惱、惂、惶、愀、愜、愕、惺、惴、愜、惻、愕、愔、愉、惲、慄、
愷、愫、愧、慌、慊、慉、愴、愼、愫、慍、慢、憅、慣、慨、慷、慳、慴、
慥、慚、慘、慪、慵、憫、憚、憐、憒、憍、憬、憔、憧、憎、憕、憤、懂、
懃、懍、懈、憸、憮、懌、憶、懦、懜、憯、懶、懷、懺、懽、懼、儡。

2. as a part of compound placed at the bottom (82 characters)

忐、忑、忌、志、忍、忘、忿、念、忽、忠、怠、怹、怒、急、怎、思、怨、
恁、恴、恐、恚、恝、息、恕、恋、恩、恙、您、患、悉、恩、悠、惠、悲、
惪、惄、惑、惠、惎、惡、悶、憨、感、衒、想、愁、惹、意、愚、態、慈、
愬、愍、愿、慂、慝、慮、慧、慼、憋、慫、慾、慰、慾、慵、憋、憑、憨、憨、
憩、憙、憲、愁、懋、懇、應、懣、懟、懲、懸、難、戀、戁。

3. other non-productive patterns of compounding

(a) 愛、慶、憂; (b) 恥、懿、忒; (c) 忝、恭、慕; (d) 必

It is worthy noting that the anti-ambiguity constraint works here to keep the distinction between the pairs: 忘 ≠ 忙; 忠 ≠ 忡; 怎 ≠ 作; 愁 ≠ 揪;意 ≠ 憶; 怒 ≠ 恢 悲 ≠ 悱. The anti-ambiguity constraint can be treated as a corollary of the principle of isomorphism for the mapping between meaning and form.

(8) 手 *shǒu* 'hand' as an independent character
1. as a semantic radical 「扌 」 on the left (312 characters)

扎、扒、扑、打、扔、托、扛、扣、扦、扦、扠、把、扳、扮、抔、批、扶、
抖、扭、抗、技、抉、抵、折、抓、找、扯、抄、抒、扼、抑、扚、抛、拔、
抱、扮、拂、拍、披、拖、拼、抨、抹、抿、拇、拊、抵、拓、拗、拈、拉、
拎、拐、拒、拘、招、拄、拙、拆、抽、抻、押、拼、挑、括、拱、拷、拮、
指、拯、拽、持、拾、拭、拶、拴、按、挖、挓、挽、捌、捕、挺、捏、挪、
捍、挾、捄、搞、挶、捐、捃、振、捉、捎、捜、挫、抄、挨、挹、捂、捭、
排、培、捧、捫、捯、掉、据、掇、掏、探、捺、推、捻、捻、掇、掄、掠、
掴、掛、捎、控、掎、接、捷、据、掬、掘、掐、掮、捨、掀、掙、捵、捨、
授、掞、捽、採、措、掃、掩、捲、捱、掖、掗、提、換、揮、揸、搜、握、
揚、插、援、揭、揀、揉、揪、揶、揞、搐、揩、揣、揍、揄、揰、揖、摒、
揆、揳、揞、揾、揎、攝、揕、掾、揙、搖、損、搬、搞、搋、搶、搭、搏、
搗、搓、搔、搪、搯、搵、搐、搧、搗、搭、榨、搠、振、構、摧、搤、搰、
搕、搢、搢、搦、搄、搨、摁、搿、摅、搛、摸、摁、撤、摘、摔、摧、摺、
撖、搜、撂、摳、摜、摑、摒、摻、搏、標、摭、摛、撓、撥、摠、播、撲、
撞、撥、撒、**掙**、撫、撐、撈、撕、撓、撰、撮、撬、撅、撍、撤、撣、搏、
撚、撏、撟、搟、攄、據、擔、擇、擁、擋、擅、撿、撼、擒、播、擄、撻、
撾、擗、擐、抬、擦、擠、擠、擬、擱、撐、擤、擢、擣、擯、擩、擺、擴、擾、
攊、擿、擷、擻、擲、擿、攏、攔、攘、攈、攖、攝、攜、攛、攤、攔、攪、
攛、攣、攫、攩、攬、攮。

2. as a part of compound placed at the bottom (20 characters)

拿、挐、挈、拳、挲、掌、掣、挲、搴、摩、摹、摯、舉、擊、擎、擘、攀、
攣、厴、摯

3. other non-productive patterns of compounding

 a. 掰、掰; b. 承; c. 拜; 弄

(9) 足 *zú* 'foot' as an independent character.
1. as a semantic radical 「足」 on the left (96 characters)

趴、趵、趺、趿、跂、趾、跋、跛、跑、跗、跌、跎、跞、跏、距、跖、跚、
趾、跺、跳、路、跟、跪、跨、跬、跡、跤、跰、跣、跩、跎、跟、跽、跼、
踊、踣、踏、踝、踦、踩、踧、踹、踶、踩、踩、蹄、踽、踔、踹、踩、
踳、蹈、踼、蹡、蹊、蹉、蹦、蹕、蹣、蹢、蹬、蹟、蹶、蹙、蹤、蹼、
蹯、蹬、蹲、蹻、蹶、蹺、蹭、蹴、蹽、躂、蹮、蹰、躁、蹟、躊、躍、躒、
躚、躑、躓、躘、躚、躓、躥、躩、躡、躦、躪。

2. as a part of compound placed at the bottom (6 characters)

 跫、踅、蹇、蹙、蹩、蹇

3.2.3 Visual Awareness

A sketch of visual awareness of Chinese characters is proposed below for the profoundly Deaf who use sign language and have little, if any, phonological aware-ness. The parameters for visual awareness of Chinese characters are listed in (10).

(10)

a. The inventory of simple and complex strokes

b. Composition of strokes (with stroke order in writing)

c. Minimal pairs by strokes and components

d. Semantic components, and no semantic components (including phonetic components for the hearing and those which can be recognized as mere components, for example, 「堇」 in the left component of 「難」 and the right component of 「漢」, and 「弋」 shared by 「戴」 and 「載」

e. Different patterns of spatial arrangement of strokes and components in squares.

f. knowledge of compound characters and their alternative affixation.

It is the argument of this paper that the profoundly Deaf using Taiwan Sign Language (or other sign languages) can use the visual awareness as sketched in (10) to learn to recognize Chinese characters without phonological inputs.

3.3 Advantage of Deafness to Phonological Noises

First, written Chinese is based on Mandarin Chinese, which is loaded with homophones. For example, 「國語日報辭典」 *guóyǔrìbàocídiǎn* 'Dictionary for the Daily National Language Newspaper, the commonly used Chinese dictionary in Taiwan lists 51 characters under /*lì*/, e.g. 力, 立, 利, 歷, 麗…

The hearing readers learned these characters through their pronunciation. It is inevitable that the abundance of homophones would interfere with the processing of Chinese characters. Yet, the Deaf readers can avoid the interference.

Second, Tone 2 and Tone 3 in Mandarin are often not clearly distinguished from each other. So are /l/ and /n/, e.g. 聾人 *lóngrén* 'deaf' and 農人 *nóngrén* 'farmer'. The Deaf only need to recognized different characters to avoid the confounding of the two tones.

Third, there exist regularity and consistency problems. Both involve the distorted sound patterns of phonetic radicals for historical reasons. Mainly, phonetic radicals remain unchanged in form regardless of sound changes through centuries. The regularity problem can be illustrated in (11) and consistency in (12)

(11)
regularity: 昔 /*xí*/, 錯 /*cuò*/, 借 /*jiè*/

(12)
consistency: 由 /*yóu*/: 10 regular (油, 鈾, 蚰, 柚…); 2 irregular (抽 /*chōu*/), 迪 /*dí*/), thus consistency rate: 2/12=0.17

Furthermore, both regularity and consistency are compounded by the frequency effect (Lee et al., 2005).

For the hearing, the errors are exhibited not only in comprehension but also in the production of Chinese characters. However, the deaf can also make errors due to confusion of the similarity between and among characters. It can be illustrated by Chinese characters produced by the Deaf in (13) (Shen, 2023, p. 62).

