Comparing the Functional Orthography Unit Between Chinese and Alphabets

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Abstract. Functional Orthography Unit (FOU) is the letter in the alphabet and is the radical in Chinese. The present study reviews how researchers come to the aforementioned conclusion utilizing same-different judgement against participants and MRI scans pointing to the posterior region of the brain as the location involved for processing FOU, and that FOUs promote reading and word recognition. The main arguments/findings of this paper are: 1) the Functional Orthography Unit in the two sets of languages perform the identical duties; 2) they differ in how semantics, spatial organization, and the number of units in each letter or word are represented. The paper may inspire future researchers to examine FOU from other types of languages and draw a more universally applicable set of characteristics for the unit.

Keywords: Chinese · Functional Orthography Unit · Abstract Letter Identity · Alphabet

1 Introduction

The process of language cognition has long puzzled psychologists, linguists and neuroscientists. In an attempt to answer the question, the concept of Functional Orthography Unit (FOU) is proposed. Through decades of research, researchers have concluded that FOU is the letter in the alphabet and is the radical in Chinese. Studies utilizing same-different judgement against participants and measuring their effectiveness demonstrate that FOUs promote reading and word recognition. Additional data from Alphabet points to the posterior region of the brain as the location involved in processing FOU. Although the units in the two sets of languages perform the identical duties, they nevertheless differ in how semantics, spatial organization, and the number of units in each letter or word are represented. This essay will review the studies that research whether radical is the FOU in Chinese, whether the letter is the FOU in Alphabet, and finally compare the two identities.

2 Functional Orthography Unit in Chinese and Alphabet

2.1 The Functional Orthography Unit in Chinese

Through experimenting the roles of radicals in reading comprehension, researchers determined that the Chinese functional orthography unit is the radical [1–4].

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A radical means "a root part." [5] Linguistically, a radical can be roughly defined as the building "block" of Chinese characters, but in order to be defined as a radical, more necessary conditions have to be fulfilled. First of all, radicals must be spatially distinct so that they do not overlap with each other and form a "block" on their own. In contrast, strokes, smaller constituents of Chinese characters, do not occupy independent space and might intersect with other strokes. Secondly, radicals carry the role of word level representation [6]. Most radicals have semantic meanings when viewed independently, and can affect the meaning of involved characters. Some also form a complete character on their own. They also affect the phonetics of the character, potentially dividing radicals into semantic radicals and phonetic radicals. This paper will elaborate on this trait in Sect. 2.3. The third characteristic is: Simplified Chinese has 214 radicals in total [7].

A functional orthography unit, or abstract radical identity, is defined as units that are consistent across different fonts corresponding to the names of the unit [1]. Functional Orthography Units (FOUs) do not serve as visual formality, phonological representation, or motor features. Word reading and comprehension account for FOUs by "access[ing] in response to processing specific visual letter shapes and are then used to search memory for the stored orthographic representations of familiar word forms." [1] As seen, FOU plays an important role in reading, providing potential insight into how language acquisition and understanding words.

Previous papers conclude that radicals serve as FOU in mandarin Chinese [1–4]. Several experiments tested the time participants need to make a judgment when researchers manipulate the texts in order to determine the role of radicals in cognition [1–4].

Li et al. conducted an experiment on the aforementioned Chinese conclusion [2]. In the first set of experiments, participants attempted to decide if pairs of radicals with a) same identity and the same form, b) the same identity but different form, and c) different identity and different form were the same. Examples of a pair of radicals with the same meaning but different forms include "水" and "氵," which both identify as "water" but are optically different. Group B exhibited more difficulty in judgment, reflected by lower velocity and accuracy, even after considering confounding variables of visual and semantic similarity, visual complexity differences, and functional differences. The data indicated that it is difficult to "suppress the information that both radicals have the same identity" when Chinese readers make the judgement. Fitting the characteristics of a FOU, the radical carries semantic meaning with it when reading [2]. The experiment was meticulous in terms of dividing groups and controlling the variables. The group diving criteria was setting a tone for later experiments about FOU and radicals in word recognition.

The following experiment tested the influence of radical forms in character on a lexical decision priming task to assess if radicals are accessed in character reading. If radicals are not considered during reading, the reaction time of group B (same radical identity, different form) will not increase compared to that of group C (different radical identity, different form). The results of the experiment revealed, however, "a significant inhibitory priming effect" in group B participants [2]. This experiment went further than the former since imitated the real context of reading by showing whole characters rather than single radicals. In combination, the findings provide strong evidence of abstract radical identity representations of radicals.

The third set measured the impact of two independent variables—the number of radicals, or stroke patterns, and the number of strokes—on the speed of making judgement. The experiment was done in two separate steps. The first paper measured the number of radicals while controlling the number of strokes. It showed that the number of radicals has a negative correlation with the amount of time needed to tell that a pair of characters have the same or different radicals [3]. The followed paper, which included a replication of the study, found that the rule only stands for high-frequency characters in the "same" judgment [4]. Researchers revised the experiment to exclude the effect of another confounding variable: phonetics. They speculated that different characters might have sounded the same since they shared the same phonetic radical, hindering fast judgments saying that the characters are different. However, the results remain similar. Therefore, experimenters turned to another hypothesis to account for the phenomenon. The different strategies used by participants in the two studies still required further evidence. In addition, the latter study took a step further in showing that the number of strokes did not affect reading and recognition in differentiating a character and a non-character, showing the unique role of FOU of radicals [4].

2.2 Functional Orthography Unit in Alphabets

Similarly, the Functional Orthography Unit in Alphabet is the letter. As the definition of FOU shows, letters have "characteristic visual shapes, spoken names and motor plans," that determine the decisive role letters play in language cognition [1]. The characteristic visual shape corresponds to the feature of having various shapes, including uppercase and lowercase, different fonts, not only in printed form, but also distinct handwriting, as well as diver modality, all correspond to the same ALI (Abstract Letter Identity). This feature is also identified as "case-specific visual form." The "spoken name" and "motor plan" are similar characteristics. Different pronunciations and different methods of producing such as written letter might refer to one ALI. These features qualify letter as a FOU.

Similar to what researchers did to Chinese radicals, same-or-different judgement experiment tested the cognition process regarding letters. Subjects were required to determine if the words or word-like combinations of letters are the same or different. It found out that recognizing letter strings with the same letter identities but different in case (e.g., "HILE" and "hile") as "same" is harder than strings pairs with the same identities and case, which is similar to "hile" and "hile". Meanwhile, letter strings with a common phonological code but different spelling (e.g. "hair" and "hare") are classified as efficiently as letter strings without a common phonological code (e.g. "hile" and "hule") [8]. This research provides behavioral evidence for a process of representing and comparing which is neither visual nor phonological but is based on letters, the ALIs. In addition, it implies that computing ALIs is necessary during reading, and therefore might have further application in the study of dyslexia. Also, this experiment is similar to that of examining Chinese radicals, aiming to study the role of FOUs through participants' response time to different word pairs. One disadvantage of the experiment method, however, is the subjectivity of participants. Unless an unusually large sample is extracted, it is hard to evade confounding variables stemming from human differences. Therefore, it is important to ensure that the study is replicable by repeating the experiment.

Further studies focusing on neurological indications of ALI located the brain areas and activities that are responsible for processing ALIs, proving the aforementioned hypothesis that single letters in alphabets are the Functional Orthography Unit. That a specific region in the brain was elicited to react in the same way, as shown by neuropsychological and neuroimaging evidence, respectively, demonstrate that the letter unit has case-specific visual form, spoken name and motor plan, and is therefore the FOU [9, 10].

Research by Dehaene et al. suggests that the posterior, inferior temporal lobe reacts to ALIs [10]. First, only two situations—when the same word was shown at the same place and when an anagram was provided at a location altered by one letter position—reduced activity in the left and right posterior fusiform, a brain part. The repetition of the identical letters at the same retinal area only occurred in those two instances. As a result, such areas may contain "letter detectors" that are calibrated to look for a certain letter at a particular spot on the retina [11]. Second, activation was decreased if the same word was shown twice, even when it was moved by one letter position, in the middle fusiform gyrus, which is located more anteriorly. It was implied by this that location invariance had been attained in this area [10]. This shows the consistency of the brain when dealing with Functional Orthography Units, proving that they play a distinctive role in language processing when people are trying to read. The two aspects form a complete proof for the hypothesis.

