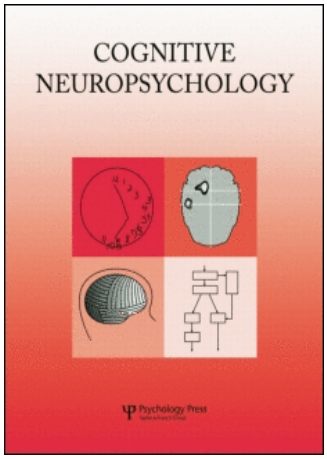

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The orthographic buffer in writing Chinese characters: Evidence from a dysgraphic patient

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We i e iga ed he e ica ce e i iig Chi e e cha ac e b d i g he dea ed c i g ef a ce fa Chi e e d ga hic a ie , W.L.Z. Hi dea ed c i g dif c c d be a ib ed e i he a de ci a d c d be eadi e ai ed b e ica e a ic fac . I ead, he c i g ef a ce a e iii e a d e g h a iab e (be f g ga- he e), a d he e a e e e g g a he e b i i . F he e, i he b i- i e , he a ge g g a he e a d e e ded ha e i a / ic a ib e . We e e ha he dea ed c i g dif c e ec a de ci he b ffe i g c e i iig (c i ed g g a he e b ffe), a d he i e ai a d a g age- eci c fea e f he b ffe i iig a e di c ed.

Chi e e cha ac e a e c e hi g. W i i g he i e a ia a age e f ke i a -di e i a a e i c ica ed a . Take he cha ac e "狮"(b ai , /*nao3*/[1]) f e a e, ke a e c ec ed i a i di ec- i (丿, 凵), a ced i a i e a i hi (一, 亠, 乂), a d . Wha g ide he iii g f he e c e? I he e a c ed e f ke c bi a i i Chi e e ha a e c a ab e e e g a he e i a habe ic ci ? I a , ca de de e ed f iii g a habe ic d be a ied iii g Chi e e cha ac e ? The c e a ice ie i e iga e he e ica ce e i iii g b d i g a Chi e e d ga hic a ie .

Re ea ch iii g i a habe ic a g age ha e ea ed ha iii g i e i e age (ee Fig e 1). Fi , he h g a hic e ie f a

[1] Wi hi he a he a e he h ei c a ci f he Chi e e d , f i g he *pinyin* e . The be de e he e f he e ecedi g ab e. The e a e f e i Ma da i . The be 0 e e e a e ed ab e.

C e de ce h d be add e ed Ya cha Bi, S a e Ke Lab a f C g i i e Ne cie ce a d Lea i g, Beiji g N a U i e i , Beiji g 100875, Chi a (-ai: bi@b .ed .c).

Thi e ea ch a e ed b g a f he Pa gde g jec (95- ecia -09), Na i a Na a Scie ce F da i f Chi a (30470574), a d he Beiji g Na a Scie ce F da i (7052035). We d ke ha k A f Ca a a a d B e da Ra f e e ie dic i a d he f c e ea ie d af f he a e a d Sa -P La a d Jia fe g Ya g f hei gge i he da a a a e . We a e e ecia g a ef W.L.Z. f hi ki d c ab a i .

h :// . e .c /c g e ch g
DOI:10.1080/02643290701381853

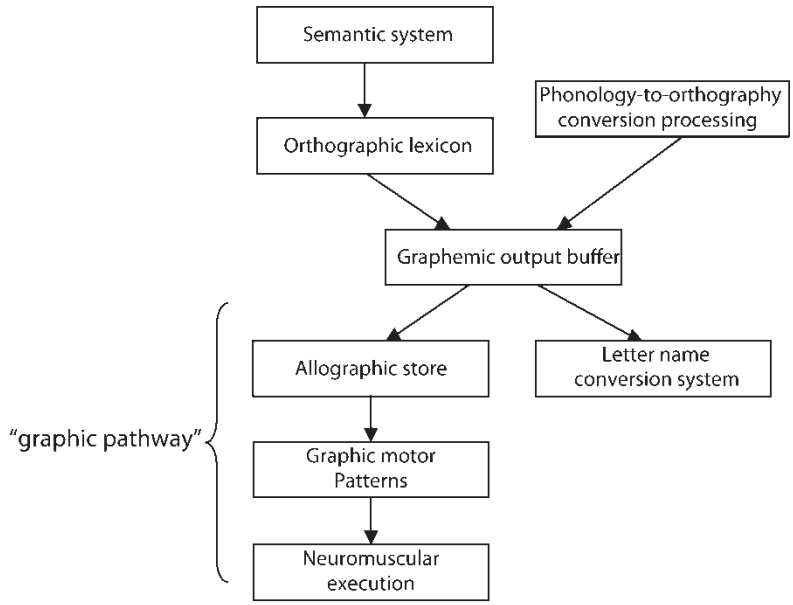

Figure 1. *A model of writing in alphabetic language (Adapted from Rapp & Caramazza, 1997).*

d c d ei he be e ie ed f e di ec , c d be c ed f he h e e ga he e c e i echa i . O ce he h ga hic i f a i i e ie ed, i i he di a a da ga he ic b ffe a ai i g f he ce i g. I i e e ei g, he ga he e i hi b ffe a e c e ed i e e ha e (e.g., a ga hic e e e a i a d ga hic a e), i c di g he c ec ca e a d f e ie , af e hich he c e- di g effec - eci c e i e ed (e.g., i , 1982, 1988; Ma g i , 1984; Ra & Ca a a a, 1997). I a e ei g, he ga he e i he b ffe a e c e ed i e e a e a d he a e d ced a (e.g., B b & Ke e , 1982).

The a ecif i g he e e e a i a d ce e i ba ed c a i a eed b a e i ica e ide ce, e ecia he b e a i f d ga hic a ie . