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Author: Margaret Thomas

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RUNNING HEAD: Air writing and L2 acquisition of Sino-Japanese characters

‘Air Writing’ as a Technique for the Acquisition of Sino-Japanese Characters by Second Language Learners

Margaret Thomas

Boston College

Abstract

This article calls attention to a facet of the expertise of second language (L2) learners of Japanese at the intersection of language, memory, gesture, and the psycholinguistics of a logographic writing system. Previous research has shown that adult L2 learners of Japanese living in Japan (similarly to native speakers of Japanese) often spontaneously produce highly articulated movements of the fingertips or hands when learning or recalling Sino-Japanese orthographic characters (*kanji*). These movements, known in Japanese as *kūsho* (‘air writing’), trace out abstract representations of *kanji*, or parts of *kanji*, presumably as a kinesthetic aid to learning and recall. The current study tests that presumption with respect to learning, by comparing the accuracy with which adult L2 learners of Japanese ($N = 75$) memorize the shapes of complex, novel, *kanji* under three different learning conditions. Results show that *kūsho* is associated with greater accuracy of recall of more difficult characters, compared to either passive visual inspection or the conventional technique of memorizing the shapes of *kanji* by iterative

paper-and-pen copying. The advantage attributable to *kūsho* is small but statistically significant when *kūsho* is compared to copying. Moreover, some participants displayed an unconscious preference for *kūsho* in that they inadvertently introduced it into trials where they had been instructed to learn *kanji* through other techniques. These results are consistent with previous research suggesting that for native speakers *kūsho* "serves as a probe which accesses motoric- or action-based representation [of Japanese *kanji*]" (Kess & Miyamoto 1999, p. 79); this research extends that analysis of the function of *kūsho* to L2 learners.

Keywords: acquisition of L2 Japanese orthography; adult learners of Japanese; 'air writing'; memorization of *kanji*; motoric memory

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Introduction

A major, consuming, task for learners of Japanese as a second language is that of gaining mastery over the complex orthographic conventions of the language. Those conventions prominently include being able to recognize and reproduce the shapes, meanings, sounds, and combinatorial privileges associated with each of up to several thousand Sino-Japanese characters, or '*kanji*'. *Kanji* (漢字, *kan* 'Chinese' + *ji* 'character') are the standard means of representing in writing the bulk of Japanese lexical items. They are not wholly devoid of phonetic or semantic properties, but are essentially logographic in nature (DeFrancis, 1989; Unger, 2004).

Memorization of the shapes of *kanji* and their associated sounds and meanings (neither of which is entirely predictable on the basis of shape) is a challenge to both first and second language learners, so that achieving facility with reading and writing *kanji* requires sustained attention and practice. There are some general principles or tendencies that constrain the shapes, meanings, and sounds of *kanji*, and the relationships among their shapes, meanings, and sounds. Learners learn to exploit these principles, and adopt or invent various other strategies, to lighten the cognitive load of the task of learning *kanji* (Miller, 1986; Haththotuwa Gamage, 2003; Heisig, 2007–8; Mori, 2012). However, extensive brute-force memorization is still essential to achieve literacy in Japanese. Second language (L2) learners of Japanese readily grasp the fact that *kanji* are foundational to the writing system. Moreover, they grasp that because *kanji* are "privileged signifier[s] in Japanese culture" (Gottlieb, 2000, p. 197; see also Gottlieb 1995;

Ezaki, 2010), native speakers highly value the acquisition of *kanji* by L2 learners as evidence of their willing socialization. It is not uncommon for learners of Japanese to characterize the extent of their expertise in the L2 in material terms according to the numbers of *kanji* that they can read and write.[1]

This article reports research on the role played by a pervasive but little-acknowledged resource that learners of Japanese apply—for the most part, unconsciously—to the task of learning *kanji*. That resource is known as '*kūsho*' (空書, *kū* 'air' + *sho* 'writing'; occasionally, *'karagaki*' 空書き, *kara* 'empty' + *gaki* 'writing'). *Kūsho* comprises rapid, abstract, but highly articulated movements of the fingertips or hands, which native speakers as well as L2 learners perform when learning *kanji* or retrieving them from memory. It is familiar to anyone who reads and writes Japanese (or Chinese; see below). Children in Japanese elementary school classrooms are commonly instructed to 'write in the air' in concert as they are taught the prescribed order of construction of the graphic elements of *kanji* (Bourke, 1996). However, in 15 interviews I conducted with college-aged native speakers of Japanese about their experiences learning *kanji* (Thomas, in preparation), all denied that they were taught *kūsho* as a mnemonic technique for private use in learning or retrieving *kanji*. Nor is *kūsho* explicitly taught to L2 learners as a device for memorization or recall of *kanji*. In post-test debriefing following an earlier study (Thomas, 2013), 44 of 44 adult L2 learners claimed either to have independently adopted the practice of air writing on observing its apparent utility to native speakers, or to have invented it on their own initiative.

What is Air Writing, and What Roles does it Play in Japanese?

Kūsho consists of the spontaneous manual tracing of the shape of a Sino-Japanese character, or parts of it, on a desktop, or on the open palm of the non-dominant hand, or on the writer's kneecap or thigh. Typically, someone producing *kūsho* will brace the heel of his or her dominant hand on a surface, then, curling inward the forefinger on that hand (or sometimes the middle finger, or, rarely, flexing the thumb inward), he or she moves the fingertip across a real or imagined surface as if substituting the fingertip for the tip of a pen, so that no visible residue is produced. Some writers dispense with a surface and simply write in space, without support, somewhere within the convenient scope of their hands. *Kūsho* may be a subtle gesture, comprised of tiny movements covering a surface area as small as a single square inch. Alternatively, the whole hand may be in motion—or even the whole arm, from shoulder to fingers. The video files in Appendix S1 of the Supporting Information online illustrate varieties of *kūsho*.

Kūsho is not unique to Japanese. There is a trickle of commentary on what may be an identical practice in among people literate in Chinese, under the name translated as 'finger tracing' (Hoosain, 1991; Yim-Ng, Varley, & Andrade, 2000). Historically, Japanese borrowed and adapted from Chinese (through Korean intermediaries) what came to be Sino-Japanese characters, and may very well have simultaneously borrowed the practice of *kūsho* / finger tracing. Japanese research on *kūsho* takes for granted that the practice exists uniquely in "*kanji* cultural area[s]" (Sasaki, 1987, p. 135), which include Japanese and Chinese speech communities. This article focuses on *kūsho* in the acquisition of L2 Japanese, with the generality of the findings to Chinese left as an open issue.

Speakers of Japanese employ *kūsho* in three contexts: (1) in interpersonal conversation, where it used to avoid anticipated miscommunication, as a repair strategy when

miscommunication arises, or to draw meta-linguistic attention to speech (Thomas, in preparation; Cibulka, 2013); (2) as a self-cuing technique during writing, when a writer faces difficulty recollecting *kanji* that he or she has already learned (Thomas, 2013); and (3) in the process of learning *kanji*. Iterative paper-and-pen (or -pencil) copying is the prime technique by which both L1 and L2 learners are taught to commit to memory the shapes of *kanji* and the conventional order in which their constituents are assembled (Naka & Naoi, 1995; Naka & Takizawa, 1990; Okita 1995; Onose, 1987). Teachers and learners treat repetitive copying as the key to cementing in memory the multiple associations of *kanji* shapes to meanings and to sounds, as the "tried and true way of learning how to write" (Kess & Miyamoto 1999, p. 79). It is not unusual for school-aged children to reproduce newly-acquired *kanji* on paper as many as 50 times as a homework exercise, checking their output against a printed model as they go along. In addition to material practice with paper and pen, learners may also cultivate their facility with *kanji* through *kūsho*, using a fingertip as an instrument (or a pen tip without contact with a surface) to produce an invisible output, which is nevertheless cognitively salient (as demonstrated by neurolinguistic research discussed below; see Matsuo et al., 2000, 2001, 2003). The practice is commonplace and treated as unremarkable. For example, it is routine to observe Japanese students in elementary through secondary school—for whom acquisition of their native orthography is a central educational task—casually executing *kūsho* in the air, on their laps, or on the open page of a book, as they commute to school on public transportation.

