The Processing and Structure of Kanji and their Implications for Kanji Acquisition: a Theoretical Approach to Kanji Literacy

Noah Hermalin

Carnegie Mellon University Dietrich College of Humanities and Social Sciences Honors Thesis
Submitted December 2015
Advisor: Professor Thomas Werner, Philosophy Department

Abstract: The following paper approaches the topic of learning Japanese logographic characters, known as kanji, from the perspectives of both linguistic processing and second language acquisition. Three existing methods of kanji learning are analyzed in relation to four proposed key criteria of kanji literacy, and research on kanji structure and processing are synthesized to achieve a stronger understanding of the relationships between kanji, the Japanese language, and literacy. Finally, the information from the first two sections is tied together and a novel method of kanji learning, which is consistent with the results and evidence regarding kanji learning and kanji processing, is proposed.

Table of Contents

Introduction: Logographs, Alphabets, Japanese Orthography, Kanji Proficiency

Logographic writing systems, such as the characters used in Chinese and Japanese, contrast in many ways with the alphabetic systems of many other world languages, including English; the main difference being which relevant linguistic unit(s) a symbol represents or maps to. Whereas the letters of alphabetic systems map at least roughly to sounds, what exactly logograms map to is still a matter of some debate, with some saying they map to words, morphemes, specific combinations of sounds, meaning, or some combination thereof. With some exceptions, it's generally agreed that logograms represent words or morphemes, perhaps including whatever semantic/phonetic value those words/morphemes carry. In essence, while an English word may be graphically represented by the combination of sounds that form the word (e.g. *logo* consisting of the symbols *l, o, g,* and *o*, which in turn contribute the sounds /l/, /oʊ/, /g/, and /oʊ/, in the correct order), a Japanese word could be represented by a single symbol, or combination of symbols, that map more directly to that word's morphological components (e.g. 速読, /*sokudoku*/ ("speed reading") consisting of the character 速, which contributes the /*soku*/ ("fast") half of the word, and 読, which contributes the /*doku*/ ("reading") half of the word).

The differences, and similarities, between these systems is a point of interest and significance for various areas within linguistics, not the least of which being written language processing and written language acquisition. The purpose of this paper is to examine these differences closely and determine how these differences apply to acquisition of second languages with logographic systems by individuals with a non-logographic first-language background. (As a brief terminology note, 'first language' shall hereafter be referred to as 'L1,' and second/foreign language as 'L2'). The language of interest for this paper is Japanese, which is

notable for its mix of syllabic (or, to be more accurate, moraic) and logographic characters in a comparatively complex system, relative to most other widely-used written languages. By examining the theoretical backbone and cognitive processes behind alphabetic proficiency, logographic proficiency, and written language comprehension as a whole, the goal is to evaluate the validity of various methods of acquisition, including novel ones presented in this paper, as well as touch on what the effectiveness of these methods reveals about learning and knowing written language.

Written Japanese

Written Japanese consists of logographic characters (*kanji[1]*), syllabic letters (*kana*) and in modern use the Roman alphabet, as well as Arabic numerals. The components relevant to this discourse are that of kanji and *kana*; in general, kanji are used for content words: adjectives, nouns, verb stems, and so on. The total number of commonly used kanji comes in at between 2000 and 3000 characters; high school graduates are generally expected to know the 2136 most common kanji.*Kana* are the syllabary of written Japanese; each *kana* represents either a consonant-vowel pair (e.g. か /*ka*/) or just a vowel (あ /*a*/); there is also a pair of *kana* for a nasal phoneme /N/. Each *kana* comes in two types, *hiragana*, used primarily for native words and grammatical purposes, and *katakana*, used primarily for foreign words; in total, the number of *kana* (both *hiragana* and *katakana*) is 92, along with two diacritics that can be applied to certain *kana* to denote a consonantal sound change.

To give a brief example of how these systems come together, consider the following sentence, where kanji are underlined, *katakana* are in bold, and *hiragana* are bereft of

---

[1] Brief Notation Note: I will not be writing kanji in italics for the remainder of the paper. Other words of Japanese origin (such as *kana*) shall be italicized.

typographical changes : ノアは論文を書いている (/ **noa** *wa* ronbun *wo* kaite iru /,

"Noah is writing a thesis.") *Katakana* is used to write the foreign name, "Noah." The noun

/*ronbun*/, "thesis," as well as the stem /*ka*/ for the verb "to write," are in kanji. The grammatical

markers /*wa*/ and /*wo*/ are in *hiragana,* as are the letters forming the inflectional ending of the

verb.

Competence in both kanji and *kana* is paramount to Japanese literacy. While words that

are written in kanji can be legally written in *kana*, in practice they rarely are, and the high

homophone count in Japanese would make such writings at higher risk of ambiguity. As such,

readers of Japanese have little choice but to be proficient in all *kana* and a large number of kanji,

lest they find themselves unable to read certain words.

The challenge of kanji literacy unfortunately extends beyond mere prolificacy; there are a

large number of kanji that have (at least) two completely disparate pronunciations depending on

what they lie adjacent to. In general, these readings are split into *kunyomi* and *onyomi*; the former

refers to the 'traditional Japanese pronunciation' while the latter is the pronunciation borrowed

from Chinese (more on this later on). Characters may have additional pronunciations depending

on various factors; the important takeaway is that learning kanji is more than just memorizing

2000 character forms, or even 2000 pronunciations; knowledge of context, syntax, and

orthographic interaction must also be learned before one can be literate in Japanese.

The Main Components of *Kanji* Proficiency

Based on a large body of research regarding written language processing and teaching of

Japanese as a foreign language (hereafter JFLT), I argue that kanji proficiency relies on the

following factors:

Visual/Orthographic Recognition

One obvious prerequisite to reading kanji is knowledge of what each kanji looks like. It would be presumptuous to label this a simple task, however; even beyond the sheer number of kanji, factors such as complexity (including highly-complex characters such as 響) and the existence of near-homographs (such as 丈 and 文) can add to the difficulty of orthographic recognition of characters. Some characters occur quite frequently in Japanese texts, while others are exceedingly rare. While most kanji can be broken down into smaller structural parts which often do contribute some information, the only real guarantee that a character can be recognized is for the reader to have knowledge of that specific character itself.

Character Production

The necessity of this factor is perhaps declining as computers take over the realm of writing, but unless handwriting ceases to be entirely the ability to retrieve and produce characters from memory is required for writing Japanese. The distinction between orthographic recognition and production is not to be overlooked; as researchers like Burling(1982) have noted, writing ability is not prerequisite to reading ability. Production of characters depends on a set of motor skills unique to writing kanji; furthermore, just as writing ability is not prerequisite to reading ability, so too does reading ability not imply writing ability, and people literate in Japanese will likely recognize more characters than they could reliably produce.

Japanese Lexical, Phonetic, Semantic, Syntactic, and Cultural Inventory

This is a broad category that could perhaps more smoothly be stated as 'Japanese linguistic knowledge;' the caveat with such a description being that there is not yet a universal

consensus regarding the degree to which each of the five 'inventories' mentioned above are connected, prioritized, and so on in relation to written Japanese. Put bluntly, a reader who does not know Japanese words (including, to varying extents, the phonetic, semantic, grammatical/syntactic, and cultural information encoded therein) cannot read Japanese. Perhaps surprisingly, it seems that this seemingly tautological assumption might in fact not be present (to a sufficient degree) in certain common methods of kanji acquisition.

Memory/Retention

Kanji proficiency is impeded if memory associated with kanji and the factors above is weak. Not only must a learner of Japanese be capable in the areas mentioned above, but their capability must extend to the long term to be literate in Japanese.

Leading from my claim that these areas are all necessary for kanji proficiency, I argue that an optimal method for kanji teaching/learning must incorporate as many of these areas as possible. As such, when considering the effectiveness of a method, it is prudent to ask: is the method aiding in visual recognition of characters? Is it strengthening the learner's ability to recall and produce characters? Most importantly, does the method draw upon and reinforce the connections between Japanese orthography and Japanese language? The issue of extralinguistic versus intralinguistic domains should not be ignored: if a method doesn't involve actual use of Japanese language skills (extralinguistic), it's unreasonable to assume that it will help foster and build Japanese proficiency, especially compared to methods that make strong connections to the actual practice of using and thinking in Japanese (intralinguistic). Finally, does the method work in the long term, or does it fail to create lasting effects on proficiency? If a method falls short in too many (or, arguably, any) of these areas, perhaps it should not be considered effective.

Section 1 of this paper examines, one by one, three methods of kanji teaching: rote memorization, whereby characters are learned via writing drills and repetition; mnemonic methods, whereby characters are learned by connecting character forms to something like a story that may be retained better in memory; and two kinds of teaching based on the historical and structural components of kanji: teaching kanji via their developmental history, and teaching kanji via instruction of their structural components. Each method is analyzed based primarily on the four criteria mentioned above, as well as in regards to their relation to how kanji are used in practice: textual reading. The second section of the paper discusses in greater detail the nature of logography, the modularity of kanji, and how kanji are processed.

Section 3 ties the analysis of the prior two parts together and presents a novel method of kanji learning called an orthographic gradient, whereby the orthography of a textual passage gradually shifts from phonetic *kana* script to logographic kanji script. For example, the word 熊 /*kuma*/ "bear" would occur written in kana as くま /*kuma*/ earlier on in the paper, but by the end all instances of the word would be written 熊 /*kuma*/; an intermediate stage would also be present in which the characters are presented with their *furigana* (small *kana* printed above the word that informs the reader of the character's pronunciation: e.g. 熊^(くま)) Such a method introduces and reinforces usage of characters in a Japanese contextual setting that is engaging and memorable for the learner. The connection between a character's phonetic, orthographic, and semantic (and/or lexical) information is retained, and the method can operate strictly within the domain of the Japanese language without being supplemented by English or any other non-Japanese linguistic input.

Section 1: Analysis of Methodology: Rote, Mnemonics, and Historical/Structural Analyses

Rote Memorization

Frequently-used materials such as *Basic Kanji Book*[2], by Kano, Takenaka, Ishii, and Shimizu, often make use of the strategy of rote memorization, whereby items are committed to memory via repetition. In the context of kanji, this commonly manifests as repeated writing of a given character, often, but not always, in isolation, and this is the definition of rote I will be using in this paper (there are other similar practices that could be considered rote which will not be considered here). Such a task incorporates both motor and visual elements. Exact repetition count varies heavily by curriculum and instructor, and students always have the option of writing a character more times if they wish. In textbooks that use rote, a given page may include a new character, its stroke order, some blank spaces in which to write the character, the character's readings, and perhaps some sample words that contain the character. In Japan, rote serves as the most frequently used method of introducing new kanji, and results from surveys of Japanese language instructors in the US (Shimizu and Green 2002) suggest that rote is also the most common method for JFLT in the US.

An analysis of the rote method must consider the assumptions that the method makes – namely, that repeated writing of a character (a predominantly motor exercise) translates to improved memory storage, recognition, and recall of the character; in turn, this assumes, or presumes, a sufficiently powerful connection between motor exercise and some combination of linguistic storage and image recognition. The next logical question then would be regarding what

---

[2] I would like to point out that I by no means feel that BKB is a bad textbook at all; I am merely citing it as a commonly used source that, to at least some degree, employs the rote method.

evidence can be found to support this connection, or at least whether or not this connection is stronger than other reasonable alternatives.

The element of muscle memory serves as an easy starting point. There is no shortage of evidence supporting the conclusion that increased use of a motor activity or routine leads to increased proficiency and automaticity of the routine (e.g. Pirolli and Anderson 1985, Ericsson et al 1993), and it's reasonable to expect this to hold for writing. In terms of production, then, the more one writes a character, the more automatic the process of writing that character becomes, which of course aids physical reproduction of the character. It would also seem reasonable to state that the effectiveness of rote is independent of orthography type, with the only difference in rate of acquisition being the number of symbols or symbol components one must learn.

While the complexities of handwriting kanji are not trivial, motor proficiency is moot if a character cannot be recalled or recognized, and is arguably useless in situations where a kanji's semantic or lexical content is unknown or forgotten. As such, in all domains of kanji proficiency and acquisition, it is important to consider whether rote memorization serves to heighten kanji processing in the context of semantic, lexical, phonological, or any other linguistic context; that is, does rote memorization aid in a student's Japanese language ability in any way other than the physical act of writing a character down?

A commonly-cited rationale for the rote method is that it mirrors how kanji are studied by native speakers of Japanese in Japan. Given that the processes by which native languages and foreign languages are acquired seem to be similar in many respects (e.g. Chikamatsu 2006, Liu et al 2007) it's not surprising that the prevalent method for native speakers would be assumed potent for second language learners. It's even been argued that, at least for Chinese, this rote

method should be encouraged for its cultural context, as it exposes students to the same cultural learning setting as native speakers(Tan 2011). This assumption that methods functional for first language learning are equally applicable to second language learning cannot be immediately dismissed given the evidence supporting carry-over of acquisition methods between L1 and L2, but there are various factors that do seem to cast doubt on the effectiveness of rote as a strategy for learning kanji. Firstly, while means of acquisition may have parallels between L1 and L2, the fact of the matter is that environmental factors, not the least of which being the setting and context in which a student lives and learns, will inevitably influence the effectiveness of a method, and the difference of environment between L1 and L2 learners will significantly alter the usefulness of rote memorization. A second caveat to rote is the often-overlook aspect of motivation and emotion; while native speakers of Japanese are driven to learn kanji since it's so necessary for living in Japan, second language learners will lack that motivation and may view kanji as an obstacle not worth overcoming(Shimizu and Green 2002, Rose 2013). Finally, another blow to rote again ties in with the idea of L2 learning reflecting L1, for there is also a body of evidence that seems to challenge this notion, especially when comparing alphabetic and logographic systems.

One of the key differences between rote for L1 and L2 learners is that the former is writing words or morphemes, whereas the latter is often just writing symbols. The distinction is that L1 speakers already have an expansive lexical and morphological inventory in Japanese; as such, when learning a new character, the character can directly link to meaningful linguistic units that are already firmly within the learner's language knowledge; linguistic ability is of little concern given that they already have native proficiency in the language, so the main hurdle is that of character production and recognition. Most L2 learners will not have this luxury of

native-level verbal Japanese ability, especially in curriculums whereby new kanji are introduced at the same time as the words they represent. Considering the research showing that phonetic awareness is a strong predictor of literacy skills and acquisition(Sparks et al 2011, Landgraf et al 2011, Matsumoto 2013), repeated writing of a character without a strong sense (or any sense, even) of its phonetic value would be detrimental, or at least inefficient. There are various theories regarding logographic character processing in relation to semantic, phonetic, or lexical information (that is, the degree and paths with which orthographic, phonetic, and semantic information connect to each other and to lexical items; see later sections for more detail on this topic), but regardless of the model one ascribes to, it seems reasonable to state that meaningful processing can only take place if there already exists some information for a character to point towards. Since the physical form of kanji themselves have no inherent, objective value outside the context of language, writing of a character ad naseum will not itself contribute towards meaningful understanding of a language. Combined with the evidence that writing ability is both separate from, and not prerequisite to, reading ability (e.g. Bi et al 2009, Hamilton and Coslett 2006), it would be erroneous to assume that rote alone will contribute significantly towards learners' Japanese literary abilities. While characters might not be introduced in a complete vacuum, L2 learners' Japanese lexical background regarding a character will often not be strong enough for the simple motor exercise of writing that character to be of much value. Evidence that aspects of language such as vocabulary and grammar is more meaningfully learned by use (e.g. Swain 2011) than rote practice confirms and supports the hypothesis that rote learning of kanji does little to actually improve the Japanese abilities of the learner, and even the commonly agreed upon notion that practice supports proficiency calls rote's effectiveness (beyond that of physical writing) into question, as repeated writing of a character doesn't reflect how knowledge

of a character would be put to use: in some textual context. Writing a character repeatedly certain increases exposure to the character, but not in the setting in which a character would actually be encountered. The sheer number of kanji does indicate some necessity for rehearsal of form, and Mori and Shimizu (2007) do cite research supporting the effectiveness of rote for logographic characters (Naka 1988, Onose 1988), but dependence on rote does seem to be at odds with the basic theory behind practice and building of linguistic knowledge.

Beyond the strictly linguistic considerations of rote are the elements of emotion and motivation, two extralinguistic areas which have been found to be significant indicators of L2 learning aptitude, seem to be inhibited by the rote method. Shimizu and Green (2002) and Mori and Shimizu (2007) report a correlation between students' positive emotions regarding kanji and strong beliefs and motivations regarding kanji learning; in fact, these studies also found a direct link between negative motivation/emotion and a belief that rote was the best, or only, way to learn kanji. Worries such as time, boredom, and assumed memory burden regarding kanji learning and rote methodology were cited as reasons that strongly discouraged students from studying kanji or even continuing with their Japanese studies. Considering how intertwined emotion and cognition can be (e.g. Gray et al 2002), the observed distaste for rote in many students who have used the rote method for kanji study, continued focus on the method might not be the best, or at least healthiest, choice in the Japanese classroom.

Thus far, rote seems to be advantageous for production of a character (at least in a motor sense) and, to much a lesser extent, recognition/exposure to a character, but with a low degree of actual linguistic connection in regards to Japanese language ability and literacy. Rate of retention of kanji learned by the rote method also seems to be less than optimal. Wang et al (1992; see also Wang and Thomas 1995) found that on an immediate recall test students who studied with

mnemonic methods performed roughly twice as well as those who studied with rote. When tested again weeks later though, both groups performed about equally; this can be interpreted as evidence that rote has low effectiveness in the short term, but is retained slightly better over time. The better retention rate should still be treated with caution though, for two reasons. Firstly, it would take significant time and energy to overcome the poor short-term effectiveness enough to build to a strong starting point. Secondly, the results of the studies above showed a convergence over the target period to about 5 characters (out of 20); though the rate of change for rote was better (still clearly negative though), this might just be because there were fewer items learned to begin with and 5 characters happens to be the number of characters firmly stored in long-term memory for the task for both methods; in essence, the short-term results were much worse than with mnemonic methods, and the long-term results were the same.

Rote's status as the apparent de facto choice for first language Japanese teaching cannot itself justify the assumption that it is also the ideal method for foreign language learners. The connection between repeated writing of a character and actual proficiency in reading and understanding the character seems to be poor, and the emotional strain it may put on learners is a significant point of consideration. Though it is the most commonly employed method in Japan, Tan (2011) point out that rote is not as common a teaching method for primary schooling in the US; as such, students who grew up in the US have less practice with, and affinity towards, rote methods. This is especially relevant regarding beginner or intermediate-level learners, as scholars have suggested how reading strategies (for new languages and writing systems) are developmental, not static (e.g. Chikamatsu 2006, Toyoda and McNamara 2001), meaning that for teaching western students, most of whom have lesser experience with rote methods, the fact that rote is commonly used in Japan does not by itself justify the use of rote for foreign learners.

Analysis of rote, on at least a theoretical level, shows that of the four factors necessary for literacy acquisition, only production, and perhaps recognition, are significantly aided, with memory and linguistic connections/acquisition, as well as extralinguistic factors such as emotion, significantly inhibited.

Mnemonic Methods

Mnemonic methods are rather frequently employed as strategies for retaining kanji. Exact form varies strongly by learner, but these methods can involve assigning names, (extra- or inter-linguistic) semantic values, stories, word associations, or other meaningful values to either whole characters or character components. Sometimes these values reside within a Japanese context (for example, linking the characters 士, 豆, and 口 with their common semantic values of "warrior," "bean," and "mouth," could aid in recalling the character 喜, meaning 'to be happy,' via a small story, like "the warrior ate the bean, which he enjoyed" (note the resemblance of 喜's component parts, from top-to-bottom and the three characters listed earlier in this parenthetical)). Conversely, the associations could be outside the domain of the Japanese language, perhaps with a focus on shapes instead (for example, noting how the character 祖 visually resembles a tombstone may aid one in remember that 祖先 means "ancestor").