However, the attribution of ALIs to this brain function remains controversial [12, 13]. For example, most of these studies did not control for the visual similarity between cross-case letter pairs, leaving open the possibility that the reported cross-case effects originated at some level of visual representation [1]. Indeed, cases were few that addressed the issue of visual similarity between cases, but those who did not show contradictory results against the hypothesis of ALI. Furthermore, given that most of these studies have used word stimuli, another possible source of interruption could be the semantic representations of the letter strings, meaning that strings with the same semantic representation can facilitate making judgements, thus interrupting the mere recognition of letters [1]. The issue, however, is addressed by a recent study, which found no priming effect for semantically similar words [14].

2.3 Comparing Chinese and Alphabet FOU

The Functional Orthography Unit in Chinese and Alphabet are share similarities but are also distinctly different. The common characteristics of the two sets of FOU lie in how they function in language cognition. The first experiment described in Sect. 2.2 and studies in Sect. 2.1 all demonstrate that FOU, or ALI in alphabet, plays a significant role in language processing through that it represents words and affects reading and word or character recognition [1, 6].

In comparison, however, letters and radicals are not alike due to the nature of the two languages. First of all, letters themselves only carry phonetic elements, no semantic implications, while radicals can hold both phonetic and semantic implications. Through reading the radicals in a Chinese character, readers can extract information about the semantic meaning already [15]. For instance, the radical "雨" means "rain" when it represents a one-radical character by itself. Furthermore, when combined with other radicals to form a multi-radical character as a semantic radical, it implies that the word is related to “rain,” e.g. “雪” contains “雨” and means “snow,” which is in a sense another type of precipitation like the rain. The reason why Chinese radicals constitute additional information lies in their formation. Chinese words originate from drawings that resemble real-life objects and situations, and then were simplified to adapt to easy application. The earliest recorded version of Chinese is known as oracle bone script. Meanwhile, letters themselves only carry meaning when they form strings, and single letters do not mean anything.

Secondly, how the FOUs arrange in a series a language do not resemble each other. Letters arrange in a strictly linear fashion, but Chinese units’ spatial arrangements vary distinctly. Single-radical characters will not be discussed below. First of all, the structures can be different. There are left-to-right structures (e.g. “林”—“forest” and “彬”—“polite”), top-to-bottom (e.g. “宝”—“treasure” and “高”—“high”), surrounding structure (“国”—“country”) and half-surrounding structure (“过”—“pass”), etc. In addition, the amount of space each radical occupies enjoys variety. There is 3–7 and 5–5 allocation in double-radical characters. The numbers indicate the ratio to which each radical accounts for a square-shaped character. Typical 3–7 characters include “冰” (ice), where “水” (water) undertakes roughly 70% of the block, and “冫” (freezing) roughly 30%. 5–5 characters involve “林” (forest), where two radicals are the same and each holds half of the space. Although letters in an Alphabet can extend vertically to occupy one to three blocks of space (e.g. c measures one unit in height, Y measures two units, and G measures three in some handwriting; as indicated in Sect. 2.2, the case of the letter does not affect ALI essentially), which is the only variance in spatial arrangement within Alphabet, on the horizontal axis, the spatial occupation is quite strict and unchanging.

Last but not least, the number of these units in each character or word varies. Generally, the number of units in English is much more than that in Chinese. In English, the average word length is 5 letters, and that the largest meaningful words in our dataset are usually 13 letters long, such as international or relationship [16]. A common Chinese character, however, contains four radicals at most. The most complicated character so far, containing 11 radicals, does not make it into the official dictionary but only exists in a dialect dictionary in Shaanxi province, China, while the longest English word can be more than 100 letters long.

3 Conclusion

In conclusion, Functional Orthography Unit in Chinese is radical, and that in Alphabet is the letter. FOUs facilitate reading and word recognition, as proven by studies using same-different judgement against participants and testing their efficiency. Further evidence in Alphabet suggests that a certain brain area, the posterior is responsible for processing the FOU. Despite the same functions shared by the units in two sets of languages, they are still distinct in representing semantics, spatial arrangement and a number of units in each character or word.

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