It is important to recognize that although literacy training in Japanese necessarily involves deliberate, iterative, copying of model *kanji* on paper, and very likely also involves the informal, un-selfconscious practice of *kūsho*, the two differ fundamentally. Material copying in the service of memorizing *kanji* entails visual inspection of the written output for its conformity

to a model: The learner's eyes move back to the printed model periodically, but otherwise the gaze is fixed on the tableau of paper, pen, and fingers so that the eyes can help regulate the movements of the hand in constructing the character, constituent by constituent. In contrast, when learners of Japanese memorize *kanji* using *kūsho*, they sometimes rest their gaze on their hand, but for the most part *kūsho* is created outside of the learner's visual field, with the gaze intentionally averted away from the *kūsho*-producing hand, or with eyes upturned to the ceiling or even closed. A writer seated at a desk may execute *kūsho* on his or her lap, completely hidden from sight beneath the desktop. In a study of 'finger tracing'—the Chinese analog to *kūsho*—Yim-Ng, Varley, and Andrade (2000) reported that its effects were present in experimental contexts which deliberately precluded visual feedback, such as when subjects traced the shapes of characters with their fingers while blindfolded (p. 565), or while substituting for their fingertips a pointer attached to their foreheads (p. 563). The study was partially replicated with Japanese by Yamashita (2014).

Therefore, memorizing *kanji* while executing *kūsho* provides kinesthetic but typically little visual feedback to a learner about his or her reproduction of the shape of the *kanji*. With visual feedback inessential or sometimes unavailable, learners are free to rest their eyes on the printed model of the target *kanji*, and some do so in a sustained manner. In contrast, during repetitive copying of *kanji* on paper, fixture of the eyes on the hands (interrupted by episodic glances back at the model) provides important regulatory feedback as the copy is produced. In this way, although both techniques of learning entail movement and vision, they differently align kinesthetic input from the hand, visual input about the movement of the hand, and visual input about the shape of the target *kanji* gleaned from inspection of the model.

Kūsho also differs from a common habit of writers of other languages (such as English) wherein a writer provisionally writes out and compares several plausible spellings of a hard-to-retrieve word on scrap paper, such as when attempting to determine the order of the adjacent vowels in the English word 'receive', or the gemination of consonants in the word 'occurrence'. Tentatively writing out a guess about the spelling of 'occurrence' is an effective self-cuing routine only insofar as one can visually compare alternative forms (e.g. 'ocurrence'; 'occurence') to each other, or compare tentatively written forms to a dimly perceived mental representation of the target word. Trial-and-error spelling on scrap paper therefore differs from *kūsho* because in the former case, the value of the practice resides in the visual feedback it provides: When I try to recall how to spell 'occurrence' by writing it on scrap paper, doing so has no value until I visually inspect what I have written to determine whether it 'LOOKS right'. In contrast, *kūsho* produces no visually perceptible output. Moreover, writers generally look away from their hands while performing *kūsho*, so that whatever mental stimulation it provides is not based on vision of the process of air writing, nor of its (invisible) output.[2]

Kūsho seems, therefore, to be part of the repertoire of skills that constitute literacy in Japanese. However, its practice is largely outside conscious awareness. Native and non-native speakers of Japanese pay little attention to *kūsho*, and rarely notice its existence, in the same way that speakers of many languages are routinely unaware of, and depreciate the complexity of, the spontaneous manual gestures they make while speaking. In the course of four years' research on *kūsho*, every speaker of Japanese consulted in this project recognized the phenomenon of air writing, and almost all acknowledged that they themselves employ it. However, no one knew the word '*kūsho*', and many seemed baffled by my interest in it. Most took for granted that *kūsho* required no explanation and provided no insight into language use or language learning.

Research on the Use of *kūsho* by Native Speakers of Japanese

Despite the low profile of *kūsho* among speakers of Japanese, a few scholars from the 1980s onwards have probed its nature and function. A pilot study by Sasaki and Watanabe (1983; see also Sasaki 1984) indicated that native speakers of Japanese were more successful at a *kanji* integration task (in which they assembled a set of *kanji* components to form actual existing *kanji*) when they accompanied the task by executing *kūsho*, as opposed to when they maintained a posture that inhibited hand movements. Sasaki and Watanabe (1984) showed that native speakers of Chinese, like native speakers of Japanese (but not learners of Japanese from "non-*kanji* cultures," p. 27) used *kūsho* in an English-language spelling task. Sasaki (1984) found that *kūsho* first appears among native speakers in early elementary school, and is established by age 11 or 12. Haga (2009) explored the facilitating effect of *kūsho* for native speakers faced with the task of counting the numbers of strokes that comprise specific *kanji*, under various learning conditions. Endo (1988), Murakami (1991), and Sumiyoshi (1996) explore *kūsho* in a similar vein; Sasaki (1987) and Kess and Miyamoto (1999) survey the research overall. More recently, Taya and Li (2009) published a case study that is ostensibly about *kūsho* in the L2 acquisition of Japanese by a native speaker of Urdu. The authors examine the order of strokes through which the learner assembled *kanji* in writing, and consider the extent to which he assembles *kanji* components into chunks, but do not firmly tie their observations to the use or non-use of *kūsho*.

A study by Mann (1986) suggests that an advantage conferred by the habit of air writing while learning *kanji* can spread to memorization of visual designs in general. This study found that for Japanese-speaking children, but not for a matched group of English-speaking children, 'good' readers surpassed 'poor' readers in tests of their memory for non-linguistic visual designs.

Mann attributed this difference to the fact that only the Japanese children spontaneously traced the visual designs with their fingers, "in much the same way that they might encode an unfamiliar *kanji*" (1986, p. 165).

In addition to these behavioral studies, a few published works in neurolinguistics address *kūsho*. Matsuo et al. (2000) reported that when native speakers of Japanese perform a *kanji*-grapheme puzzle task, fMRI results demonstrate "cooperation between visuospatial and motor executive functions" (p. 285); the authors link this conclusion to earlier findings that *kūsho* assists Japanese patients with pure alexia in recognizing *kanji*. Subsequently, Matsuo et al. (2001) used fMRI to compare brain activation during *kanji* production under various conditions. A task that involved performing *kūsho* induced extensive activation that was readily distinguishable from the profiles of activation induced by either copying printed *kanji* or transcribing *kanji* from dictation. A third study, Matsuo et al. (2003), examined the neurolinguistics of air writing in a pair of *kanji* analysis tasks under two conditions: When participants could freely perform *kūsho*, versus when hand movements were disallowed. The fMRI results showed that free use of *kūsho* "lightened neural loads in the recognition of ideographic characters" (2003, p. 269) in the sense that the movement-disallowed condition increased activation in specific parts of the brain compared to the profile of activation recorded when participants could freely use *kūsho*.

These studies, though provocative, provide only a few sketches of the status and function of *kūsho* from diverse perspectives. No synthetic, in-depth analysis has appeared, and even within Japanese and Chinese psycholinguistics, *kūsho* is acknowledged only rarely (e.g., by Kess & Miyamoto, 1999; Paradis, Hagiwara, & Hildebrandt, 1985), or not at all (e.g., by Chen, 1997; Leong & Tamaoka, 1998; Nakayama, 2001; Nakayama, Mazuka, & Shirai, 2006).