Heisig supports this strategy in his book *Remembering the Kanji*, wherein he demonstrates how assigning names and values to the smaller components of characters can be used to connect the character's meaning via a story incorporating the component parts. For example, consider the character 泊 (the root of the verb meaning "to stay the night"); Heisig's

proposed mnemonic connects the left half of the character, which he calls the 'water' primitive, and the right half of the character, which is identical to the kanji 白 /*shiro*/'white,' with the character's via the following story: "*[when one stays underlined overnight], all you expect is a bit of water for a wash and a set of clean white sheets…*" As long as the learner can remember this brief, but memorable, story, they can remember the character and its meaning. While the book itself lists sample mnemonic devices that he himself used to great success, Heisig encourages students to find the methods that work for them personally. This reliance on personal difference is a double-edged sword, whereby some students may find the method particularly helpful but others will struggle and perhaps be unable to come up with stories; this makes mnemonic methods a risky choice when planning a curriculum, as the results could vary significantly across students. Nonetheless, individual differences are relevant to many aspects of learning in general (e.g. Tóth 2014), so mnemonic methods should not be ruled out on that basis alone.

The mnemonic method can be seen as potentially useful for both recall and recognition of characters, and cases like that of Heisig demonstrate how powerful it can be for some individuals (indeed, association tricks like this are often employed by frontrunners in memory competitions). While the power of mnemonic methods for recall/recognition of specific items is well-attested, at least for certain individuals, there remains the question of its linguistic effectiveness; in essence, will these methods improve actual Japanese language ability, or merely proficiency with a character's image? Even the subtitle of Heisig's book, *A complete course on how not to forget the meaning and writing of Japanese characters*, is notable missing any mention of phonetic ability or even word-level semantic comprehension. In Heisig's first volume, characters' Japanese pronunciations are not given. In fact, I argue that mnemonic methods like those

suggested by Heisig have the potential to be detrimental towards *kanji* acquisition if not used properly.

The most dangerous element of mnemonic methods is that of linguistic connection to the target language. Perhaps even more so than rote, many mnemonic methods are lacking in lexical and phonetic information, which runs counter to the evidence that phonetic processing is necessary even for logographic characters (Sakuma et al 1998, Flores d'Arcais et al 1995 to name a couple; more of this will be discussed in section 2), as well as this paper's running point that without lexical knowledge, the potential to make meaningful neural connections between orthography and other lexical components is significantly hampered. As can be seen in the above "staying the night" example, the component names and character stories are entirely in English. As such, it seems that Heisig-esque mnemonic methods are doing little more than forging form-based connections in memory. This is not necessarily a bad thing, as recall and visual recognition are indeed among the factors I argue are necessary for kanji proficiency; what I do argue is that the trade-off for this boost in memory ability is coming at the expense of Japanese ability. Simple lack of phonetic and lexical connections is itself not insurmountable – perhaps additional methods could cover this shortcoming – but what Heisig-esque mnemonics run the risk of is making connections between kanji and the learner's L1; especially if the stories and associations being made are outside the realm of Japanese (i.e. based on semantic values of characters or simple shape-associations), the characters may be mapped to some semantic/lexical value that is not sufficiently present in the learner's Japanese lexical inventory. This means that while the method may aid the learner in recognizing 祖先 as "ancestor," this association ignores the Japanese word /*sosen*/ and does not aid in morphological awareness and breakdown of the word. This effect has indeed been observed in L2 learners of Japanese who use mnemonic methods: a

student may recognize a character and its meaning, but not the Japanese word it maps to, which means the student is essentially reading their L1, just in a different orthography (Rose 2013). Even worse, students will sometimes remember the story associated with a kanji but neither the Japanese word it maps to nor the meaning of the character at all (Rose 2013). This does not seem to be particularly beneficial towards kanji learning on a linguistic level, and it demonstrates how strictly memory-based neural connections regarding physical form do not imply meaningful linguistic connections.

In fact, even regarding memory there is some doubt regarding the efficiency of mnemonics. As mentioned earlier, Wang et al (1992) looked specifically at mnemonic and rote methods and found that while mnemonic methods were much stronger in the short term, students forgot characters learned with the rote method twice as fast, so after a moderate period the rote group and the mnemonic groups performed the same. This suggests that mnemonics might not be the best long-term method, and that mnemonics require some upkeep to stay relevant; the matter of upkeep was considered by Wang and Thomas (1995), who confirmed that the poor long-term retention rate can be abated with consistent practice; once practice ceases, however, the poor retention rate kicks in. The long-term efficiency of mnemonics is called further into question when one considers the aforementioned cases of students remembering the mnemonic itself, but not the relevant linguistic information associated with the character. The effect of diminishing returns is yet another potential problem with mnemonics, as many students report some degree of exhaustion with the method (Shimizu and Green 2002, Rose 2013). While mnemonics may be sufficient for the first few hundred characters or so, there is a limit to how many mnemonic associations one can keep track of in the long term.

Speed of recall presents itself as yet another factor impeding the effectiveness of mnemonic methods. If access to a character can only be mediated via mnemonic story, reading of a Japanese text could become repeatedly halted if the reader needs to stop and remember the character for each character; furthermore, it seems reasonable to postulate that having to pause and access the semantic information present in the mnemonic will interrupt the flow of reading; it also could require the exhausting task of constant switching between L1 and L2 in the case where the mnemonic is mediated via the L1.

One last point regarding mnemonics is their potential for propagating misconceptions about the structural morphology of kanji and kanji development. Even in Japan usage of mnemonics is not a rare occurrence, and kanji may have 'origin stories' associated with them that often bind semantic values of components, sometimes with additional background information. These origin stories are often apocryphal. Whether or not this is a good thing is hard to say; on one hand, such stories do provide cultural context that could aid in cultural knowledge and understanding, but it does lead to misconceptions regarding kanji which could lead to further confusion down the line with characters that cannot even anachronistically be broken down into some semantic story; of greater consideration is the propagation of the idea that kanji characters themselves have inherent semantic value, which is a point of contention regarding this paper's theories. As the influence of such 'origin stories' has not been clearly examined to my knowledge, I shall leave it as merely a point of future consideration.

A reasonable rate of orthographic retention associated with mnemonic methods is offset by unreliable connectivity with linguistic factors, especially phonetics. Dependence on semantics outside the context of the target language can run certain risks, especially regarding recall of actual Japanese lexical items, and speed of processing will be slower if access to characters is

mediated by entire stories; furthermore, as with rote, mnemonics don't necessarily involve kanji in their natural setting of meaningful text, and don't provide practice with reading kanji as Japanese words. Mnemonic methods certainly have their advantages, especially in the short term, but their long-term detriments and limitations seem to recommend against using mnemonics as the primary method of learning kanji.

Kanji History, Development, and Structural Morphology

The origins of the Chinese writing system as a whole is not a topic one would necessarily expect to see, at least in significant detail, in a JFL course. This is not to say that stories of character origins (be they historically accurate or not) are not used; such stories, which could be seen as falling under the mnemonic strategy, are sometimes employed by educators in an effort to aid in student's kanji ability. The most commonly accepted theory of the origins of Chinese characters is in fact not quite how mnemonic tales might suggest; rather it is the product of a long combination of semantic and phonetic factors. As Boltz details in *The Origin and Early Development of Chinese Characters* (2003), Chinese characters started as what Boltz calls *zodiographs*, which were essentially pictographic characters in the context of spoken ancient Chinese. The distinction between zodiographs and logographs is subtle, but extremely important: to oversimplify somewhat, zodiographs refer to the earliest stage of linguistic writing, wherein simple images that actually depicted the real world item were presented according to the syntactic rules of ancient Chinese. Logographs such as modern day kanji are not drawings of real items, and kanji especially involve complex context-based phonetic/semantic changes that would not have been present for early zodiographic systems. The evolution to the logographic system known today occurred via rebus principle. Zodiographs, being primarily drawings of concrete objects, could only show those concrete objects, such as the ancestors of the characters 目 "eye,"

象"elephant," and 口"mouth;" how, then, would more abstract ideas be written? Ancient Chinese written language took advantage of homophony in the language and used characters to represent words that were phonetically similar to the character's intended word (an English example would be using a picture of an eye to mean the first person pronoun 'I'). There were also cases of a character being semantically extended to a range of word, such as the character for 'mouth' also being used for the verb 'to call.' These usages of course led to confusion regarding which reading of the character the writer intended; to account for the ambiguity, the system of determinants was introduced, determinants being additional marks added to a character to dispel ambiguity. There are two kinds of determinants: semantic and phonetic. Semantic determinants would be added to characters for which the multiple possible meanings were phonetically related, while phonetic determiners were added to characters where the ambiguity was due to semantic similarity (examples: phonetic determinant 夕 /*ming*/ provides phonetic clarification for semantically ambiguous 口(either /*k'ou*/ "mouth" or /*ming*/ "to call") to make 名 /*ming*/ "to call;" semantic determinant イ 'person' provides semantic clarification for phonetically ambiguous 象 (either /*hsiang*/ "elephant" or /*hsiang*/ "image") to make 像/*hsiang*/ "image"). Determinants are commonly referred to as 'radicals' in modern use. The development of the characters is a fascinating process that unfortunately will not be discussed is further detail in this paper, but its implications for kanji learning will be. The primary takeaway is that due to the somewhat complex and inconsistent development process the characters underwent, only a modest percentage of characters carry a semantic value bound directly to their written form/components; this also accounts for the lack of consistency regarding phonetic information in character reading. Even in modern Chinese, where each character generally has only one pronunciation, only 18 of

the 1,522 phonetic radicals are truly consistent; all the others have at least some exceptions (Ehrich and Meuter 2009).

The implications that kanji's nature has for JFLL should not be overlooked; if characters truly do follow a reliable pattern, or set of patterns, regarding the relationship between determinants, then knowledge of said patterns could serve to mitigate one of the more frequent problems JFLL face: that of reading kanji that are not yet part of the learner's repertoire. Research shows that JFLL past a certain level of exposure gain strong inference skills regarding recognizing/reading unknown kanji based on radicals, and it's possible that more explicit teaching of this relationship could improve or hasten the development of this skill. The fact that this is not a more common aspect of JFLT would suggest that either it's impractical, as the aforementioned research arguably refutes, or that it's not particularly common knowledge even amongst educators of JFL (the latter option being at least partially supported by polls of teaching methods across JFLT (Shimizu and Green 2002, Mori and Shimizu 2007)).

Using information about kanji history and development as a method of kanji education does rely heavily on two assumptions that unfortunately do not hold: the assumption that kanji have not continued to change and warp over the years, and the assumption that kanji are used in Japanese the same way they were in (ancient) Chinese. Linguistically, Japanese and Chinese are quite different languages, so the assumption that simply making mappings of kanji to Japanese in an analogous fashion as mapping kanji to Chinese is dubious. To make a long story very short, there was not a single consistent way that kanji were adapted for written Japanese. Some characters were used primarily as phonograms, some were linked to words based on semantics, others were only used to write borrowed Chinese words, and many characters were used in more than one of these ways; the fact that the same character was sometimes borrowed multiple times

at different points in history, with different pronunciations or semantic applications, does not

simplify the matter (Taylor, Taylor, and Martin 1995). This is the origin of the *onyomi-kunyomi*

split; the same character may be used to write phonetically distinct native Japanese words and

borrowed Chinese words; in the context where it maps to the Japanese word, the *kunyomi*

reading is used, and in contexts where it maps to a Chinese word or pronunciation the *onyomi*

reading is used. For example, the character 今"now" is read by its *kunyomi* /*ima*/ by itself and by

its *onyomi* /*kon*/ in various compounds, such as 今回 /*konkai*/ "this time." In general, *onyomi* are

used in compounds of two or more characters, while *kunyomi* are used for single characters.

However, it's not always this cut and dry; some native Japanese words, including ones that were

monomorphemic, were assigned two-character representations; as such, the two character word

今日/*kyō*/ "today" involves neither characters' *onyomi*, nor does it involve the *kunyomi* the

character would have by itself; the semantic value is exactly what one would expect, however:

'this day.' Tranter (2013) provides the example 美味しい of a native Japanese single morpheme

that had a two-character mapping; the word /*oi-shī*/ is a bimorphemic word in Japanese meaning

delicious; the しい/*shī*/ part is a typical inflectional ending for adjectives, and the 美味/*oi*/ part is

a single morpheme denoting deliciousness; however, since the way deliciousness was written in

Chinese was the two characters 美味 (literally 'beautiful flavor'), that was how it was applied to

the native Japanese word as well. To make matters even more confusing, some native Japanese

words received more than one kanji assignment; the Japanese verb /*naosu*/, meaning "1. to heal

an illness, or 2. to fix or repair something," is written differently depending on which of the two

meanings it's referring to (the former written 治す, the latter written 直す). In short, the degree

of inconsistency present in the kanji system is far from trivial, which makes it challenging to

come up with system-governing rules for kanji phonetic information that don't have various common exceptions.

Teaching based on the radical components of kanji, shows more promise, and researchers have begun giving more attention to the role that radicals play in kanji learning and processing in recent years. Researches such as Takashi (2001) note that knowledge of trends in radicals is used by learners of Japanese to help understand and learn new characters, both from semantic and phonetic information. For example, the character 食 is used in words related to food or eating, such as 食べる/*taberu*/ "to eat;" as a semantic radical, it shows up in words like 飲む/*nomu*/ "to drink" and ご飯/*gohan*/ "meal." On the phonetic side of things, the visually similar characters 簡 and 間 share the *onyomi* /*kan*/, but are semantically distant. Learners with a good understanding of how radicals influence the information contained in a kanji therefore have a better time with new characters and can better draw connections between new and old characters, which aids in learning characters and, importantly, stays within the linguistic domain of Japanese. Kubota and Toyoda (2001) found that explicit teaching of radicals to students of Japanese significantly helped with retention rates, and others are beginning to design novel methods of teaching with a stronger focus on radical components in general (e.g. Shin and Shimizu 2012). Nakagawa (1994) compared reading of two types of pseudo-kanji derived from real kanji; one type was derived from a real character by changing the order of its radicals (e.g. 月日 instead of 日月), and the other type was derived from a kanji by erasing one of its strokes (leading to ill-formed radicals); participants in the study had a much easier time with the rearranged characters than the erased characters, showing the strong effect that radicals can have on character processing. Evidence from patients with Broca-type aphasia (Hashimoto et al 1998) and crossed Wernicke's aphasia

(Ihori et al 1994) found that to a certain level radicals, rather than whole kanji characters, are processed as graphemic motor units, which provides additional support for the idea that radicals play a key role in kanji processing. In the context of production, research by Conditt et al (1997) found that motor systems learn new tasks as a sum of movements rather than a whole sequence; in the context of kanji production, this could suggest that greater focus on individual radicals, rather than whole characters, more closely mirrors the way the motor system learns to write kanji in general. Since the same radical may appear in many different characters, explicit radical knowledge will aid production as well by noting how orthographically, many characters are just combinations of parts the learner has already learned.

Radical analysis faces a handful of challenges that perhaps prevents it from being sufficient on its own. As previously noted, despite the presence of general trends in kanji composition, there are numerous inconsistencies; to reuse the 食 example, while characters like 飲 'drink' and 飯 'meal' share a clear semantic connection, 館 'building' does not, and a learner that depends on radical analysis to evaluate this character might falsely assume it is directly related to food/meals, when it's not; when the learner tries to link this new character back to ones s/he has already learned, there might be some confusion as to the lack of food-ness in the meaning of the new character. Toyoda and McNamara (2011) observed this exact effect, whereby advanced L2 readers of Japanese had a much harder time learning new characters that were not consistent with previously learned characters in terms of semantic radicals, pointing to some degree of overdependence on radicals; conversely, less experienced students who did not yet have as strong a dependence on radicals made fewer errors on semantically-inconsistent kanji. Students in this study even reported that they were hesitant to trust radicals due to how inconsistent they seemed to be. Similarly, Saito et al (2002) found that students with high

awareness of radical knowledge were more error prone when dealing with characters that contained familiar radicals in ways inconsistent with previously-learned characters that contained that radical. Structurally, radicals indeed are inconsistent; while some radicals have a somewhat reliable pattern of semantic or phonetic information across characters, some radicals contribute nothing other than form distinction, and even seemingly consistent radicals are not without their various exceptions (Trenter 2013). On a similar note, even a consistent semantic radical does not guarantee a consistent phonetic radical and vice versa, and learners that encounter a new character may know its semantic gist but not its reading, which would mean they wouldn't have a Japanese internal lexical entry to connect it to.

The method of radical analysis seems to be a mixed bag; while it performs well in all four proposed areas of kanji proficiency, it encounters significant problems with exceptions and inconsistencies. In addition, radical analysis too does not present characters in a textual passage or context and thus does not stimulate kanji knowledge as it is used in practice. The advantages of radical analysis should not be ignored, and in conjunction with other methods that make up for its few shortcomings could prove to be quite beneficial for learning and teaching of kanji.

Section 2: Logography, Modularity, Processing of Kanji and Written Language

Logography and Modularity

"Logograph" is used as somewhat of a blanket term that covers a comparatively broader spectrum of writing system types when compared to systems labeled as "phonetic." As pointed out by Tranter (2013), the systems and characters that fall under the 'logogram/logographic' umbrella include morphograms, whereby a symbol maps to a morpheme, or perhaps a whole word; so-called ideograms, which map to semantic meaning; syllabograms/phonograms, which map to set sound combinations; as well as systems that seem to combine morphological, phonetic, and/or semantic elements. Various logographic systems throughout history have made use of the previously mentioned determinant/radical system, whereby characters consist of semantic and phonetic components, and there's an observed general pattern of logography development from being primarily semantic to primarily phonetic: Chinese characters, Egyptian hieroglyphs, and Sumerian cuneiform are all examples of systems that, at varying points of history and development, have made use of semantic-based characters, the determinant system, and more phonology-based character usage. The natural progression seems to start out grounded in semantics, as seen in what Boltz (2003) calls *zodiographs*, progress to a combined semantic-phonetic stage, and, in the case of many writing systems, eventually becomes entirely phonetic; Egyptian logographic hieroglyphs are the ancestor of nearly every alphabetic script used in the modern era, including the roman alphabet (Sacks 2004), and Japanese *kana* were derived from certain kanji. In order to better understand how kanji might be processed and acquired, it seems prudent to understand their compositional nature; where on the logography spectrum do they seem to fit in? If kanji content leans towards semantics, we might expect to see a preference for semantic processing in kanji; if kanji actually provide more phonetic information, then

26

phonological processing seems more likely. It's also reasonable to expect some degree of middle ground between semantics and phonetics.

Boltz (2003) and Tranter (2013) (among other researchers) both use the concept of a 'frame' to define the spatial or holistic unit a written symbol takes up; in simplest terms, one symbol takes up one frame. In the context of Japanese, a frame would house a single *kana* or kanji (so, the *kana* じ and the kanji 字 each are one frame). For kanji, each frame contains one or more radicals; the distribution of written information in frames is relevant for distinguishing between multiple *kana* and a single kanji in certain situations; for example, the two separate *kana* イ /i/ and ヒ /hi/ from the kanji 化 (*onyomi*: /ka/, "change"). As discussed previously, not every component within a frame may actually contribute specific information, which might indicate the necessity of holistic processing strategies for kanji comprehension. The results regarding radical analysis for kanji comprehension and teaching also demonstrate a need for more componential approach to kanji processing as well, which is cause to examine the nature of determinants as well. Boltz and Tranter both identify four types of radicals: **S** radicals contribute semantic, but no phonetic, information; **P** radicals contribute phonetic, but not semantic, information, **Ψ** radicals contain both types of information, while **X** radicals don't really contribute either type of information. Especially in cases of character borrowing, as with Japanese, disparities between phonology of the two languages involved in the borrowing act, coupled with effects of phonetic change within a language over time, lead to many radicals that were once **P** radicals becoming **X** radicals, or very inconsistent **P** radicals (which do not contribute the same, or even similar, phonetic values across characters). This inconsistency of phonetic information might suggest a preference for semantic processing, though the earlier example with the component 食 also point out semantic inconsistency. The multivalence of characters, whereby the same character has

multiple readings and/or meanings depending on context, further complicates the issue. Since individual characters do not follow a conclusive trend regarding information with, or even across frames, it may be more fruitful to consider how kanji occur, and are used, in actual language, rather than in isolation.

An important characteristic of a writing system is what I call its modularity: how easily and reliably can symbols be put together to make words? A truly phonetic script, with a consistent and (ideally) one-to-one symbol-phoneme correspondence, would be considered highly modular: any word would be written as the sum of its phonetic parts, and new words could be easily written using existing characters; furthermore, a character will (beyond any phonotactic effects) contribute the same value no matter what its context, and the spelling of a word is easy so long as the word's phonetic values are known. I would consider English to be somewhat modular: in general, letters contribute the same sound or set of sounds in a reasonably consistent manner, though there are various exceptions and rules that govern these exceptions (for example, a 'c' at the beginning of a word almost always has an /s/ sound before 'i' (city), 'y' (cymbal) and 'e' (cerebral), but has a /k/ sound before the other vowels (cop, cap, cup); some specific exceptions, such as the silent 'm' in 'mnemonic,' must simply be learned on a case by case basis). Though there are exceptions and inconsistencies, they are, when compared to written Japanese, rather few, and there are of course far fewer total characters to learn than in Japanese. The modularity of kanji, I argue, is rather poor, to the degree that perhaps individual character teaching and analysis is not effective. *Kana* is highly modular: each symbol will represent the same value in virtually all situations, and any Japanese word can be legally and accurately written in *kana*, and any nonsense word (that only made use of sounds present in Japanese) could be easily written in *kana* as well. This is absolutely not true for kanji: from a phonological

perspective, even if one ignores the *kunyomi-onyomi* issue, two characters with the same phonological value cannot be used interchangeably: 千/*sen*/ "thousand" and 線/*sen*/ "line" represent completely separate words, and one cannot transcribe a nonsense word using kanji; from a semantic perspective, most semantically-similar characters cannot be used interchangeably, an extreme example being the aforementioned 直す/*naosu*/ "fix" versus 治す /*naosu*/ "heal, cure" difference. Knowledge of a Japanese word does not predict knowledge of how it is written, nor does knowledge of a kanji compound itself necessarily inform the reader of the word's pronunciation or meaning, even if the reader knows both kanji in the compound (for example, 青 "blue/green" plus 年 "year" makes 青年 "youth," a meaning that might not be apparent without explicit explanation (or extensive East-Asian cultural knowledge)). Even if one knows all of a character's possible pronunciations, the fact that the correct pronunciation may vary by compound, with little to no clues within that compound as to which reading is correct, further necessitates more whole-word lexical knowledge (though compounds predominantly elicit *onyomi* readings, compounds that mix *onyomi* and *kunyomi*, as well as compounds consisting solely of *kunyomi*, are far from few in number, and certain words like 今日 which involve neither individual characters' *onyomi* or *kunyomi* are also present). Another significant factor regarding kanji modularity is what Shimomura (1999) calls 'kanji lexicality:' whether or not a kanji can be a word by itself. While some Japanese words are written using a single character, there are many characters that, by themselves, do not map to a word. From the perspective of kanji processing, the significance of kanji modularity is affected by whether or not kanji words, especially compound words, are processed holistically or as the sum of their parts. As an example of how models of compound character processing might look, Morton et al (1992) proposed two possible models for compound word processing: in one model, visual

information goes directly to internal representations of the two separate characters involved, which then leads to the internal representation of the compound word; in the second model visual information goes directly to internal representations of the two separate characters and the two character compound (in other words, access to the compound is simultaneous to, rather than facilitated by, access to each individual character). If compound words, which make up a significant portion of Japanese vocabulary, are processed more as single units than as sums of characters, it would suggest an advantage to a more holistic treatment of kanji words from a pedagogical perspective.

The theoretical supposition that there is a low modularity value of kanji, which influences the effectiveness of single-character-based instruction, is corroborated by empirical evidence from a significant body of research. In a set of word-reading tasks carried out by Wydell et al (1995), the results showed a facilitation effect for character frequency and familiarity, both not consistency; that is, whether or not a character's phonetic component is consistent across characters was of little consequence when compared to how frequently the target character occurs in standard Japanese texts. The trend that this effect showed across various trials strongly suggested that kanji phonology is processed at a word-level, not a character level, and Wydell et al argued that extracting phonological information at the word-level is the most consistent and accurate strategy. Nakagawa (1994) explored differences in processing strategies (comparing the right and left hemispheres of the brain) between kanji words, *kana* words, and English words: a left hemisphere advantage was found for kana and English, while a right hemisphere advantage was found for kanji; however, the right hemisphere advantage for kanji was only true for single-character words; for 2-character compounds, processing more closely resembled that of English processing, suggesting a more word-level processing strategy for whole-word phonology. An

fMRI study by Ino et al (2008) found that areas of the brain used for visuospatial attention were more activated for word recognition than read-aloud tasks, which was interpreted as demonstrating how phonology extraction is less dependent on visual detail, showing that perhaps phonology is processed more on a whole-word level than on a detailed componential level. Results from Morton et al (1992) are especially relevant to the topic of kanji modularity, as Morton et al showed that word identification was strongly facilitated by prior exposure to that exact word, and only weakly, if not at all, facilitated by exposure to the characters that made up the word, or to words that shared a character with the target word.

These results don't necessarily imply that individual kanji shouldn't be taught, nor do they explicitly address the topic of kanji proficiency development, and it could very well be that the results listed above only come about after a developmental process that starts with learning kanji individually. Nonetheless, they do demonstrate the weakness of kanji modularity in respect to word processing, which can certainly be viewed as evidence towards the advantages of a more word-level focus on kanji and kanji teaching. Returning to the topic of frames, the observed preference for whole-word processing, as well as the low lexicality value of many kanji, demonstrates how a single frame does not necessarily provide lexical information, but rather morphological information, which suggests that kanji should be classified as some type of morphogram (a classification that many scholars have already suggested.) The next question then relates to phonetic versus semantic processing; a morpheme/lexeme involves semantic and phonetic information to some degree, and examining the ways in which semantic and phonetic information are extracted from kanji during processing could help better inform methodology for kanji teaching.

Kanji Processing

There have been multiple proposed models for written language processing both in general and in specific relation to Japanese and kanji. For the most part, these models differ in terms of the channels between semantic, phonetic, (lexical/morphological,) and orthographic information, and even within similar models there is disagreement regarding the time it takes for various information to activate and for different neurological pathways to fire. These models generally fall into the following three categories:

Orthography → *Semantics* → *Phonology* (OSP)

The premise in an OSP model is that the visual system recognizes an orthographic input, which link directly to the semantic portion of a lexical entry, which then goes to the phonetic portion of that lexical entry. Traditionally this model was thought to be valid for logographic characters, including those used in Chinese and Japanese; while its popularity has significantly decreased, some researchers (e.g. Komori 2006) still support this model, at least for native speakers of Japanese.

Orthography → *Phonology* → *Semantics* (OPS)

OPS models predict that orthographic stimulus activates phonological information, which then activates semantic information. This is often assumed to be how alphabetic written languages are processed, though some have also proposed some degree of direct orthography-to-semantics processing even in alphabetic writing systems. There is not much support for this model as an accurate predictor for processing of written Japanese.

Orthography → *Semantics and Phonology* (dual-route, parallel processing)

Dual-route processing and parallel processing (sometimes used interchangeably) refer to processes by which orthographic information simultaneously activates semantic and phonetic information; various versions of these models further predict that the activated phonetic information then helps to activate semantic information, or vice versa. This is by far the most popular model type for kanji processing (and perhaps even written language processing in general), though the exact degrees to which semantic and phonetic information are activated, the degree to which they activate each other, and the time onset of information activation is a point of considerable debate amongst scholars.

Within the three basic model types listed above, there is also a distinction between models that support radical analysis and models that involve more holistic character processing, as well as a difference between models that support form-first processing (whereby orthographic information is completely processed before the brain proceeds to the next stage (e.g. Rastle et al 2004)) and processing by which phonetic/semantic information starts getting extracted before the orthographic information is fully processed (Feldman et al 2009, 2015).

Evidence for OSP Models

Komori (2006) observed that aspects of phonology, as introduced via phonetic priming, exerted no influence over native Japanese speakers' processing of common kanji, which was taken as evidence towards a model of direct orthography-semantics system for kanji processing, at least in native speakers. While not directly supportive of an OSP model per se, Fushimi et al

(2003 and 2009) found that in patients with semantic dementia, certain phonetic readings of kanji were lost (i.e. a character's *kunyomi* couldn't be retrieved, but the *onyomi* could be), suggesting that semantic information at least plays a role in mediating phonetic output (partially as a result of the variable phonetic values of kanji). An interesting note regarding semantic values of kanji comes from prelingually deaf readers of Japanese; when compared to deaf readers of English, deaf readers of Japanese have a much higher memory span and attention rate (comparable to that of non-deaf readers), at least for kanji, which demonstrates how kanji could involve more direct semantic connections than a phonetic script would (Flaherty and Moran 2004). Beyond these factors though, most recent research has found at least some degree of direct orthography-phonology connections, which casts doubt on the idea of a strict OSP model.

Evidence for OPS models

Evidence from studies both on Japanese foreign language learners (e.g. Chikamatsu 2006) and native Japanese speakers (e.g. Sasanuma et al 1992, Saito et al 1999) demonstrate that there are certainly direct orthography-phonology channels for written language, perhaps activating earlier than semantic channels. In her study on how native English speaking students of Japanese, at varying levels of proficiency, process kanji, Chikamatsu (2006) noted that lower-level students depended heavily on phonological information when reading, though this effect was diminished in the higher-proficiency learners; this was interpreted as evidence towards a predominantly OPS model for English speakers, but also as evidence that OPS models don't work as well for kanji, as the more experienced learners involved more orthographic information in lexical and semantic decisions. Sasanuma et al's (1992) report of an Alzheimer's patient with severe semantic dementia (for whom semantic processing and decision making was severely impaired but phonological processing and production were completely fine) showed that

phonological reading of kanji was relatively preserved, suggesting that there are direct orthography-phonology channels for kanji comprehension even in native Japanese speakers (though this doesn't preclude the presence of direct orthography-semantics channels). Saito et al (1999) approached the topic of phonological processing by tracking the influence of phonetic radicals on kanji reading, and found that readers seemed to look at the (assumed) phonetic radical first, and, if the radical contained valid phonetic information, phonological processing started right away, perhaps before semantic processing (or even whole-character processing); while mostly cited as evidence against the idea of holistic kanji processing, the results do demonstrate some degree of early direct phonological access strategies, and perhaps shows that high-frequency, highly-consistent characters go straight to phonology first, with semantic information derived solely from the easily-obtained phonetic information. Still, none of the studies listed above necessarily rule out the presence of direct orthography-semantics channels, at least for kanji reading, meaning that a strict OPS model is probably not accurate either. Furthermore, if kanji were processed in an OPS manner, then we would expect patients with severely damaged phonetic processing systems to be unable to access semantic information from written words; however, there are patients with highly damaged phonological abilities seem to still be able to semantically process kanji, though not kana (Hashimoto 1998).

Dual-Route/Parallel Processing

There is a pretty strong consensus among scholars these days that kanji processing is characterized by direct connections between orthography and semantics and between orthography and phonetics that operate in parallel. An example of such a model on a general level is the Dual-Route Cascade (DRC) model proposed by Coltheart, Curtis, Atkins, and Haller (Coltheart et al 1993); to oversimplify somewhat, the model predicts that visual input splits to

phonetic information (from any visual items that have a direct grapheme-phoneme correspondence) and orthographic information, which connects the stimulus into lexical or morphological chunks; this visual lexical information then splits to semantic lexical information and phonological lexical information; these two lexical information sets then meet up with the grapheme-phoneme information and reach a verdict on the correct reading of the word. The model works in a cascading, rather than threshold-based, fashion, meaning that the neural channels involved fire continuously as information comes in and is processed; this contrasts with models whereby channels only fire after certain thresholds are met (for example, a cascading model would predict grapheme-phoneme information to start being extracted right away and finish over time, while a threshold model would expect a certain threshold of visual parsing and processing to be complete before any further steps were taken). As Coltheart et al note, their model does not necessarily accommodate systems like kanji that seem to lack direct grapheme-phoneme connections. However, I feel that the lexical portion of the model could remain valid; as kanji orthographic information is processed, both semantic and phonetic information is extracted, and the two information sets are then combined to reach a lexical decision.

In regards to specific models of kanji processing, the primary disagreement seems to be over the exact nature of the semantic-phonetic interaction. Sakuma et al (1998) support a predominantly orthography-to-semantics system, but agree that the orthography-phonology connections are far from trivial; on lexical decision tasks, subjects made more errors with orthographically similar foils, and the error rate increased even further if the foils were also homophones of the target word. Orthographically dissimilar foils had a rather low error rate, regardless of phonetic similarity. The interpretation of these results was that orthographic information strongly activates a set of internal lexical items, as well as possible phonetic

information. If the orthographic connection between the stimulus and target is weak, it triggers a negative response without even consulting the phonetic information; however, if the input is similar enough to the target to be considered, a positive response is favored; the orthographically-derived phonetic information is then used to help make a decision, meaning that if the phonetic information is also similar to the target lexical item's phonology, a positive response will likely be triggered, which can lead to frequent false-positives on foils that are both orthographically and phonetically similar. Wydell et al (1993) showed similar results, though with a slightly higher influence of phonology, finding that homophonous foils had a slight inhibitory effect even in the visually distinct foils.

Evidence for a stronger role of phonology can be found in studies focused on radical analysis of characters (e.g. Saito et al 1999, Masuda and Saito 2002). Effects of radical consistency across kanji and radical validity within a character do seem to influence speed and error rates of character processing; a radical is considered consistent if it reliably contributes the same phonetic information across the characters it's present in (e.g. characters containing the radical 意, such as 億 /*oku*/ and 臆/*oku*/, share the same pronunciation and thus are consistent), and a radical is considered valid in a character if the radical has the same phonetic value both in the character and by itself (e.g. the single character 帝/*tei*/ and the character for which is serves as a radical 締/*tei*/ have the same pronunciation, making 帝 valid for 締; since 意 by itself is pronounced /*i*/, it is not valid for 億 /*oku*/). Subjects had shorter latencies reacting to targets that were considered consistent, and subjects had lower error rates when the target was considered valid; the fact that there was an influence exerted on character recognition and reaction by phonological information demonstrates a significant role in orthographically-derived phonological information in kanji processing. A point worth noting regarding this study is that

characters that share radicals are inherently orthographically similar, meaning that the effects observed in these studies could possibly just be similar to those discussed in the previous paragraph (primarily orthography-semantics channels mediated by orthography-phonetics channels). A different experiment exploring radical analysis in kanji comprehension (Flores d'Arcais et al 1995) tested priming effects of radicals and found that phonetic radicals had a strong facilitation effect in the short term (60 ms before stimulus onset) and an even stronger effect in the long term (180 ms), whereas the semantic radical exhibited only a weak effect in the short term and almost no effect in the longer term. These results were be interpreted both as evidence for powerful, quickly activated orthography-phonology connections and as evidence for contribution effects between phonetic and orthographic access to semantics. If a semantic radical is processed first, it evokes representations of all the varied items which share that radical and are semantically related, and the phonetic radical picks the best choice based on how close it matches the stimulus' phonological info; if the phonetic radical is processed first, it evokes the items that are phonetically similar, and then the semantic radical's information picks the best candidate.

Patients with various forms of brain damage show varying degrees of phonetic and semantic impairment when processing kanji and provide further evidence for some degree of cooperative mediation between phonetics and semantics: patients with semantic dementia (detailed in Fushimi et al 2003 and Fushimi et al 2009) could access a character's common phonetic value but not any less common or exceptional phonetic values, demonstrating that while the phonological channels remained intact, without semantic mediation only the less contextually-dependent values could be recognized. However, Jibiki and Yamaguchi (1993) reported a patient who could distinguish between *onyomi* and *kunyomi* readings despite their

semantic impairments; taken together, these studies suggest that while semantics can mediate phonetics, other complementary systems may also be involved, and character phonology may be extracted from both individual character orthography and the whole-word orthography, without semantic mediation. In patients without brain damage, fMRI studies find that kanji reading activates phonetic, semantic, and visuospatial areas of the brain; when compared to kana words, Thuy et al (2004) found that kanji words enlisted more visual-orthographic retrieval areas and lexical-semantic areas, while kana activated more phonological areas.

Processing may also be task-dependent; in word recognition tasks, reading of kanji activated more of the brain's visuospatial attention network than with kana, but with a read-aloud task both script types activated the same areas (Ino et al 2008), showing that if the task is not phonologically demanding automatic phonological extraction of a character may be reduced. Morita and Tamaoka (2001 and 2002) also found that extraction of both semantic information and phonetic information is task dependent; in lexical decision tasks and reading comprehension tasks, phonetically similar foils led to more and fewer errors respectively, while phonetic similarity had no effect on typographic proofreading tasks; semantically similar foils led to more errors and slower reaction times for lexical decision, reading comprehension, and proofreading tasks, suggesting a slightly higher contribution of orthography-semantics channels than orthographic-phonetic channels.

The data regarding kanji processing is not in complete agreement, but it can be confidently stated that there are important networks connecting orthography to both sound-based information and meaning-based information, as well as networks connecting phonetics and semantics to some degree. This confirms this paper's hypothesis regarding the importance of Japanese lexical knowledge for kanji proficiency, as native-level processing of characters does

not depend solely on phonology or semantics, and does of course rely on orthographic knowledge. Methods of teaching kanji like rote and mnemonics do little to develop or reinforce the cognitive channels that are clearly necessary for kanji proficiency. In order to foster literacy in second language learners of Japanese, kanji should be taught in a manner that involves phonetic and semantic information while still aiding orthographic skills. The following section details a novel method of kanji teaching that attempts to tie all these points together.

Section 3: Orthographic Gradient

In order to combine semantic information, phonetic information, and orthographic information, without going outside the domain of written Japanese, I propose a method called and orthographic gradient (OG). The premise of OG takes advantage of the multiple scripts used in written Japanese to teach kanji in a textual setting by presenting a passage which starts out entirely in kana (and previously learned kanji), and gradually transitions to being entirely in kanji (for words that have kanji spellings).

Each passage would have some number of target words; these may or may not be words that the learner has already encountered, but the point is that they would be words for which the learner has not already learned the kanji spelling. At first, the targets would be written only in *kana*. At an intermediate stage, the words' kanji would be introduced, and the character would be written in both *kana* and kanji using *furigana*, small *kana* letters placed above a character to assist in pronunciation. By the end of the passage, the words would be written only in kanji, with no *furigana* assistance. As reading of passage continues and meaningful connections are made between the words and the passage, the words are replaced with their kanji equivalents in a manner that makes it clear that the new character is simply representing an already-learned word. For example, if one of the actors in the passage was always referred to as 赤いくま/*akai kuma*/ "the red bear," and nothing else in the story was red, then when the reader encounters 赤い熊 /*akai kuma*/ "the red bear," they will be able to connect the dots that 熊 is just the kanji representation of くま, and the *furigana* above the word will help to confirm the learner's conclusion. Eventually, the crutches of the *furigana* and of the 'red' descriptor will be dropped,

but by then the learner will recognize the new character and be able to finish the story completely in kanji.

The speculated advantages for this method are numerous. From the perspective of development and acquisition, OG more closely resembles how native speakers would learn, both insofar that they know the 'word' first, then the kanji, and that the learning is of a more incidental nature based more on exposure to writing than explicit drills. The fact that words are first presented in the phonetic script is beneficial for learners who come from an alphabetic background, as such learners tend to have a greater reliance on phonological information for written word processing (Takahashi 2001, Komori 2006). Furthermore, since the kanji representations may be introduced shortly after the word's introduction, it accelerates the transition from an easier phonology-based processing to the processing strategy observed in high-proficiency speakers (including naïve speakers) that considers form, semantics, and phonetics to a more shared degree.

Another beneficial feature of OG is the flexibility of the context; multiple passages for the same character sets could be devised to account for individual differences in personal preference. Passages would work well narratives or stories which, if well written, could be a lot of fun and encourage students to continue their studies; this could also carry the memory-based benefits observed in mnemonic methods, as students will be able to forge a strong, meaningful relation between the new characters and the story they were learned in, without running the same risk of having the memory-enhancing method be detached from the target kanji as with more Heisig-esque methods.

Perhaps most importantly, OG is strictly within the context of the Japanese language, and more specifically, within the same context with which kanji knowledge is actually used: reading. New words are introduced with their phonetic and semantic values in an engaging and meaningful context, fostering the neural connections which have been shown to be prominent for kanji learning and kanji processing. While the method's use of *furigana* is not some novel concept (*furigana* are commonly used in texts for people who are still learning Japanese, and are even used in Japan for exceptionally rare characters), it is important that OG makes use of it only briefly. Though explicit research on the subject of *furigana* processing is still sparse, intuition suggests that over-use of *furigana* runs the risk of students simply glossing over the kanji and only reading the *furigana*. By keeping the *furigana* stage brief and making it easy and natural for students to move on to the kanji-only stage, this potential risk is mitigated.

