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Oral spelling and writing in a logographic language: Insights from a Chinese dysgraphic individual

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ABSTRACT

The oral spelling process for logographic languages such as Chinese is intrinsically different from alphabetic languages. In Chinese only a subset of orthographic components are pronounceable and their phonological identities (i.e., component names) do not always correspond to the sound of the whole characters. We show that such phonological identities can nevertheless be selectively preserved when visual-motoric compositions are lost. We report a Chinese right-handed dysgraphic individual with left temporal and occipital damage, MZG, who was severely impaired in writing Chinese characters but was able to orally spell the same characters using the names of pronounceable components. MZG's writing deficit arose at the level of processing that is dedicated to the retrieval of the shapes (allographics) of the writing components. Such patterns show that phonological identities of components are part of the orthographic representation of Chinese characters, and that dissociation between oral and written spelling modalities is universal across different script systems. The temporal and occipital lobes in the language-dominant hemisphere are possibly important regions for allographic conversion in writing.

1. Introduction

The cognitive process of writing or spelling an English word is conventionally described by the following dual-route model (Baxter & Warrington, 1985; Coltheart, Patterson, & Marshall, 1980; Patterson, 1986; Shallice, 1981; see Fig. 1): one accesses the orthographic property by either retrieving the representation in the orthographic lexicon (a lexical route) that is most highly activated by the target concept or going through a phoneme-grapheme-conversion procedure (a sublexical route) in the case of writing to dictation. Such retrieved information is abstract and format-independent and is held in a temporary store, the graphemic output buffer. The output information of the grapheme output buffer is translated into letter shapes with the appropriate font and case (allograph), and then the graphic motor program is developed, leading to the execution of corresponding neuromuscular commands (see Rapp & Caramazza, 1997, for a review). The information in the graphemic output buffer can also be converted into letter names for oral spelling.

The graphemic output buffer is shared by written spelling and oral spelling processes because individuals with selective graphemic output buffer deficit show highly similar types of errors in the two modalities of output (e.g., Caramazza, Miceli, Villa, & Romani, 1987; Rapp & Kong, 2002). The written and oral modalities of spelling can be selectively damaged. Some brain-damaged cases have been reported showing selective impairment in writing but intact oral spelling ability (e.g., Chialant, Domoto-Reilly, Proios, & Caramazza, 2002; Rapp & Caramazza, 1997), or vice versa (e.g., Bub & Kertesz, 1982; Kinsbourne & Warrington, 1965). Such modality-specific writing deficits were not due to peripheral impairment in writing or naming individual letters, but reflected that letter-shape and letter-name conversions from graphemes are independent processes.

On an anatomical level, using functional brain imaging techniques on healthy subjects, researchers have identified certain brain regions that participate in various aspects of spelling. For instance, the left posterior inferior temporal cortex was found to be activated in tasks involving lexical-orthographic processing (e.g., Beeson et al., 2003; Hiromasa et al., 1999; Nakamura et al., 2000), the left supramarginal gyrus was found to be sensitive to phoneme-to-grapheme conversion (Sugihara, Kaminaga, & Sugishita, 2006), the left superior parietal lobe was observed to be relevant to the sequential execution of writing components (Beeson et al., 2003; Katanoda, Yoshikawa, & Sugishita, 2001), and the posterior part of the superior and middle frontal gyri (i.e., Exner's area) participated in employing the motor programs for producing letters (Katanoda et al., 2001). While these studies painted a general picture of the neural correlates of spelling, they were silent about the neural basis corresponding to more specific cognitive components. In particular, to our knowledge, none have looked at the neural activation patterns for oral vs. written spelling. Furthermore, only correlational relationships can be established based on these imaging studies. Therefore, it is crucial to consider the

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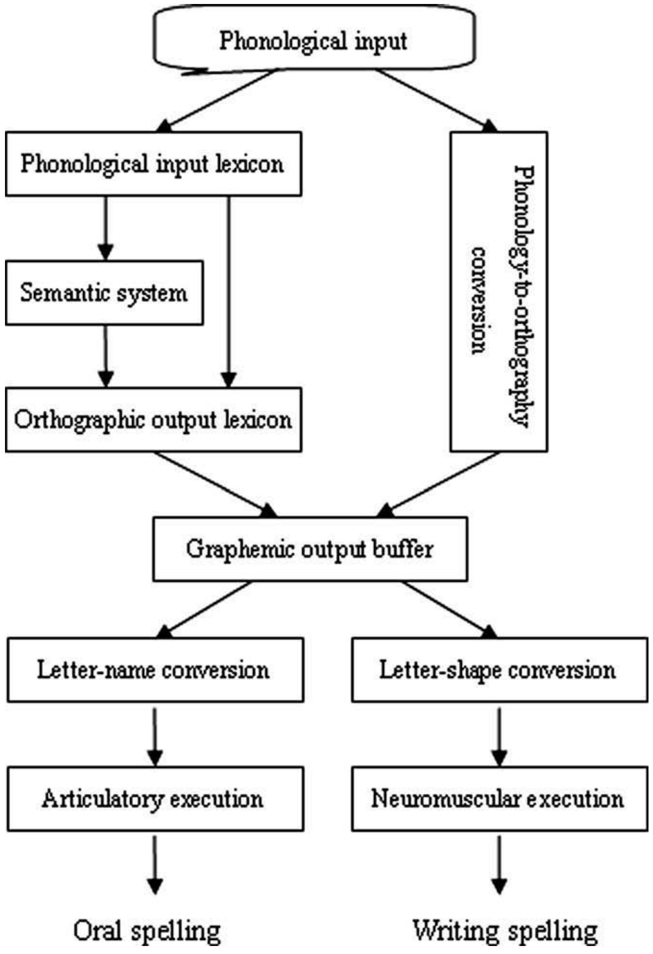

Fig. 1. A model of writing in alphabetic language (Adapted from Houghton & Zorzi, 2003).

cognitive neuropsychological evidence. Indeed, detailed studies on individuals with dysgraphia have revealed specific relationships between deficits of certain cognitive components in spelling and lesion sites (e.g., Exner, 1881; Henry, Beeson, Stark, & Rapcsak, 2007; Hillis, Wityk, Barker, & Caramazza, 2003; Rapp & Caramazza, 1997; Rapcsak et al., in press). Most relevant to our current interest, patients with intact oral spelling and allograph retrieval deficit in written spelling (allographic agraphia) were found to share a left posterior temporal–occipital lesion (e.g., Chialant et al., 2002; Rapp & Caramazza, 1997), suggesting the contribution of this brain region in the processing stage of allographic conversion, i.e., the retrieval of the letter-specific graphic/motor representations (see Rapcsak & Beeson, 2002; Rapp & Caramazza, 1997).

Although the cognitive architecture of writing described above has been supported by vast evidence from neuropsychological studies involving speakers of alphabetic languages (e.g., English, Italian, French), we have little knowledge of what in this architecture is universal to all languages that have a written script, and what is driven by the specific features of alphabetic scripts. While there is no reason to assume that the selection mechanism of orthographic lexical representation based on semantic activation is language-specific, other aspects of the theoretical model are rather specific to alphabetic scripts and do not apply directly to logographic scripts such as Chinese. For instance, there is no phoneme-grapheme-correspondence in Chinese characters, and therefore that particular sublexical route for writing is not applicable on a character level. In the current article we focus on one particular aspect of the functional structure for writing – two dissociable modalities of output following a shared output orthographic buffer – by exploring the relationship between the oral “spelling” and writing of Chinese characters. We will first present briefly the linguistic characteristics of Chinese characters and then discuss the lack of an obvious theoretical motivation to adopt a dual-modality output system for writing/spelling in logographic scripts. Then we will present a Chinese-speaking individual who showed impairment in writing characters but preserved the ability to orally spell the same characters. This case provides empirical evidence for the universality of dual-modality of output from the orthographic output buffer.