Research on the Use of *Kūsho* by L2 Learners of Japanese

Sasaki and Watanabe (1984) and Sumiyoshi (1996) observed native speakers of Chinese and Japanese extending the practice of *kūsho* in their L1 to their non-logographic English L2. But aside from Taya and Li's (2009) case study, which adverts to an L1 Urdu speaker's use of *kūsho*, Thomas (2013) provides a first survey of air writing by L2 learners of Japanese (and also documents the dearth of discussion of *kūsho* in publications on L2 Japanese and its pedagogy).

Thomas's (2013) central question was whether L2 learners employ *kūsho*, and if so, when. Forty-four adult L2 learners of Japanese were videotaped learning, writing, and recalling characters. Tasks included learning novel, complex, *kanji* (in different trials, with participants' hands restrained in an attempt to prevent *kūsho,* or with hands unrestrained; in both cases without calling attention to the phenomenon of *kūsho*, or to participants' use or non-use of it). Later, participants recalled and wrote the newly-learned *kanji*. In another task, they recalled and wrote down *kanji* drawn from their own repertoires of previously-learned characters, under several conditions: *kanji* recalled by meaning; by sound; by shape. Of 44 participants, all 44 spontaneously exhibited *kūsho* in at least one context—or in any number of contexts. Some used *kūsho* prolifically; some sparsely; some strategically in the performance of specific tasks. In particular, *kūsho* was especially prevalent in contexts where learners recalled *kanji* by shape, or where they faced difficulty recalling *kanji*. At the end of the procedure, when I disclosed the focus of the study on *kūsho,* many participants asserted that adopting a posture that inhibited *kūsho* had made learning *kanji* seem more difficult.

Although Thomas (2013) established the existence of *kūsho* in the orthographic practices of L2 learners, and incidentally gleaned evidence of learners' investment in it, many questions

remain. One key issue is whether *kūsho* can be shown to have objective value in the task of memorizing the shapes of *kanji*. Recall that Sasaki and Watanabe (1983) and Sasaki (1984) found that *kūsho* improved native speakers' performance on a *kanji* integration task, relative to their performance with hands restrained. In addition, Matsuo et al. (2001, 2003) demonstrated that *kūsho* lightens the neurological burden of recollection of *kanji*. Whether *kūsho* facilitates acquisition of *kanji* among L2 learners is a question posed in Thomas (2013), but data from that study proved inconclusive: In one condition, participants memorized novel *kanji* with their hands free so as to permit spontaneous use of *kūsho*, but not all participants chose to use *kūsho* in the hands-free condition. Conversely, more than 20% of participants found ways to subvert the hands-restrained condition, so that they managed to perform *kūsho* despite the imposition of a posture designed to inhibit it. Therefore the data in Thomas (2013) do not cleanly contrast the accuracy of memorization of *kanji* in contexts where *kūsho* is, versus is not, employed. A new approach is warranted.

Rationale of the Present Study

This research has obvious relevance to the teaching and learning of Japanese, as better insight into the resources that L2 learners can exploit in their acquisition of *kanji* may lead to more effective pedagogy (see Thomas, 2014). More broadly, this research may be of general interest in applied linguistics: Compared to many other languages, Japanese is often conceived as having an unusually difficult, 'less transparent' writing system (Cook & Bassetti, 2005, p. 9; see also Erbaugh 2002). Insofar as the utility of *kūsho* as a technique to ease the demands of literacy could be demonstrated for L2 learners, this study would augment our understanding of the psycholinguistics of logographic versus non-logographic writing systems.

Viewed from an even broader perspective, this research is also relevant to phenomena that Kirsh (2011, 2013) discusses as 'embodied cognition' or 'thinking with the body.' Kirsh's research explored a practice that dancers (in the classical, modern, and contemporary traditions) call 'marking.' In private practice and group rehearsals, dancers typically execute simplified, schematic, movements with their hands, heads, or limbs as a technique of memorizing the form and sequence of gestures that make up the totality of a dance they are learning; the execution of these movements for this purpose is known as marking. As a technique for learning—especially when it is used in private practice, as opposed to practice with a partner—marking seems to bear a relationship to the full performance of a dance something very like the relationship that *kūsho* bears to the full, material, writing of Japanese *kanji.* In an experiment carried out with professional dancers, Kirsch (2013) compared the efficacy of marking a novel phrase of a dance, to full-out rehearsal of that phrase, and to mental simulation of it carried out while passively lying down. The results showed that marking led to significantly better performance relative to the other two learning techniques. Kirsh depicts this finding as "counterintuitive" (p. 17), since it indicates that the abstract, sketchy, simplified practice of marking was more successful at cultivating mastery of a dance phrase, compared even to explicit, fully articulated, rehearsal of its component moves and their sequence. Kirsh accounts for this finding with reference to several hypotheses: That marking serves "as a mediating structure to facilitate mental stimulation" (p. 21); that it helps dancers "manage their attention during practice" (pp. 21–22); and that because different senses open up different kinds of access to cognition and experience, marking shows how "running ideas through the body that were first encountered visually can lead to perceiving creative possibilities that otherwise were hidden from sight" (p. 25).

Kirsh's experimental results and his analysis of dancers' use of marking are provocative in the context of this study of *kūsho*. Both the behavioral and neurolinguistic studies of *kūsho* reported above provide diverse evidence that writers of Japanese (and likely Chinese) use air writing as a kinesthetic tool to help store and retrieve *kanji*, easing the special burdens imposed by a logographic writing system. Kirsh's depiction of marking as a mediating structure that facilitates mental stimulation, which moreover helps dancers "manage their attention during practice" (pp. 21–22) seems apt with respect to what we know about *kūsho*.

The present study builds on the varied empirical evidence for the psycholinguistic value of *kūsho,* and presupposes on the basis of Thomas (2013) that the fundamental research question, namely, Do L2 learners of Japanese employ *kūsho* in learning and recalling *kanji*?, can be securely answered in the affirmative. It addresses whether L2 learners' accuracy of recall of novel *kanji* is demonstrably facilitated when they employ *kūsho* as a technique for learning relative to repetitive paper-and-pencil copying. In addition, I added a third technique to the comparison, in which a learner merely passively inspects the target *kanji* without writing (either on paper, or in the air), with his or her hands restrained. Passive visual inspection lacks pedagogical sanction as a learning technique, compared to the gold-standard practice of paper-and-pencil copying. However, it has been used in research (e.g. Matsuo et al*.,* 2003; Naka, 1998; Sasaki & Watanabe, 1983; Xu et al*.*, 2013), as a comparison against repetitive copying, or *kūsho*, or both; it has something in common with Kirsh's third experimental condition, in which dancers mentally simulated the novel dance phrase while lying down, without moving—that is, without "running ideas through the body" (Kirsh, 2013, p. 25). In the present research, I contrast *kūsho* to both copying and simple visual inspection to try to tease apart the role of the eyes versus the role of the hands in learning *kanji*. Both *kūsho* and copying provide kinesthetic information to

learners about the shapes of *kanji*, because in both cases learners' hands are in motion. During *kūsho*, however, learners can look freely at the model *kanji*. During copying, learners' eyes are occupied with the form emerging from their pen, and therefore they consult the model only episodically. During visual inspection without use of *kūsho* or copying, no obvious kinesthetic information is available to learners, but they have full access to visual input about the target *kanji*.

On the basis of earlier research showing that, for native speakers, *kūsho* facilitates analysis of the parts of *kanji* (in stroke-counting tasks and *kanji* integration tasks) and facilitates the spelling of L2 English words, I predict that L2 learners' accuracy of reproduction of the shapes of novel, complex, *kanji* will be higher following a learning condition in which they use *kūsho,* relative to learning through use of either repetitive copying with paper and pen, or passive visual inspection with the hands restrained.