This is not to say that OG is some magic cure-all for the problem of kanji teaching, and it has its share of potential shortcomings. Two noticeable missing elements are those of radical analysis/knowledge and kanji modularity. For the latter, previous discussion in this paper has cast some doubt on the validity of kanji modularity, and the fact that OG does not introduce individual characters in some sort of vacuum may in fact be a good thing. Though it may have poorer results for when students encounter new kanji words in other situations, this isn't necessarily so, and with enough exposure to kanji words students may figure out morphological trends on their own. For example, the character 化 */ka/* occurs at the end of many words to denote some process of change (e.g. 悪化*/akka/* "make worse," 国際化 */kokusaika/* "globalization," 機械化 */kikaika/* "mechanization"); after learning a few words containing that character, the student would likely catch on to the trend, and wouldn't be surprised to find that 近代化 */kindaika/* meant 'modernization.' There are of course exceptions, but such exceptions

are a challenge for kanji acquisition even for teaching methods that assume greater modularity of characters. As mentioned earlier in this paper, there's evidence that kanji words are processed at more of a whole-word-level anyways, which is consistent with how OG introduces characters, and in the context of learning Japanese as a foreign language, it sits will with the evidence that learners with an alphabetic L1 tend to remember kanji as lexical items rather than modular parts anyways (Matsumoto 2013).

Topics of radical analysis, which certainly show promise for kanji education and are a significant part of kanji processing, are admittedly not covered within the boundaries of OG beyond whatever trends students happen to pick up on their own. As noted earlier, radicals too face problems with inconsistency, but their positives might outweigh their negatives, and shouldn't be disregarded. Of course, OG doesn't preclude the use of other methods, and a combination of radical analysis and OG could prove to be quite effective; even rote and mnemonic methods could make good compliments to OG. It would also be advantageous for passages to be read out-loud so that students can further build their phonetic awareness regarding any new vocabulary, as phonetic awareness and ability have bound found to be strong predictors of literacy development (Sparks et al 2011, Landgraf et al 2011, Matsumoto 2013).

Another potential drawback is that truly beneficial and interesting stories might not be so easy to come up with, and production of passages could prove challenging at first; however, once a good set of passages is devised, there's little reason to have to design more. In fact, the method could even be altered to aid production by assigning students to make their own OG stories. Once a student gets to a very advanced reading level and has to start learning very complex or uncommon words OG might not prove as effective, but by that time the student's lexical

inferencing abilities and morphological awareness may be enough for successful reading comprehension.

One last advantage to OG is that of time. At least in the context of college study, a student only has four years to build proficiency in the target language, and the time and effort required of methods like rote are not efficient. The ability to have OG teach more than just kanji helps to make a more efficient and compact curriculum, and theoretically OG may just be more efficient for kanji learning anyways.

At this point, the orthographic gradient is merely a theory with no direct empirical data to support its validity. A similar experiment by Burling (1982) was carried out to good success, though: Burling used passages that started with only English vocabulary and transitioned to only French vocabulary. Despite various inherent challenges with Burling's method, including managing the differences between French and English in terms of syntax and pronunciation, he reported that students found the process highly enjoyable and motivating, and even students with little to no French background finished the materials without issue over the course of a semester. Considering the success Burling had, it would not be unreasonable to expect an even greater success with OG, which does not face the problems of cross-language changing. Even though OG has not yet been tested, the evidence regarding literacy acquisition and kanji processing strongly suggest that OG would aid orthographic recognition, retentions in memory, and Japanese linguistic connections, which is every area of my proposed literacy requirements besides production (and even that could possibly be achieved with OG).

Conclusions

As kanji continue to be a stumbling block for learners of Japanese as a foreign language, it seems prudent to stop and consider both the validity of common methods and the neural processes by which kanji are processed and learned. This paper proposed that kanji literacy depends on four components: orthographic recognition, character production, Japanese linguistic knowledge and connects, and the ability for these three things to be retained in memory (as well as perhaps experience with kanji in a realistic and practical setting). A critical analysis of three existing teaching methods found that two of the more common ones, rote memorization and mnemonics, do not satisfy these four criteria to a significant degree and thus cannot, on their own, be considered practical methods. The third method, radical analysis, showed significantly more promise, but also had a couple significant drawbacks suggesting a need for supplementation from another method. Evidence of kanji processing and kanji structure revealed a low measure of kanji modularity and found that kanji are processed in terms of phonetic, orthographic, and semantic information, at both a holistic and componential level. In considering the drawbacks of various methods and the nature of kanji and kanji processing, a novel method was introduced that answers many shortcomings of other methods, is consistent with what we know about how kanji are processed, and shows significant promise in (at least) three of the four factors of kanji literacy.

Research on this subject is far from reaching a definitive conclusion, and the validity of the orthographic gradient method can only truly be confirmed by experimental application. The topics of logography acquisition and processing certainly call for further research, and the connections between logograms and morphology, semantics, and phonetics should continue to be explored.

References

Alvarez, G.a., and P. Cavanagh. "The Capacity of Visual Short-Term Memory Is Set Both by Visual Information Load and by Number of Objects."*Psychological Science* 15.2 (2004): 106-11.

Anderson, John R. "Expertise." *Cognitive Psychology and Its Implications*. New York: Worth, 2010. 242-71. Print.

Bi, Yanchao, Zaizhu Han, and Yumei Zhang. "Reading Does Not Depend on Writing, Even in Chinese." *Neuropsychologia* 47.4 (2009): 1193-199.

Boltz, William G. *The Origin and the Development of the Chinese Writing System*. New Haven, CT: American Oriental Society, 2003. Print.

Chee, Michael W.l., Brendan Weekes, Kok Ming Lee, Chun Siong Soon, Axel Schreiber, Jia Jia Hoon, and Marilyn Chee. "Overlap and Dissociation of Semantic Processing of Chinese Characters, English Words, and Pictures: Evidence from FMRI." *NeuroImage* 12.4 (2000): 392-403.

Chikamatsu, Nobuko. "Developmental Word Recognition: A Study of L1 English Readers of L2 Japanese." *The Modern Language Journal* 90.1 (2006): 67-85.

Collentine, Joseph, and Barbara F. Freed. "LEARNING CONTEXT AND ITS EFFECTS ON SECOND LANGUAGE ACQUISITION: Introduction."*Studies in Second Language Acquisition Stud. Sec. Lang. Acq.* 26.02 (2004)

Coltheart, Max, Brent Curtis, Paul Atkins, and Micheal Haller. "Models of Reading Aloud: Dual-route and Parallel-distributed-processing Approaches." *Psychological Review* 100.4 (1993): 589-608.

Conditt, Michael A., Francesca Gandolfo, and Ferdinando A. Mussa-Ivaldi. "The Motor System Does Not Learn the Dynamics of the Arm by Rote Memorization of Past Experience." *Journal of Neurophysiology* 78.1 (1997): 554.

D'arcais, Giovanni B. Flores, Hirofumi Saito, and Masahiro Kawakami. "Phonological and Semantic Activation in Reading Kanji Characters."*Journal of Experimental Psychology: Learning, Memory, and Cognition*21.1 (1995): 34-42.

Ehrich, J. F., and R. F. I. Meuter. "Acquiring an Artificial Logographic Orthography: The Beneficial Effects of a Logographic L1 Background and Bilinguality." *Journal of Cross-Cultural Psychology* 40.5 (2009): 711-45.

Ericsson, K. Anders, Ralf T. Krampe, and Clemens Tesch-Römer. "The Role of Deliberate Practice in the Acquisition of Expert Performance."*Psychological Review* 100.3 (1993): 363-406.

Fata-Hartley, Cori. "Resisting Rote: The Importance of Active Learning for All Course Learning Objectives." *Journal of College Science and Teaching*40.3 (2011): 36-39.

Feldman, Laurie B., and Patrick A. O'connor. "Early Morphological Processing Is Morpho-Semantic and Not Simply Morpho-Orthographic."*PsycEXTRA Dataset* (2008): n. pag.

Feldman, Laurie Beth, Fermin Moscoso Del Prado Martin, and Patrick A. O'connor. "Must Analysis of Meaning Follow Analysis of Form?"*PsycEXTRA Dataset* (2010): n. pag.

Flaherty, Mary, and Aidan P. Moran. "Deaf Signers Who Know Japanese Remember Words and Numbers More Effectively Than Deaf Signers Who Know English." *American Annals of the Deaf* 149.1 (2004): 39-45.

Fujimaki, Norio, Tomoe Hayakawa, Aya Ihara, Qiang Wei, Shinji Munetsuna, Yasushi Terazono, Ayumu Matani, and Tsutomu Murata. "Early Neural Activation for Lexico-semantic Access in the Left Anterior Temporal Area Analyzed by an FMRI-assisted MEG Multidipole Method." *NeuroImage*44.3 (2009): 1093-102.

Fushimi, Takao, Kenjiro Komori, Manabu Ikeda, Karalyn Patterson, Mutsuo Ijuin, and Hirotaka Tanabe. "Surface Dyslexia in a Japanese Patient with Semantic Dementia: Evidence for Similarity-based Orthography-to-phonology Translation." *Neuropsychologia* 41.12 (2003): 1644-658.

Gray, J. R., T. S. Braver, and M. E. Raichle. "Integration of Emotion and Cognition in the Lateral Prefrontal Cortex." *Proceedings of the National Academy of Sciences* 99.6 (2002): 4115-120.

Hamilton, A. Cris, and H. Branch Coslett. "Impairment in Writing, but Not Reading, Morphologically Complex Words." *Neuropsychologia* 45.7 (2007): 1586-590.

Hashimoto, Ritsuo, Yasufumi Tanaka, and Mitsuo Yoshida. "Selective Kana Jargonagraphia Following Right Hemispheric Infarction." *Brain and Language* 63.1 (1998): 50-63.

Heisig, James W. *Remembering the Kanji*. Honolulu: U of Hawai'i, 2008. Print.

Ihori, N., T. Kashiwagi, A. Kashiwagi, and H. Tanabe. "Jargonagraphia in Kanji and Kana in a Japanese Crossed Wernicke′s Aphasic." *Brain and Language* 47.2 (1994): 197-213.