The basic writing unit in Chinese is the character, and a Chinese character (e.g., 译) usually corresponds to a syllable in sound (*/yi4/*[1]) and a morpheme in meaning (“to translate”). Visually and motorically it is composed of chunks of strokes that are arranged in a two-dimensional square. Two types of “chunks” are considered to be functional units of characters in reading and writing – radicals (Law, 1994, 2004; Law & Caramazza, 1995; Law, Yeung, Wong, & Chiu, 2005) and logographemes (Han, Zhang, Shu, & Bi, 2007; Law & Leung, 2000). About 80% of characters are so called composite characters (Li & Kang, 1993), each of which is composed of a semantic radical and a phonetic radical, providing some degree of semantic and phonological cues of the whole character, respectively. About 64%[2] of radicals can further be divided into logographemes, which are the smallest units in a character that are spatially separated (Han et al., 2007; Law & Leung, 2000; State Language Commission, 1998), the remaining radicals correspond to a single logographeme. There is no segmental correspondence between these constituent visual components (radicals and/or logographems) and the pronunciation of the character. The only orthography–phonology correspondence operates on the whole-syllable level by means of phonetic radicals (usually the right part) and can only apply to a subset of characters (Shu, Chen, Anderson, Wu, & Xuan, 2003; Weekes, Yin, Su, & Chen, 2006). Furthermore, only about 49% of character components are pronounceable, allowing oral spelling of some Chinese characters (State Language Commission, 1998), and for those that are, the pronunciation rarely has any relation with the sound of whole characters. Pronounceable components include those that are characters themselves and those having conventional verbal labels. Take the character “江” (*/jiang1/*, river) for example. The left part “氵” (a logographeme that corresponds to a semantic radical) is not a character but is called */san1-di1-shui3/* (literally three drops of water). The right part “工” (*/gong1/*, a logographeme that corresponds to a phonetic radical) when it stands alone is a character meaning “labor”. Although the sound of neither of these two components contribute to the pronunciation of the whole character (*/jiang1/*), and although the component’s verbal labels cannot be deduced from the character’s pronunciation, the character can nevertheless be orally described as “*/san1-di1-shui3/* on the left and */gong1/* on the right”. This is how people communicate about the writing of unfamiliar characters.[3]

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[1] Within the slashes are the phonetic transcripts of the corresponding character using the pinyin system. The Arabic digits represent tones of the preceding syllable. There are four tones in Mandarin Chinese.

[2] This percentage was derived from the analysis on the elementary school Chinese character corpus, which contains 3262 characters used in the elementary school textbooks in Beijing and exhausts the majority of common characters used by adults (Sun, 1998). Characters in the database contained 1105 radicals.

[3] There are other ways to orally communicate the writing of unfamiliar words if they contain unpronounceable components. People either refer to another character containing the same components, e.g., describe the right part of “译” (*/yi4/*, translate) as the right part of “择” (*/ze2/*, select), or describe the strokes, e.g., describing the right part of “行” as “two horizontal lines and one hooked vertical line”. However, these ways are not further considered in the current context because they clearly depart from the conventional oral spelling process using letter names, resembling the case of describing “t” as “a horizontal line and a vertical hook”.

Regarding the functional architecture of writing/spelling beyond the selection of orthographic (output) lexical representation, an orthographic (output) buffer in writing Chinese characters was recently proposed based on the behavioral profile of a Chinese dysgraphic individual (Han et al., 2007). He made numerous errors in delayed copying, and the most prevalent errors were logographeme substitutions. The difficulty could not be attributed to peripheral motor deficit and could not be readily explained by lexical or semantic factors (e.g., word frequency, concreteness, grammatical class). Instead, the copying performance was sensitive to a word length variable (number of logographemes), which is a marker effect for buffer impairment. The authors therefore proposed that this subject suffered a deficit to the orthographic output buffer (coined "logographeme output buffer") in writing, in which the logographeme identities are represented (see also Law & Leung, 2000).[4]

This logographeme buffer is comparable to the graphemic output buffer in writing/spelling alphabetic languages, but the contents being represented and the connecting components both upstream and downstream in the two systems might differ. First, as mentioned earlier, in the writing to dictation of Chinese characters, there is no phoneme-grapheme-conversion mechanism available to feed into the logographeme buffer. Critically for the current article, it is also speculated that the logographeme buffer in Chinese might only output visual/motoric information to a writing modality. This is because, again as introduced earlier, only half of the components in Chinese characters have verbal labels, and some labels are used only in these spelling contexts and do not contribute to the sound of the whole characters. In such specific situations, the retrieval of these verbal labels of the components might be accomplished through a "posthoc", metalinguistic process: the information being stored in the logographeme buffer only converts to the shape/motoric properties of the components, and once such shape properties are retrieved, the corresponding labels for these shapes units are "read" out. In other words, oral spelling using verbal labels of character components by normal Chinese speakers might be dependent on the writing process of a Chinese character, as opposed to being a dissociable process from written spelling like in English or other alphabetic languages. If this were true, a written spelling deficit would necessarily associate with an oral spelling deficit. Conversely, if oral spelling and written spelling processes are functionally autonomous beyond the logographeme output buffer, as in the alphabetic system, we would predict that oral spelling is still possible in spite of a written spelling impairment.

The purpose of this paper is to establish that oral spelling of Chinese characters can indeed be accomplished without the mediation of written spelling modality, and that the functional architecture of an orthographic output buffer followed by two modalities of output for writing/spelling also applies to Chinese despite the many differences in the linguistic characteristics outlined above. We present a Chinese speaker, MZG, who has intact ability in oral spelling of characters but is significantly impaired at writing them. His brain lesion sites overlapped with those of the individuals reported to have selective written spelling deficit in alphabetic languages.

2. Method

2.1. Case background

MZG is a 43-year-old, right-handed man with 18 years of education who is a college professor and a native speaker of Mandarin Chinese. He was diagnosed with cerebral artery malformation (AVM) in 1999, and underwent γ-knife radiation therapy in 2000 and 2001. Reductions in the lesion size were detected in annual follow-up MRI scans and in 2004 a slight edema was revealed in the lesion area. In September, 2005, he checked in the hospital complaining that his right limbs had been weak for four months, his memory had deteriorated, and in particular he had great difficulty with writing. He exhibited normal language comprehension and his spontaneous speech was fluent and grammatical. Routine T1- and T2-weighted MRI scans revealed irregular mass abnormal signals with unsmooth contours in the left occipital and parietal cortex and their subcortexes, reflecting the edema that were resulted from the γ-knife treatments. The left frontal, temporal, occipital and parietal cortex and their subcortical regions showed irregular signals on T1 and abnormal signals on T2. Their margins were vague. It was also observed that the brain midline shifted towards the right hemisphere (see Fig. 2). A proton-density-weighted imaging (PDWI) scan was also conducted, revealing an irregular, homogeneous, abnormal intensified region on the left temporal and occipital cortex. MZG was tested between October and December 2005.

MZG was initially administered a language screening battery developed in our lab (see Bi, Han, Weekes, & Shu, 2007). He had normal auditory digit span (forward: 9; backward: 3) and was perfect in various comprehension tasks including auditory word/picture matching (50/50 correct), auditory sentence/picture matching (20/20), visual word/picture matching (50/50), visual sentence/picture matching (20/20). His oral production was also near perfect, being 99–100% correct in oral repetition (40/40), oral reading (57/57) and oral picture naming (81/82). His writing ability was severely impaired, as indicated in the poor performance for written picture naming (1/10) and writing to dictation (0/10) tasks. He could nevertheless perform well in direct copying of words (10/10) and drawings (2/2).

We further compared systematically MZG's performance across different modalities using an identical set of items. Thirty items from the Snodgrass and Vanderwart (1980) picture set (see Shu, Cheng, & Zhang, 1989, for the Chinese norms) were selected to be used in oral reading, oral picture naming, written picture naming, writing to dictation, delayed copying and direct copying tasks. MZG was near perfect (93–100%) in oral reading (30/30), oral picture naming (29/30), delayed copying (28/30) and direct copy (30/30), and again had significant difficulty in written picture naming (19/30, 63%) and writing to dictation (17/30, 57%).

We noticed a striking phenomenon when he performed these writing tasks: he always correctly spoke out the names of the components whenever it was possible to do so, i.e., whenever any of the components had a verbal label, even for targets for which he failed to produce any written response. Take the character 扳 (*/ban1/*, turn around) for example, he could not produce any written response at all, but said "左边提手旁 ,右边是 反对的反" (on the left is */ti1shou3-pang2/*, on the right is */fan3/* as in */fan3dui4/*, "oppose"), which were the accurate names of the components specified at the correct positions. Intrigued by this observation, we selected ten characters whose components all had verbal labels and asked MZG to do writing to dictation and oral spelling to dictation on them in two separate blocks. He was significantly more accurate in oral spelling (10/10) than in writing (3/10) (χ^2 (1) = 7.91, $p < .01$). The following experimental study aims to investigate this pattern of performance on oral and written production of Chinese characters by employing a larger set of items and by comparing them to those of a control group.

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[4] Besides logographemes, phonetic radicals and semantic radicals are also candidate units for the orthographic representation. Law and colleagues (Law, 1994, 2004; Law & Caramazza, 1995; Law et al., 2005) reported a series of Cantonese dysgraphic speakers who made writing errors primarily on the radical level, where semantic and phonetic radicals were replaced, deleted, or added, while the overall configuration was maintained. Although the locus (loci) of the deficit was not specified, such patterns of errors indicate that radicals and the spatial properties of these radicals are also represented in the orthographic system.

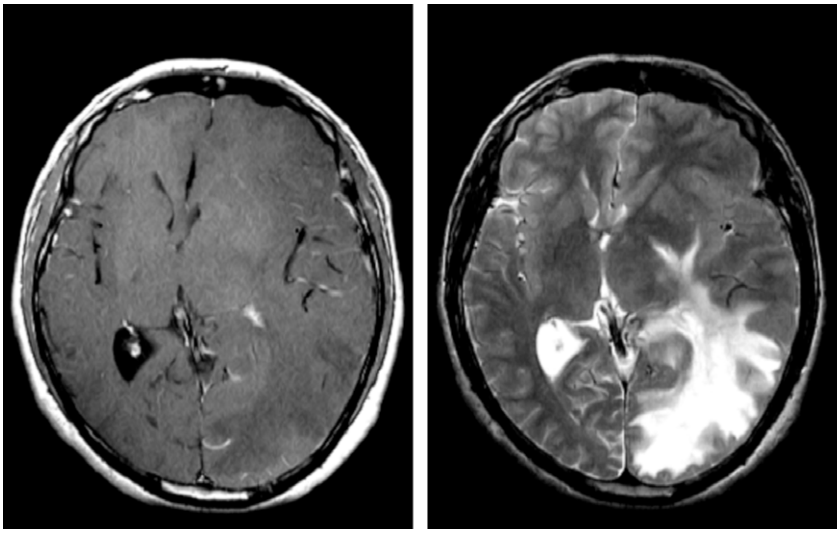

Fig. 2. MRI images of MZG.

2.2. Material

One hundred common characters were selected, each of which is composed of two pronounceable components (radicals or logographemes). Note that about 36% of all semantic/phonetic radicals correspond to single logographemes in Chinese (see Introduction section 1). Because the focus of the current paper is not to distinguish the processing mechanisms of these two types of components (radicals versus logographemes), we did not attempt to distinguish them in our stimuli. Additionally, some constituent components can be either classified as radicals or logographemes. We therefore refer to them as "components". To probe whether the positional information of the components was preserved, we used characters having various spatial compositions, including 86% with left-right structure (e.g., 对), 13% with top-down structure (e.g., 委), and 1% with surrounding structure (e.g., 屉). We took additional caution to ensure that a substantial proportion (31%) of the characters contained neither transparent semantic nor transparent phonetic radicals, i.e., the constituent radicals do not associate with the whole character by meaning or phonology. This is to avoid direct deductions of the sound and/or allographic entities of the radicals from the meaning or sound of the target characters (see Law et al., 2005), which might benefit oral spelling or written spelling differently. For instance, if the target character contains a transparent phonetic radical, it might be easier to retrieve the sound of this radical in oral spelling, and by the same token for those containing a transparent semantic radical, writing to dictation might be easier (see Law et al., 2005). In the remaining characters, 39% have either transparent phonetic radicals or transparent semantic radicals, and 30% have both. The characters span a wide range of frequency (range: 1/million–2854/million; mean: 185/million ± 349/million, Institute of Language Teaching & Research, 1986) and a wide range of visual complexity (stroke-numbers, range: 4–15; mean: 8.39 ± 2.05).

2.3. Procedure

The complete set of items was presented in a writing to dictation task and an oral spelling to dictation task in separate blocks. Given the prevalence of homophony in Chinese characters, the dictation of each character was presented in a context of a compound word to disambiguate among homophonic candidates, e.g., 委 (*/wei3/*) was presented as "*/wei3/* as in */wei3tuo1/* (委托, consign)". The same dictation contexts were used for oral spelling and writing tasks. In writing to dictation, MZG was asked to write down the target character on a piece of paper, and in the oral spelling to dictation task he was asked to orally describe the target character by giving the verbal labels of the components and their corresponding positions within the character. The items were assigned to the two tasks using the ABBA method and were completed in two sessions three days apart. The oral spelling task was recorded and then later transcribed. For both tasks the first complete responses were scored.

Three participants without any history of neuropsychological disease who matched MZG on gender (all men), age (mean: 41.3, range: 39–44) and education level (mean: 18.7 years, range: 16–20 years) were selected to serve as the control group. They were tested using a testing procedure identical to the one used with MZG.

3. Results

In writing to dictation, MZG's accuracy was 75% (75/100), and the control group's mean accuracy was 92% (range: 91–95%; SD: 2.3%). In oral spelling to dictation of the same items, MZG's accuracy was 97% (97/100), and the controls' mean was 92% (range: 89–94%; SD: 2.6%). Among the 25 characters MZG failed in writing, seven responses were orthographically similar real characters, including component omissions and substitutions (e.g., 软 (*/ruan3/*, soft) → 轨 (*/gui3/*, track); 劝 (*/quan4/*, persuade) → 力 (*/li4/*, strength)), 17 were noncharacters with component substitution (e.g., 呈 (*/cheng2/*, submit) → 早; 扬 (*/yang2/*, raise) → 扌匕) and one no response. The three items that he misspelled orally included two real character responses that were homophonic and orthographically similar to the target but incorrect in the target word context (猾 (*/hua2/*, cunning) → 滑 (*/hua2/*, slide); 蜻 (*/qing1/*, dragonfly) → 青 (*/qing1/*, blue)) and one noncharacter response where a component was added (伏 (*/fu2/*, pronate) → 亻伏). The control group altogether miswrote 24 characters. The erroneous responses included 12 real characters (seven phonological errors, three orthographic errors, one semantic error, and one mixed error), four non-characters (all orthographically similar to the targets) and eight "do not know" responses. They altogether made 23 errors in oral spelling. The erroneous responses included seven real characters (two phonological errors, three orthographic errors, and two mixed errors), seven non-characters (all orthographically similar to the targets) and nine "do not know" responses.