(13)

1. 構 (溝) 通	2. 薪 (新) 手	3. 偶 (遇) 到
4. 平版 (板)	5. 桃 (挑) 選	6. 遭 (糟) 糕
7. 辨 (辦) 露營	8. 彩卷 (券)	9. 屏柬 (東)
10. 主特 (持)	11. 中搶 (槍)	12. 翻釋(譯)

3.4 Advantages of the Deaf in Visual Working and Short Memory

Although the Deaf lack auditory working and short memory in reading, they are compensated by the stronger visual working and short memory than those of the hearing readers (Maller, 2003; Marschark, 2003; Ronnberg, 2003). Recently, Lee (2021) used eye-tracking and ERP to compare the reading processes of English by the Deaf and the hearing, and found that the Deaf pay more attention to the reading than the hearing. It is reasonable to infer that the Deaf in Taiwan can focus more on the forms and meanings of Chinese characters, ignoring their phonology and the ensured irregularity and inconsistency of sound patterns in their mental lexicon.

Flaherty (2003) summarized results from previous experimental studies on visual memory tests of deaf signers and showed that deaf signers consistently outscored their hearing non-signing counterparts. She therefore proposed that long-term use of a sign language may enhance visual abilities and extended her proposal to argue that the long-term use of logographic script Chinese characters appears to boost visual memory. Both learning a sign language and mastering Chinese characters involve a relatively complex task of visual recognition and memory.

Furthermore, in their study comparing deaf signers with and without spoken language base in Taiwan, Chiu and Wu (2013) found that phonological coding is not required for Chinese reading comprehension of the deaf signers without spoken language base. Chiu and Wu (2016) further confirmed that deaf signers use TSL phonological representations during reading.

3.5   Conclusion

In this paper, we propose a visual approach to the acquisition and recognition of Chinese characters by the Deaf in Taiwan. The long-term goal is to develop a fairly elaborate theory, which aims to account for the fact that a certain portion of the profoundly deaf can manage to read Chinese and to write their MA thesis in Chinese. In fact, it has been pointed out by Goldin-Meadow and Mayberry (2001) that reading requires two related but separable capabilities: familiarity with a language and understanding of the mapping between the language and the printed words. The Deaf signers in Taiwan are certainly not only familiar with but skillful in TSL. The mapping between TSL and Chinese characters is facilitated by the iconic motivations and structural similarities between the two.

On the other hand, at this point, we need to have some tentative explanations for the fact that the reading ability of the Deaf universally lags behind their hearing peers, and that many of them cannot go beyond the level of the 4th graders in reading comprehension. First, deaf individuals with little language experience in early life perform poorly in language learning (Mayberry et al., 2002). Note that more than 90% of the deaf are born to hearing parents, thus lack the language environment to develop language like their hearing peers. Between the hearing parents and the deaf child, the communication channels are simple gestures and home signs. The full-fledged sign language is to be developed among the deaf children community when they enter the school for the deaf. Second, the written language is largely based on spoken language, and for the deaf to learn to read amounts to learning a second language because of grammatical differences between signed and spoken languages. Third, without the phonological bases, the Deaf are naturally double-disadvantaged in learning to read as their hearing peers. In the theory of teaching schoolers in elementary schools, the first three grades are focussed on 'learn to read', and from grades four to six, the focus is on 'read to learn'. When the education system fails to teach deaf children to read from the first to the third grade, the majority of deaf children will have difficulties in entering the stage of 'read to learn'. Without the successful second stage, their learning is seriously jeopardized, and, as a consequence, their metacognition and their desire to read for new knowledge are greatly hampered.

The decoding of Chinese characters is the first step towards the comprehension of reading Chinese. The structure of spoken Chinese also needs to be learned for the second step of reading Chinese. This second step consists of the segmentation of Chinese compound words with different structures, and different types of garden paths in processing Chinese simple and complex sentences. Thereby, a theory of the acquisition of Chinese characters and reading largely on the visual basis is proposed to account for the ability to read and write Chinese by the Deaf in Taiwan.

As to the acquisition of Chinese reading, we can start with SVR (simple theory of reading, as expounded by Gough & Tunmer, 1986; Perfetti, 1999; Scarborough, 2001; Tunmer & Hoover, 1992) and the essence of Chinese grammar as identified by Tai (2023). We will step-by-step unweave the entangled threads of reading Chinese

by the Deaf and hopefully gradually contribute to the reading education of Chinese by the Deaf children as well as the hearing children with reading difficulty.

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