Method

Overview

Participants memorized the shapes of sets of three novel, complex, *kanji*. This task was repeated three times, using different sets of target *kanji*, in three separate timed intervals, and carried out under three different learning conditions: In one trial, I directed participants to use *kūsho*; in another, to copy the *kanji* with paper and pen; and in the third trial, to memorize the target *kanji* solely by visual inspection with their hands restrained.[3] Each memorization trial was followed by a brief oral interview conducted in Japanese, to gather information about participants' backgrounds and to provide a distraction between the memorization and recall phases of each trial. After each interview, I asked participants to write down from memory the

three target *kanji* they had just learned. Their responses were later collated, assigned scores for accuracy, and compared across learning conditions. The entire experimental procedure was videotaped, focusing on participants' hands, arms, heads, and the orientation of their gaze relative to their hands.

Participants

Seventy-five adult intermediate to advanced learners of Japanese who were living in Japan participated, with each paid ¥1000 (approximately US$15.00). Twenty participants were male, 55 female. All were affiliated with universities near or in Tokyo or Osaka, as undergraduate or graduate students. The minimum criteria for participation were: (a) age 18 or older; (b) at least one year prior study of the Japanese language; (c) at least two months residence in Japan. Criteria (b) and (c) effectively eliminated beginners to the study of Japanese, but I did not otherwise assess participants' competence, nor do I relate the results of the study to differential levels of L2 proficiency. I restricted the study to learners residing in Japan because Thomas (2013) found that these learners spontaneously employ *kūsho*, whereas whether classroom learners of Japanese as a foreign L2 outside of Japan do or do not adopt *kūsho* remains an open issue. (Casual observation suggests that they do, but that impression remains to be explored.) Table 1 provides additional demographic information.

Participants in this study reported diverse native language backgrounds. English was the largest native-language group, comprising 29 of the 75 participants. The remainder included 3 native bilinguals, and native speakers of 20 additional languages belonging to the Austroasiatic, Austronesian, Indo-European, Sino-Tibetan, Tai-Kadai, and Uralic families, as specified in Table 2.

[Insert Tables 1 and 2 near here]

Materials

A consent form meeting the requirements of my local Institutional Review Board was distributed, explained, and signed by participants in advance of the experimental procedure. I also asked participants to orally reaffirm their willingness to be videotaped. I recorded on a separate data sheet the participants' oral responses to questions posed during the interview tasks (see below), and noted observations of their gestures and postures as a supplement to the video recordings. Participants recorded their responses to the three trials of the *kanji* memorization and recall task (and additional tasks) in a booklet comprised of an 8.5 by 11-inch sheet folded sideways to form four 8.5-inch-long vertical columns. I creased the sheet accordion-style, and turned back its pages after each trial so as to always present participants with a clean space on which to write. An Arabic number at the top of each page identified the trial, followed by a column of three 1.75-by-2-inch boxes, where participants wrote the three *kanji* elicited in that trial, one to a box. To encourage participants to produce large, legible, *kanji*, I provided them with a thick-nibbed ballpoint pen.

There were 12 target *kanji* used in the memorization and recall task, enlarged to 2.5-by-2.5 inches, then mounted on individual index cards. Their selection was a multi-stage procedure, which in part relied on the results of Thomas (2013). In the course of that study, I first retrieved a pool of potential target *kanji* from Nelson and Haig (1997) using three criteria: *Kanji* that are (a) not among the list of 1,945 *kanji* defined by the Japanese Ministry of Education as the first targets of acquisition (for child first language learners, although L2 instruction inherits this traditional sequencing as well); (b) visually complex (i.e., assembled out of 17 to 26 individual strokes, mean 21); and (c) not exhaustively decomposable into common, easily recognizable,

components (Toyoda [2009] discusses the salience to learners of components out of which characters are composed). I presented about 35 *kanji* meeting these criteria to five adult native speakers of Japanese, asking them to identify those they had not previously encountered, and deemed difficult in shape. Out of the pool of 35 characters, I extracted 15 that all five native speakers identified as both unfamiliar and difficult, which were then incorporated into the design of Thomas (2013). As a first step in that study, learners identified from an array of *kanji* (which included both the 15 target *kanji* and additional, easier, *kanji*) those with which they were completely unfamiliar. Participants reliably identified the 15 target *kanji* as unfamiliar.

For the purposes of the present study, I scrutinized the results of the *kanji* memorization-and-recall task in Thomas (2013) and discarded the 3 *kanji* from among the 15 that had the highest average recall accuracy rates (i.e. the 3 *kanji* participants found easiest to memorize), to arrive at the total set of 12 *kanji* used in the current study.[4] I then sorted those 12 to create 4 fixed sets of 3 *kanji*, using the recall accuracy scores of the participants in Thomas (2013) to create sets with commensurate mean accuracy scores. Each participant was presented with a random subset of 3 of those 4 sets; the fourth set was used in a pilot test, the results of which are not discussed here. No information was provided about the meanings or pronunciations associated with the target *kanji*. Appendix S2 in the Supporting Information online lists the 12 target *kanji*, by set, labeled as A, B, C, and D.

An iPad 2 recorded audio and video footage of the test procedure and post-test de-briefing, creating 75 video files averaging 37.68 minutes in length (ranging from 23.50 to 44.30 minutes; *SD*=3.34).

Procedure

The data were gathered from each participant individually in a single session, seated at a desk or table. English was used to communicate with most participants, with some code switching into Japanese. So as not to exclude learners with weak or no skills in English, Japanese was used with L2 learners who felt more comfortable with Japanese than English (the author / experimenter is a high-intermediate L2 learner of Japanese). For all participants, the interviews conducted between the memorization and recall phase of each trial (see below) were conducted entirely in Japanese.

The three successive trials of the learning-and-recall task formed the first event of the research procedure. The order of presentation of the trials was randomized by learning condition (memorization by writing; by visual inspection; by use of *kūsho*). The association of learning conditions to *kanji* sets A through D was randomized as well. I mentioned to participants that they would have 2.5 minutes to memorize each set of three target *kanji*, and that later I would ask them to recall and write their shapes from memory. At the beginning of each trial, I gave the participants instructions to use a specific technique for memorization, which varied by learning condition:

In the memorization by writing condition, I provided participants with a pen and a single 7-by-10 inch paper, blank on one side and printed on the other side with the grid-like boxes used for *kanji* writing practice. The instruction was to learn the shapes of the target *kanji* by copying them repeatedly, at the participant's own pace, using either the blank or grid-lined sides of the sheet.

In the memorization by visual inspection condition, I asked participants to sit with their arms parallel to their sides, then to rotate the wrists inward so as to trap each hand between the

same-side thigh and the seat of the chair. The instruction was to memorize the shapes of the target *kanji*, "This time, without using your hands, just your eyes."

Finally, in the memorization by kūsho condition, I first asked participants if they knew the word '*kūsho*', then explained and demonstrated some of its varieties until (as was universally the case) they recognized the phenomenon. Many seemed surprised to have their attention drawn to *kūsho*, but volunteered that they were accustomed to using it, and had observed others doing so as well. No participant was unfamiliar with air writing and none seemed inhibited about using it in the experimental context. I then invited them to use *kūsho* freely, in any location or style and on any scale, as they memorized the target *kanji*.

When participants evinced confidence that they understood the instructions, I presented them with one randomly selected set of three target *kanji*, mounted on a separate index cards, and began timing the first 2.5-minute learning interval. At the conclusion of each trial I collected the cards and launched into a 2-minute oral interview organized around the sequence of questions given in Appendix S3 of the Supporting Information online. The interviews were conducted in Japanese, and fixed in the order of questions posed, although some of the less experienced learners of Japanese did not work their way through the complete set of questions in the time allotted for the between-trial interviews. The interviews served several purposes. One purpose was to relieve the intensity of timed memorization of *kanji* and to function as a distraction between the memorization and recall phase of each trial. Another was to gather data about each participant's background and experiences learning to write in Japanese. A third purpose was to videotape learners' spontaneous speech in the L2 in conversation with another L2 learner, to study whether in this context they would employ conversational *kūsho*, that is, air writing as an

adjunct to oral communication—and if so, serving what apparent communicative ends (see Thomas, in preparation).