Using the statistical program developed by Crawford and Garthwaite (2005,2007), we compared MZG's performances with those of the controls in the writing and oral spelling tasks. The results revealed that MZG's writing was significantly impaired compared to normals ($p < .02$). His oral spelling performance, however, showed a non-significant trend of being even better than the control group ($p = .12$). Critically, his pattern of performance on written spelling and oral spelling fulfilled the criteria for a classical dissociation ($t = 4.36$, $p < .05$), taking into account the normals' performance patterns on these two tasks. The transparency of the semantic and phonetic radicals did not seem to affect MZG's spelling or writing performance, although he made too few errors in oral spelling to allow statistical analyses. We did notice that his three errors distributed evenly among characters with and without transparent radicals. His writing accuracy was 80% for characters with both transparent semantic and transparent phonetic radicals, 72% for those with only transparent semantic radicals or with only transparent phonetic radicals, and 74% for those with neither. No statistical differences were observed among them ($ps > .5$), suggesting that MZG did not use the cues from semantic or phonetic radicals to help with writing target characters (see Method section).

A caveat to consider is that MZG had an even higher accuracy than the control group on oral spelling. Although it is common for educated Chinese adults not to know how to spell some characters given the opacity of Chinese sound-orthography matching, it is necessary to exclude the possibility that the selected controls do not provide an adequate representation of this skill in typical Mandarin Chinese speakers/writers. We therefore collected the data of four graduate students at Beijing Normal university who were younger (mean age: 24, range: 23–25) than MZG and comparable in education level (mean: 17 years, range: 16–18 years). In the oral and writing spelling tasks, mean accuracies of the young subjects were 96% (*SD*: 1.7%) and 97% (*SD*: 0.5%), respectively. Comparing to these younger controls, MZG's performance was normal in oral spelling ($p = .29$) and was significantly impaired in writing ($p < .0001$). A classical dissociation was observed between these two tasks ($t = 5.41$, $p < .02$).

To further understand the nature of MZG's character writing deficit, we carried out a post hoc multiple (logistic) regression analysis to examine what relevant variables might predict his writing accuracy. The written accuracy of the character components (245 logographemes) in the 100 target characters was treated as the dependent variable, with correct ones coded as 1 and incorrect as 0. The independent variables included the frequency of the target character, the frequency of the target logographeme (Standards Press of China, 1994), the position of logographemes in the target character (State Language Commission, 1998), and the visual complexity of the logographemes (measured by number of strokes). None of these variables was found to significantly predict the logographeme writing accuracy ($ps > .4$). This null result might be due to the rather small number of errors.

4. Discussion

We reported a Mandarin-speaking individual suffering from brain-injury, MZG, who had severe disruption in writing while retaining a normal ability to orally produce the verbal labels of the characters. This is the first Chinese-speaking case documenting an oral spelling preservation in the face of dysgraphia. His auditory and visual comprehension and oral production were all normal, indicating that his input processing and conceptual system were preserved. The fact that MZG could perform at a near perfect level on oral spelling of characters indicates that he was able to access the correct code for output in the orthographic output lexicon. His intact direct copying and delayed copying ability, and the fact that his writing errors were mostly well-formed component substitutions, further show that his writing difficulty was not due to deficit to graphic motor patterns and/or the peripheral motor executive programs. Therefore MZG's writing deficit should lie in the processing stages between lexical retrieval and motor execution, probably at the retrieval of the shapes of the character components. As discussed in the Introduction, such pattern parallels those presented by individuals with "allographic agraphia" in alphabetic languages (see Rapp & Caramazza, 1997, for a review). Briefly put, such patients show various patterns of deficit with specific kinds of letter shapes. For instance, some patients produced frequent letter substitutions (e.g., Chialant et al., 2002; Rapp & Caramazza, 1997), some showed a disturbance in the ability to select the right case (e.g., Semenza, De Gelder, Piree, & Pizzi, 1998), and some had selective difficulty in writing one specific font or case (e.g., Hanley & Peters, 1996; Menichelli, Rapp, & Semenza, 2008; Patterson & Wing, 1989). In the spelling framework of alphabetic languages, this pattern of deficit is explained by an impairment to the processing stage(s) that retrieve the correct shapes for specific letters of certain case and font. Processing components higher than the graphemic output buffer and those specific to oral spelling (see Fig. 1) are left intact, allowing for normal oral spelling.

Worth noting is that MZG's brain lesion – the left posterior temporal–occipital region – is consistent with the lesion sites of those Indo-European speakers reported in the literature who had selective deficits of allographic retrieval in written spelling (e.g., Chialant et al., 2002; Rapcsak & Beeson, 2002; Rapp & Caramazza, 1997). This indicates that the left posterior temporal–occipital region plays an important role in the allographic conversion process regardless of the linguistic differences among scripts. As reviewed in the Introduction, the evidence from functional neuroimaging studies and neuropsychological studies have both suggested that the left inferior temporal regions processes the lexical orthographic properties (e.g., Beeson et al., 2003; Hiromasa et al., 1999; Nakamura et al., 2000) and that the left superior parietal areas were involved in the sequential execution of writing components (Beeson et al., 2003; Katanoda et al., 2001). Cases like ours with allographic conversion deficit, which selectively affected written spelling but not oral spelling, seem to be due to the disruption of the flow of information from the inferior temporal cortical regions to the left superior parietal areas. Such a finding motivates further functional neuroimaging studies to seek convergent evidence for the specific role of the left posterior temporal–occipital region in the allographic conversion processes.

Our data showed that oral spelling without the mediation of "visual shape" retrieval is indeed possible in Chinese. For those components that do have verbal labels, oral spelling and writing can be dissociated in much the same way as they are in alphabetic languages, although verbal labels cannot be deduced from or contribute to the sound of whole characters. The phonological labels of the components can be retrieved directly even when the allographic contents (shape/motoric features) of the components are not available. Similar to the processes of spelling alphabetic words, the abstract identities of logographemes (Han et al., 2007; Law & Leung, 2000) and probably radicals (Law, 1994, 2004; Law & Caramazza, 1995; Law et al., 2005) that are retrieved from the orthographic representations and stored in the logographeme output buffer can be directly converted into the verbal labels of components. Although we do not have independent evidence that oral spelling in Chinese goes through the orthographic output buffer as is the case in alphabetic languages, we assume here under the parsimony principle that this aspect of the functional structure is the same across languages. In oral spelling, MZG accesses the abstract identity of the components in the "logographeme output buffer", which in turn activates the corresponding verbal labels for successful oral output.

One caveat to consider is that in our study, most of the stimuli confounded logographemes and radicals. Because we were constrained to characters whose components all have verbal labels, the constituent logographemes tended to correspond to radicals. Such dissociation between oral spelling and writing might either entail the radical level or the logographeme level, or both. Further studies would be necessary to distinguish between pronounceable logographemes versus pronounceable radicals to clarify whether it is the phonological entity (names) of the logographemes or of the radicals are represented and used in oral spelling of Chinese characters.

To conclude, we documented a first case in logographic languages with selectively-preserved oral spelling (retrieving the verbal labels of the components) and impaired writing. Such a pattern highlights a universal functional architecture of the writing system, with two modalities of output being functionally distinct from each other. The retrieval of allographic contents, which is crucial for written spelling, seems to depend upon the posterior temporal–occipital region regardless of script type. The phonological identities of the visual components can be retrieved bypassing the shape/motoric contents of these components in logographic scripts.

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