Imada, Toshiaki, Masaki Kawakatsu, Makoto Kotani, and Masaki Tojo. "Neuromagnetic Signals Associated with Reading a Kanji Character Formed by Combining Two Kanji Radicals." *Japanese Psychol Res Japanese Psychological Research* 42.1 (2000): 15-25.

Jibiki, Itsuki, and Nariyoshi Yamaguchi. "The Gogi (Word-Meaning) Syndrome with Impaired Kanji Processing: Alexia and Agraphia." *Brain and Language* 45 (1993): 61-69.

Jincho, Nobuyuki, Thomas Lachmann, and Cees Van Leeuwen. "Dissociating Congruence Effects in Letters versus Shapes: Kanji and Kana." *Acta Psychologica* 129.1 (2008): 138-46.

Kano, Chieko, Yuri Shimuzu, Hiroko Takenaka, and Eriko Ishii. *Basic Kanji Book. Vol. 1*. Tokyo: Bonjinsha, 1989. Print.

Komori, Kenjiro, Takao Fushimi, Manabu Ikeda, Matthew A Lambon Ralph, and Karalyn Patterson. "The Association between Semantic Dementia and Surface Dyslexia in Japanese." *Neuroscience Research* 65 (2009): n. pag.

Komori, Saeko. *L2 Kanji Recognition Processing*. Dissertation, University of Hawai'i. Ann Arbor: ProQuest/UMI, 2006. (Publication Number 3213067).

Ku, Yu-Min, and Richard C. Anderson. "Chinese Children's Incidental Learning of Word Meanings." *Contemporary Educational Psychology*26.2 (2001): 249-66.

Kuo, Wen-Jui, Tzu-Chen Yeh, Jun-Ren Lee, Li-Fen Chen, Po-Lei Lee, Shyan-Shiou Chen, Low-Tone Ho, Daisy L. Hung, Ovid J.-L Tzeng, and Jen-Chuen Hsieh. "Orthographic and Phonological Processing of Chinese Characters: An FMRI Study." *NeuroImage* 21.4 (2004): 1721-731.

Landgraf, Steffen, Reinhard Beyer, Isabella Hild, Nancy Schneider, Eleanor Horn, Gesa Schaadt, Manja Foth, Ann Pannekamp, and Elke Van Der Meer. "Impact of Phonological Processing Skills on Written Language Acquisition in Illiterate Adults." *Developmental Cognitive Neuroscience* 2 (2012): n. pag.

Liu, Ying, Susan Dunlap, Julie Fiez, and Charles Perfetti. "Evidence for Neural Accommodation to a Writing System following Learning." *Human Brain Mapping Hum. Brain Mapp.* 28.11 (2007): 1223-234.

Masuda, Hisashi, and Hirofumi Saito. "Interactive Processing of Phonological Information in Reading Japanese Kanji Character Words and Their Phonemic Radicals." *Brain and Language* 81.1-3 (2002): 445-53.

Matsumoto, Kazumi. "Kanji Recognition by Second Language Learners: Exploring Effects of First Language Writing Systems and Second Language Exposure." *The Modern Language Journal Modern Language Journal* 97.1 (2013): 161-77.

Mcdaniel, Mark A., Michael J. Cahill, Mathew Robbins, and Chelsea Wiener. "Individual Differences in Learning and Transfer: Stable Tendencies for Learning Exemplars versus Abstracting Rules." *Journal of Experimental Psychology: General* 143.2 (2014): 668-93.

McDougall, Siné, Charles Hulme, Andrew Ellis, and Andrew Monk. "Learning to Read: The Role of Short-Term Memory and Phonological Skills."*Journal of Experimental Child Psychology* 58.1 (1994): 112-33.

Mori, Yoshiko, and Hideko Shimizu. "Japanese Language Students' Attitudes Toward Kanji and Their Perceptions on Kanji Learning Strategies."*Foreign Language Annals* 40.3 (2007): 472-90.

Mori, Yoshiko. "The Roles of Context and Word Morphology in Learning New Kanji Words." *The Modern Language Journal Modern Language J* 87.3 (2003): 404-20.

Morita, Aiko, and Katsuo Tamaoka. "Phonological Involvement in the Processing of Japanese at the Lexical and Sentence Level." *Reading and Writing: An Interdisciplinary Journal* 15 (2002): 633-51.

Morita, Aiko, and Katsuo Tamaoka. "Semantic Involvement in the Lexical and Sentence Processing of Japanese Kanji." *Brain and Language* 82.1 (2002): 54-64.

Morton, John, Sumiko Sasanuma, Karalyn Patterson, and Naoko Sakuma. "The Organization of the Lexicon in Japanese: Single and Compound Kanji." *British Journal of Psychology* 83 (1992): 517-31.

Nakagawa, Atsuko. "Visual and Semantic Processing in Reading Kanji."*Journal of Experimental Psychology: Human Perception and Performance* 20.4 (1994): 864-75.

Pirolli, Peter L., and John R. Anderson. "The Role of Practice in Fact Retrieval." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 11.1 (1985): 136-53.

Rose, Heath. "L2 Learners' Attitudes Toward, and Use Of, Mnemonic Strategies When Learning Japanese Kanji." *The Modern Language Journal* 97.4 (2013): 981-92.

Sacks, David. *Letter Perfect: The Marvelous History of Our Alphabet from A to Z*. New York: Broadway, 2004. Print.

Saito, Hirofumi, Hisashi Masuda, and Masahiro Kawakami. "Subword Activation in Reading Japanese Single Kanji Character Words." *Brain and Language* 68.1-2 (1999): 75-81.

Saito, Hirofumi, Osamu Yamazaki, and Hisashi Masuda. "The Effect of Number of Kanji Radical Companions in Character Activation with a Multi-Radical-Display Task." *Brain and Language* 81.1-3 (2002): 501-08.

Sakuma, Naoko, Sumiko Sasanuma, Itaru F. Tatsumi, and Shinobu Masaki. "Orthography and Phonology in Reading Japanese Kanji Words: Evidence from the Semantic Decision Task with Homophones." *Memory & Cognition* 26.1 (1998): 75-87.

Sasanuma, Sumiko, Naoko Sakuma, and Kunitaka Kitano. "Reading Kanji without Semantics: Evidence from a Longitudinal Study of Dementia."*Cognitive Neuropsychology* 9.6 (1992): 465-86.

Shimizu, Hideko, and Kathy E. Green. "Japanese Language Educators? Strategies for and Attitudes toward Teaching Kanji." *The Modern Language Journal Modern Language J* 86.2 (2002): 227-41.

Shimomura, Michiko. "Kanji Lexicality Effect in Partial Repetition Priming: The Relationship between Kanji Word and Kanji Character Processing." *Brain and Language* 68.1-2 (1999): 82-88.

Shin, Jungpil, and Yusuke Shimizu. "Learner-Friendly Kanji Learning System with Radical Analysis." *International Journal of Evaluation and Research in Education (IJERE)* 1.1 (2012): n. pag.

Sparks, Richard L., Jon Patton, Leonore Ganschow, and Nancy Humbach. "Relationships among L1 Print Exposure and Early L1 Literacy Skills, L2 Aptitude, and L2 Proficiency." *Read Writ Reading and Writing* 25.7 (2011): 1599-634.

Swain, Merrill. "The Inseparability of Cognition and Emotion in Second Language Learning." *Language Teaching Lang. Teach.* 46.02 (2011): 195-207.

Takahashi, Etsuko. *Nature of JFL Learner's Phonological Representations in Kanji Processing*. Dissertation, University of Pittsburgh. Ann Arbor: ProQuest/UMI, 2001. (Publication Number 3013345)

Tan, P. L. "Towards a Culturally Sensitive and Deeper Understanding of "Rote Learning" and Memorisation of Adult Learners." *Journal of Studies in International Education* 15.2 (2010): 124-45.

Thuy, Dinh Ha Duy, Kayako Matsuo, Kimihiro Nakamura, Keiichiro Toma, Tatsuhide Oga, Toshiharu Nakai, Hiroshi Shibasaki, and Hidenao Fukuyama. "Implicit and Explicit Processing of Kanji and Kana Words and Non-words Studied with FMRI." *NeuroImage* 23.3 (2004): 878-89.

Tóth, Péter. "The Role of Individual Differences in Learning." *Acta Polytechnia Hungarica* 11.No. 4 (2014): 183-97.

Toyoda, Etsuko, and Tim Mcnamara. "Character Recognition among English-speaking L2 Readers of Japanese." *International Journal of Applied Linguistics* 21.3 (2011): 383-406.

Tranter, Nicolas. "Logography and Layering: A Functional Cross-linguistic Analysis." *Written Language and Literacy WL&L Written Language & Literacy* 16.1 (2013): 1-31.

Wang, Alvin Y., and Margaret H. Thomas. "Effect of Keywords on Long-Term Retention : Help or Hindrance?" *Journal of Educational Psychology* 87.3 (1995): 468-75.

Wang, Alvin Y., Margaret H. Thomas, and Judith A. Ouellette. "Keyword Mnemonic and Retention of Second-language Vocabulary Words."*Journal of Educational Psychology* 84.4 (1992): 520-28.

Wydell, Taeko N., Brian Butterworth, and Karalyn Patterson. "The Inconsistency of Consistency Effects in Reading: The Case of Japanese Kanji." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 21.5 (1995): 1155-168.

Wydell, Taeko N., Karalyn E. Patterson, and Glyn W. Humphreys. "Phonologically Mediated Access to Meaning for Kanji: Is a Rows Still a Rose in Japanese Kanji?" *Journal of Experimental Psychology: Learning, Memory, and Cognition* 19.3 (1993): 491-514.

Yang, Weidong, and Weiping Dai. "Rote Memorization of Vocabulary and Vocabulary Development." *English Language Teaching ELT* 4.4 (2011): n. pag.

Zhang, Dongbo, and Keiko Koda. "Contribution of Morphological Awareness and Lexical Inferencing Ability to L2 Vocabulary Knowledge and Reading Comprehension among Advanced EFL Learners: Testing Direct and Indirect Effects." *Read Writ Reading and Writing* 25.5 (2011): 1195-216.

Zhu, Linlin, Yaoxin Nie, Chunqi Chang, Jia-Hong Gao, and Zhendong Niu. "Different Patterns and Development Characteristics of Processing Written Logographic Characters and Alphabetic Words: An ALE Meta-analysis." *Human Brain Mapping Hum. Brain Mapp.* 35.6 (2013): 2607-618.