After each 2-minute interview, I presented participants with a pen and the response booklet (marked in advance with their name and participant number) opened to the appropriate page. I invited them to recall and write down the three *kanji* from the most recent learning trial, in any order, to whatever extent their memory allowed, indicating that partial reproductions would be welcome, earning partial credit. Each recall phase was limited to 2 minutes. After 2 minutes, or earlier if participants completed their reproductions before the time limit, I removed the response booklet and proceeded on to the next trial. At the conclusion of all of the memorization-and-recall trials, participants continued with various pilot tests, involving integration or recall of the components of familiar *kanji*, with and without access to *kūsho*.

Examples of the Collected Data

Excerpts of sample video files made during the experimental procedure are viewable on the Internet to readers of this article at a password-protected site, as detailed in Appendix S1. These video clips include examples of participants executing the memorization-by-writing trial (Video Files 2 and 3); the memorization-by-visual inspection trial (Video File 4); and the memorization-by-*kūsho* trial, illustrating some of the popular styles of executing *kūsho*: *kūsho* produced on the desktop (Video Files 5 and 6); on the palm of the non-dominant hand (Video File 7); on the learner's knee or thigh (Video File 8); and unsupported, in the air (Video Files 9 and 10). Video Files 11 through 13 illustrate 'surreptitious *kūsho*,' that is, learners' unprompted extension of *kūsho* into the writing and visual inspection trials, to be discussed below.

Video File 1 portrays conversational *kūsho*, added for the sake of illustrating another context in which *kūsho* appears. In this excerpt from a commercially available video prepared for

intermediate L2 learners of Japanese (Colligan-Taylor, 2007), a Buddhist clergyman explains a point in theology to an off-screen interviewer. The speaker employs *kūsho* twice to call attention to the heavily-freighted word translated as 'path' or 'way' (道). He writes the character in the air two times, each time supplying two alternative pronunciations for the character, both '*dō*' and '*michi*', as he expounds the complementarity of Buddhism and Shinto. His point seems to be that the same word and concept, written identically but having two pronunciations, participates in parallel in both philosophies. His use of *kūsho* draws attention to the word '*dō* / *michi*', elevating its phonetic multiplicity but conceptual unity into a symbol representing his assertion of the essential lack of conflict between Buddhism and Shinto.

Coding the Data

I examined the *kanji* that learners reproduced in the test booklets for accuracy, assigning a whole-number accuracy score ranging from 0 (no response) to 10 (fully accurate reproduction of the target *kanji*). Following Onose (1987) and Hatta, Kawakani, and Tamaoka (1998), I used a scoring technique that provided partial credit for correct formation of the components that make up complex *kanji* and for their correct placement in space with respect to each other. To ensure the consistency and independence of my evaluations of individual *kanji* I photocopied the raw data and separated each participant's reproduction of each character onto 675 slips of paper (75 participants x 3 sets of *kanji* x 3 tokens in each set), suppressing the identity of the learning condition under which it was produced. I then sorted these slips of paper by target *kanji* into 12 piles, one for each of the 12 target *kanji*. Working through the piles one by one, I first identified fully accurate reproductions (assigned a score of 10, or 100% accurate), and null or fully inaccurate reproductions (scored as 0). Then I used the rubrics illustrated in Appendix S4 of the

Supporting Information online to assign scores to each of the remaining reproductions, from 1 (10% accurate) to 9 (90% accurate), sorting them into piles by score. After repeating this process for all 12 target *kanji*, I reassessed the coherence of reproductions assigned to every *kanji* within every score category, and the coherence of reproductions assigned to every score category across every *kanji* (while continuing to mask the identity of the learning condition used to memorize each character; the accuracy of that learner's reproductions of other characters; and all personal information about the learner).

In a few cases, I consulted native speaker teachers of Japanese when it proved difficult to discern whether a learner's reproduction displayed an idiosyncratic but well-formed graphic style, as opposed to a faulty representation of the shape of a *kanji*. I also consulted native speaker teachers of Chinese for help distinguishing between faulty reproductions and recognizably Chinese variants of Japanese *kanji*, occasionally produced (as was revealed at the completion of the scoring procedure, when the identities of the learners was unmasked) by participants for whom Chinese was the first language. Chinese variants of the target *kanji* were not treated as errors.

When I was fully satisfied with the consistency of the scoring procedure, I unmasked the learning condition under which every reproduction was memorized, then tabulated the results by participant, by *kanji* set, and by learning condition. Appendix S4 illustrates participants' reproductions of *kanji* and the assignment of accuracy scores.

As a test of the validity of my evaluation of the data, a second rater (a native speaker of Japanese) independently repeated the scoring procedure for the total pool of 675 *kanji* reproductions, while similarly blinded to the learning condition under which each *kanji* was memorized, and all other information about the data and participants. Because inter-rater

reliability proved very high (Cronbach's alpha = .99), the analysis proceeded on the basis of the scores assigned by the first rater.

Results

Accuracy of Reproduction of *Kanji*

Overall, the mean rate of accuracy of reproduction of the target *kanji* for the total participant pool varied by learning condition: For memorization by writing, 23.00 out of a maximum score of 30, or 76.67% accurate (*SD*=6.98); for memorization by visual inspection, 24.00 out of 30, or 80.00% accurate (*SD*=6.59); for memorization by *kūsho*, 25.01 out of 30, or 85.38% accurate (*SD*=5.84). To investigate the significance of these different rates of accuracy of reproduction, I fit a linear mixed-effects model, with accuracy of reproduction as the response, random effects for participants (to account for within-subject correlation), and fixed effects for learning condition, for rater, and for learning condition x rater. I subsequently dropped the learning condition x rater term based on the outcome of the likelihood ratio test ($F = 0.050$, 3, 444, $p = 0.952$). Removing the learning condition x rater term, the likelihood ratio test for learning condition was significant ($F = 69.445$, 3, 529, $p < 0.001$). The likelihood ratio test for rater was borderline significant ($F = 3.320$, 1, 529, $p = 0.073$), so I chose to retain the term for rater in my model. Table 3 summarizes the result of the analysis of fixed effects. It shows that the higher rate of accuracy of reproduction of *kanji* under the *kūsho* learning condition compared to under the writing learning condition was statistically significant ($p = 0.018$). The differences in rates of accuracy of reproduction of *kanji* under writing versus visual inspection, and under *kūsho* versus visual inspection were not statistically significant ($p = 0.207$ and $p = 0.264$, respectively). The fact that iterative writing, the conventional technique for memorizing *kanji*,

did not lead to more accurate reproduction of their shapes compared to passive visual inspection was surprising, but not an unprecedented result (see Naka & Takizawa, 1990; Xu, Chang, Zhang, & Perfetti, 2012).[5]

[Insert Table 3 near here]

To further examine the scope of the advantage *kūsho* apparently affords to learners, and to explore the consistency of that advantage across the four sets of *kanji*, I repeated the analysis adding a fixed effects for *kanji* set (A, B, C, D) and for *kanji* set x learning condition. Because the interaction between *kanji* set and learning condition proved statistically significant ($p = .011$), I then examined the effect of each learning condition within each *kanji* set. Table 4 presents the result of this analysis.

[Insert Table 4 near here]

Table 4 shows that the finding that *kūsho* confers an advantage as a technique of memorizing *kanji* over iterative writing or passive inspection derives from participants' accuracy scores on Sets C and D. The participants' scores with Sets A and B do not distinguish *kūsho* from iterative writing or visual inspection, as no statistically significant difference in accuracy rates emerged. But in Set C *kūsho* proved to be significantly more effective as a technique of learning over visual inspection, and in Set D *kūsho* proved to be significantly more effective as a technique of learning over iterative writing, both at the level of $p < .01$. The contrast between Sets A and B on one hand on Sets C and D on the other shows that the efficacy of air writing as an instrument for memorization of the shapes of characters emerges in the contexts of learning some *kanji*, but not in others. In particular—despite an experimental design that assembled the target *kanji* in sets of equal predicted difficulty—it is notable that the overall rates of accuracy of reproduction in Sets C and D are lower than those in Sets A and B, suggesting that the

participants found Sets C and D more difficult, and Sets A and B easier, to memorize. That is, it was exactly in the more difficult Sets C and D that *kūsho* was demonstrably more effective as a technique for memorization compared to writing or visual inspection.

Effect on the Data of Displacement of other Learning Techniques by *Kūsho*

Reviewing the video recordings of participants' behavior during the various trials of the memorization-and-recall task uncovered an unanticipated finding. In the memorization-by-writing trial, participants were given a pen and paper and asked to learn the shapes of the target *kanji* by writing them repeatedly, at their own pace. The majority of the participants readily and conscientiously followed those instructions, which was expected since as experienced L2 learners of Japanese they had all had long exposure to the technique of learning *kanji* by iterative copying. However, 6 of the 75 participants interrupted their copying of the target *kanji* during the memorization-by-writing trial to spontaneously execute *kūsho*—at least once, and sometimes in a sustained manner. That is to say, these 6 participants either set down the pen to use a bare finger to trace the shapes of the target *kanji* on the table top or their open palm; or while still holding the pen, they raised it off the surface of the paper to execute *kūsho* in mid air (leaving no material record); or they inverted the pen to write in the air with the 'wrong' end of the pen extending from their fingers (see Video Files 11 and 12 for illustration). None of the 6 participants who introduced *kūsho* into the memorization-by-writing trial in these ways seemed aware that they were, in fact, surreptitiously subverting the instructions presented to them. None of them entirely supplanted writing by *kūsho*, so that every participant produced at least some material output when asked to memorize *kanji* by copying them on paper. But by introducing 'surreptitious *kūsho'* into the writing task, even briefly, this small subset of participants seemed to unconsciously signal a preference for *kūsho* over writing, or an assumption that *kūsho* would be

more effective than writing in helping them succeed at the task of memorization. I do not have direct evidence that this subset of 6 participants were acting on this assumption at the specific moments when they displaced writing with *kūsho*. But in post-test conversations, many participants in this study, as in Thomas (2013), expressed confidence that *kūsho* facilitated learning and recall of *kanji*.

Further analysis of the video files revealed an additional, though rare, incidence of surreptitious *kūsho* performed during the memorization-by-visual inspection trial. Recall that in the visual inspection trial, participants were asked to sit on their hands, and then to learn *kanji* "without using your hands, just your eyes." With hands thus restrained, however, 3 of the 75 participants proceeded to unwittingly move their heads, or even torsos, in a manner that unmistakably mimicked the movements entailed in the writing of *kanji*. These movements comprised sharp, tightly controlled, jerks, shakes, or bobs, clearly distinguishable from the slight swaying or shifting of weight that constitute the normal periodic easing of muscular tension for a person in a seated posture.[6] All 3 participants who inadvertently introduced *kūsho* into the memorization-by-visual inspection trial also inadvertently introduced *kūsho* into the memorization-by-writing trial. It is salient that even in the context of instructions designed to fully inhibit it, *kūsho* proved irrepressible to at least a few L2 learners.

Whatever motivation participants may have had for introducing *kūsho* into the writing or visual inspection trials, the data from these 6 individuals is worth attending to because it may have contaminated comparison of the accuracy of recall of *kanji* under the three different learning conditions. To explore whether this behavior had an impact on the data, I provisionally removed the 6 individuals who performed any form of surreptitious *kūsho* from the total pool of participants. I then repeated the linear fixed effects analysis with the trimmed subject pool, n =

69. The advantage in accuracy of reproduction of *kanji* following the *kūsho* learning condition versus following the writing learning condition remained intact: difference -2.29; standard error = .78; *t* (df) =-2.95 (410); *p* = .003. In fact, removing the participants who surreptitiously spread *kūsho* into the writing or the writing and visual inspection trials increased the overall apparent advantage of *kūsho* as a tool for learning *kanji* (from an average of 1.79 points to 2.29 points, on an accuracy scale of 0 to 30 for each set of 3 *kanji*), and increased the statistical significance of this difference (from *p* = 0. 018 to *p* = 0.003).[7]

Removal of participants who practiced surreptitious *kūsho* also increased the apparent advantage of *kūsho* over visual inspection as a technique for learning *kanji*, although that difference still did not reach the level of statistical significance: difference -1.27; standard error = .78; *t* (df) =-1.63 (410); *p* = .104.

Discussion

The present study hypothesized that learning complex, novel *kanji* using *kūsho* would result in more accurate reproduction than learning by iterative writing or by visual inspection alone without movement of the hands. Considering, first, the participants' overall rates of accuracy following the three learning conditions, memorization by *kūsho* did show an advantage over visual inspection, and a larger advantage over memorization by writing; the latter difference proved statistically significant. This is surprising granted that repeated material copying is considered the long-standing received method for learning how to write in Japanese.

Closer analysis of the data by *kanji* set revealed that the advantage conferred by *kūsho* resided in Sets C and D. Recall that the design of the experiment assembled 12 *kanji* into sets of 3 with the goal of equalizing each set in its difficulty to learners, based on the results of Thomas

(2013). However, it is impossible to predict with full accuracy which characters any particular learner will find especially difficult or easy to memorize. As it turned out, for the subject population in this study, Sets A and B proved easier, overall, for learners to memorize, and Sets C and D harder, as inferred from depressed rates of accuracy of recall in Sets C and D. One way of understanding these results is that the effect of *kūsho* may be masked at lower levels of task difficulty, whereas that effect stands out when the target *kanji* present more challenge. That is, perhaps there is a threshold of perceived difficulty beneath which *kūsho* is not significantly more facilitative relative to iterative writing or visual inspection; only above that threshold does an advantage for *kūsho* emerge. In the terms of Kirsh (2013) *kūsho* may not serve "as a mediating structure to facilitate mental stimulation" (p. 21), or help writers "manage their attention during practice" (pp. 21–22) equally at every level of complexity of a learning task. Rather, the boost to memorization gained by "running ideas through the body" (Kirsh, 2013, p. 25) via *kūsho* is only significantly greater than the effects of iterative writing or passive visual inspection of *kanji* when the cognitive bar is set relatively high. Further study of *kūsho* in L2 acquisition of Japanese is called for, in particular, study that assesses individual learners' judgments of the relative difficulty or ease of acquisition of target *kanji*, then compares their judgments against the effects or non-effects of different learning techniques.

In the present study the distinction across the three learning conditions was undermined by 6 participants who surreptitiously introduced *kūsho* into the memorization by writing or by visual inspection trials. However, this transgression added value to the data. Reanalysis of the rates of accuracy of reproduction of the target *kanji* excluding these 6 participants increased the contrast between writing and *kūsho,* and between memorization-by-visual inspection and *kūsho,* heightening the advantage that *kūsho* apparently affords in both cases. The adoption of

surreptitious *kūsho* by these 6 participants may have had the effect of raising their accuracy of reproduction of *kanji* in the writing and visual inspection tasks, disguising the actual contrast within the overall participant pool between learners' difficulty of memorizing *kanji* with versus without access to *kūsho*.

Returning to the rationale for this study with these results in mind, it is clear that, first, *kūsho* warrants more study as a pedagogical adjunct to the L2 acquisition *kanji*. Second, the phenomenon of *kūsho* is worth considering for its contributions to applied linguistics. It is commonplace to represent *kanji* as comprising tripartite units, around which learners build associations linking shapes, meanings, and sounds (Paradis, Hagiwara, & Hildebrandt 1985; Richmond 2005). The phenomenon of *kūsho* suggests that this three-sided representation omits a fourth fundamental facet, namely, the kinesthetic routines associated with logographs. Those routines are independent of the visually perceptible shapes of *kanji* (Murakami 1991), but can be exploited to access the shapes of *kanji* in memory—even, apparently, by L2 learners. It remains to be seen whether *kūsho* is merely facilitative, as opposed to essential, in the acquisition of logographic writing.

Third, the comparison between dancers' use of marking and *kūsho* is worth returning to, in reflecting on the finding that the efficacy of visual inspection generally fell between *kūsho* and iterative writing, even when those differences were not statistically significant. In Kirsh's (2013, p. 18) data, learning a new dance phrase through marking produced the best performance; full-out rehearsal was less effective; and passive mental simulation, where the facilitative effect of "running ideas through the body" (2013, p. 25) was minimized, proved least effective. In the present study, the instruction to memorize characters "without using your hands, just your eyes" put learners in a position somewhat less passive than Kirsh's dancers, who in the third learning

condition lay prone on the floor with their eyes closed while mentally rehearsing the target dance phrase. The visual inspection condition in this study of *kūsho* allowed unrestricted visual access to the target *kanji*, and unlike in the writing condition, learners did not have to divide their gaze between input from the model and regulation of their own act of manual copying of it. In this sense, visual inspection shares a feature of *kūsho,* which also allows unrestricted visual access to the target *kanji* because it is rarely executed with the eyes resting on the *kūsho*-producing hand in a sustained manner. On the other hand, what writing and *kūsho* share—but visual inspection, as well as Kirsh's mental simulation condition lack—is kinesthetic input, which supplies critical somatic information about the shape of the target *kanji* and how to reproduce that shape. In this sense, Kirsh's three learning conditions (each of which produced statistically significantly different outcomes from the others) are more spread apart across a continuum from purely passive mental simulation, to full physical engagement, to marking, in which physical engagement is abetted by mental mediation that helps dancers "manage their attention during practice" (pp. 21–22). The three *kanji*-learning techniques studied here are more closely aligned in the physical and cognitive resources they draw on.

If this analysis is on the right track, continued study of *kūsho* may contribute to Kirsh's (2011, 2013) hypotheses about how the body participates in cognition, by further triangulating the contributions of the eyes versus the hands in the process of memorization of *kanji*. To probe the consequences of differential visual versus kinesthetic input, one might conduct trials in which L2 learners attempt to memorize *kanji* with hands restricted but while viewing video animation of the target *kanji* being constructed stroke by stroke; or trials with hands unrestricted and *kūsho* encouraged, but with oral-only input about the shape of the target *kanji*, and no visual input.

Conclusion

It is worthwhile placing the modest results reported here in the context of the extensive labor entailed in acquiring literacy in L2 Japanese. *Kūsho* is apparently familiar to L2 learners as it is to native speakers, if under-acknowledged by both groups. Its self-conscious adoption as a technique of memorization would require no special apparatus or training. It is highly flexible and adaptable, and can be practiced in settings where the conventional technique of memorizing by writing would be inconvenient. Moreover, this study shows that the outcome of *kūsho* was more than on a par with writing: *Kūsho* significantly out-performed the standard practice of iterative copying of target *kanji* on paper as a technique for memorizing the shapes of *kanji*, an effect that apparently emerges when the overall difficulty in the task of memorization approaches a threshold. It remains to be seen whether the advantage afforded by *kūsho* recorded in the context of a short-term learning and recall task under experimental conditions can be transferred to the contexts of either classroom or independent study of *kanji*.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Contents of the Video Files

Appendix S2: Target *Kanji*

Appendix S3: Texts of the Interview Questions

Appendix S4: Illustration of the Scoring of Learners' Reproduction of *Kanji*

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Notes

[1] See Jorden (2002). Modern Japanese is written in a combination of *kanji* and two different native syllabaries. Each syllabary comprises about 50 individual graphemes representing a single vowel, a single consonant plus vowel, or a syllabic nasal. While *kanji* represent lexical morphemes, the syllabaries are typically employed to represent grammatical morphemes, inflections, foreign loanwords, and onomatopoeic words. Memorization of the syllabaries is a limited and straightforward task, in comparison to the challenges of memorizing the shapes of *kanji* and their multiple associated sounds and meanings (Gottlieb, 2005). The ability to recognize 3000 to 3500 *kanji* is required to read a modern Japanese newspaper (Gottlieb, 2000). Dictionaries may contain 12000 to 50000 characters (Kess & Miyamoto, 1999). But the exact number of existing *kanji* is indeterminate.

[2] There is another sense in which *kūsho* is 'abstract' and distinct from material writing. The movements that comprise *kūsho* are often executed iteratively in a single location, as if piling up on top of each other, without shifting the hand forward incrementally from the top of a page to the bottom (or from left to right) as one would when writing a sequence of visible characters with a pen.

[3] The complete protocol of the study from which these data derive included additional tasks that pilot-tested other methods of exploring the role of *kūsho* in L2 learners' orthographic practices. I do not report these data here.

[4] It is impossible to predict with complete certainty which *kanji* a learner will find complex or novel. However, I felt justified in treating these 12 characters as likely to be viewed as such by the participants in this study, since (1) as described above, they had already been judged

as unfamiliar and difficult by a panel of native speakers; (2) the L2 learners who participated in the current research were drawn from the same populations as those in Thomas (2013); and (3) based on their extent of exposure to L2, participants in the earlier study may have been somewhat more advanced relative to those in the present study: the average length of study of L2 in Thomas (2013) was 5.5 years (*SD*=3.92) versus in the present study, 4.3 years (*SD*=2.42). If so, that would likely render the target *kanji* more complex and less familiar to participants in the present study relative to those in Thomas (2013).

[5] An anonymous reviewer asked that I repeat the analysis excluding L2 learners whose native language was Chinese, to explore how the inclusion of participants in whose L1 *kūsho* is an established practice affected the results. The rate of accuracy of reproduction of *kanji* following the *kūsho* versus writing learning conditions for the trimmed subject pool, $N = 70$, was sustained: difference -1.96; standard error = .76; t (df) =-2.59 (416); $p = .010$.

[6] See Video File 13 for illustration of the intrusion of surreptitious *kūsho* into the memorization-by-visual inspection trial. In a similar attempt to inhibit *kūsho* in a *kanji*-learning task, Thomas (2013) had asked L2 learners of Japanese seated at a desk to bend the arms at the elbow across the chest, then lock each hand around the opposing upper arm. However, this posture proved even less effective in restraining surreptitious *kūsho*, in that 10 out of 44 participants (23%) unthinkingly freed one or more fingers to execute *kūsho* in the air while still maintaining the prescribed hand grip.

[7] For the trimmed subject pool, $N = 69$, the mean rates of accuracy of reproduction of *kanji* were as follows: following memorization by writing, 22.83 out of a maximum score of 30, or 76.09% accurate (*SD*=6.96); for memorization by visual inspection, 23.88 out of 30, or

79.61% accurate (*SD*=6.46); for memorization by *kūsho*, 25.30 out of 30, or 84.35% accurate (*SD*=5.82).

Table 1

Age, Length of Study of Japanese, and Length of Residence in Japan, for the L2 Learners (N=75)

	Mean	Min.-Max.	*SD*
Age (in years)	22.4	19–31	2.61
Years prior study of Japanese	4.3	1–13	3.95
Months living in Japan	10.2	2–108	12.40

Table 2

Native Languages of the L2 Learners

Native language	*N*	% of total group
Bengali	2	2.7
Bulgarian	1	1.3
Bulgarian / German bilingual	1	1.3
Catalan	1	1.3
Chinese	5	6.7
Danish	1	1.3
Dutch	1	1.3
English	29	38.7
French / Finnish bilingual	1	1.3
German	1	1.3
Hungarian	1	1.3
Indonesian	1	1.3
Italian	5	6.7
Khmer	1	1.3
Korean	4	5.3
Persian / Dari bilingual	1	1.3
Polish	2	2.7

Portuguese	2	2.7
Russian	2	2.7
Spanish	4	5.3
Tagalog	2	2.7
Thai	4	5.3

Table 3

Analysis of Estimates of Fixed Effects, Comparing Accuracy of Rate of Reproduction of Kanji under Three Learning Conditions

Learning Condition	Difference	Standard Error	95% Confidence Interval	*t* (df)	*p*
Kūsho vs. Writing	-1.79	0.75	-3.26, -.312	-2.38 (446)	0.018
Writing vs. Visual Inspection	-0.94	0.75	-2.41, 0.53	-1.26 (446)	0.207
Kūsho vs. Visual Inspection	-0.84	0.75	-2.32, -.635	-1.12 (446)	0.264

Table 4

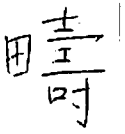
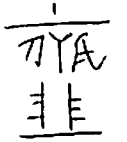
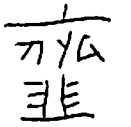
Mean Accuracy of Reproduction of Target Kanji, by Kanji Set, Following Memorization by Kūsho Compared to Following (a) Memorization by Writing, or (b) Memorization by Visual Inspection

Kanji Set	Mean Accuracy Following *Kūsho*[a]	Difference between following (a) Writing, or (b) Visual Inspection[a]	Difference between following *Kūsho* and (a) Writing, or (b) Visual Inspection[a]	*p*
Set A	23.14	(a) 25.64 (b) 23.72	(a) -2.50 (b) -0.58	0.168 0.695
Set B	25.26	(a) 25.27 (b) 25.48	(a) -0.01 (b) -0.22	0.996 0.866
Set C	23.92	(a) 22.15 (b) 19.09	(a) 1.77 (b) 4.83	0.193 0.004
Set D	24.85	(a) 20.22 (b) 22.96	(a) 4.63 (b) 1.89	0.003 0.293

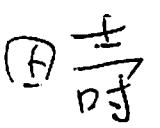
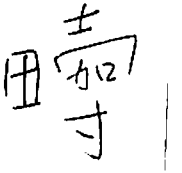
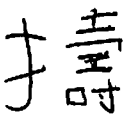
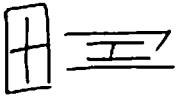
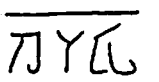
[a] Maximum accuracy score = 30 (3 *kanji* per set x maximum 10 points each for accuracy of reproduction).

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

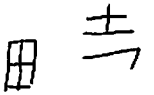
Appendix S4: Illustration of the Scoring of Learners' Reproductions of *Kanji*

Description of coding category	Representative learners' reproductions: Target *kanji* 疇	Representative learners' reproductions: Target *kanji* 韲	Score
Fully accurate reproduction			10 points
(Only) 1 detail missing, added, or inaccurate			9 points
(Only) 2 details missing, added, or inaccurate			8 points

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

1 component missing, added, or inaccurate; no more than 25% of surface area deformed			7 points
1 to 2 components missing, added, or inaccurate; >25% but <50% of surface area deformed			6 points
2 components missing, added, or inaccurate; 50% of surface area deformed			5 points
>50% but <75% of surface area deformed by missing, added, or inaccurate elements			4 points

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

75% of surface area deformed by missing, added, or inaccurate elements			3 points
(Only) 1 component, or 2 details, represented accurately		This score unattested for this *kanji*	2 points
(Only) 1 detail represented accurately			1 point

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

Appendix S1: Contents of the Video Files

Note: Viewable at http://capricorn.bc.edu/LearnKanjiKuusho . Login using Username < AirWriteL2J >; Password < KuushoL2J >

File	Task	Learner L1	Comments
1	Free conversation	(Japanese native speaker)	'Conversational *kūsho*' executed twice, in mid-air, outside of speaker's direct gaze, at 2:11:35 and 2:11:40 (Colligan-Taylor 2007)
2	Memorization by writing	English	Memorization of *kanji* by iterative copying
3	Memorization by writing	Persian/Dari	Memorization of *kanji* by iterative copying
4	Memorization by visual inspection	Russian	Memorization of *kanji* by visual inspection only, without using hands

5	Memorization by *kūsho*	English	Memorization of *kanji* by execution of *kūsho* on desktop
6	Memorization by *kūsho*	Bengali	Memorization of *kanji* by execution of *kūsho* on desktop, and in the air
7	Memorization by *kūsho*	Bulgarian	Memorization of *kanji* by execution of *kūsho* on open palm of the non-dominant hand
8	Memorization by *kūsho*	Finnish & French	Memorization of *kanji* by execution of *kūsho* on the knee
9	Memorization by *kūsho*	Spanish	Memorization of *kanji* by execution of *kūsho* in the air, unsupported by any surface
10	Memorization by *kūsho*	Catalan	L2 learner illustrates memorization of *kanji* by execution of large, dynamic, *kūsho* in the air, unsupported by any surface and directly in

			front of the face, but with eyes upturned
11	Memorization by writing, with surreptitious *kūsho*	Portuguese	Memorization of *kanji* by iterative copying, interrupted by execution of brief surreptitious *kūsho*
12	Memorization by writing, with surreptitious *kūsho*	English	Memorization of *kanji* by iterative copying, interrupted by execution of sustained surreptitious *kūsho*
13	Memorization by visual inspection, with surreptitious *kūsho*	English	Memorization of *kanji* by visual inspection, interrupted by sustained surreptitious *kūsho* executed with head and trunk

Appendix S2: Target *Kanji*

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

Note: Listed by Set Identified by Number in Nelson and Haig (1997)

Set A	# 2363	羸
	# 2289	擒
	# 4674	斃
Set B	# 918	嚠
	# 2926	欝
	# 6313	饎
Set C	# 3771	疇
	# 4632	鑵

	# 7007	鷹
Set D	# 339	儼
	# 6367	鑞
	# 7087	壟

Appendix S3: Texts of the Interview Questions

Note: I posed this series of questions to participants, in Japanese between the learning and recall phases of each experimental trial. For all participants the order of presentation of the questions was preserved, as was the two-minute interval allotted to each successive interview. Some lower-proficiency learners did not work their way through full battery of questions, but for each of the three learning conditions, two minutes of conversation intervened between the learning and recall phases.

Supporting Information for: Thomas, M., 'Air Writing' and SLA of Sino-Japanese Characters. Article accepted in *Language Learning* on 21 August 2014.

What is your age at present?

For how many years have you studied Japanese?

For how many months have you lived in Japan?

What is or are your native language(s)?

What other languages do you know, if any?

In what level are you now enrolled, within the your current Japanese language course?

Are you enrolled in a special *kanji* class?

What facets of the Japanese language do you find most difficult?

Approximately how many *kanji* do you study in the course of a week?

Please describe whatever strategies you use to master *kanji*.

How is your acquisition of *kanji* evaluated?

Do you write Japanese using a keyboard?

At what point in your study of Japanese did you begin to write with a keyboard?

At present, about what percentage of your total output in Japanese is written using a keyboard, as opposed to being written by hand?

What kinds of writing tasks do you characteristically carry out by hand versus by typing on a keyboard? (Prompt, if necessary: Notes taken in class? Essays? Homework exercises? Letters? Examinations?)

What advantages do you attribute to typing Japanese on a keyboard versus writing by hand?

What disadvantages do you attribute to typing versus writing by hand?

What do you think are the larger-scale social, cultural, or educational consequences of the shift from writing Japanese by hand versus typing on a keyboard?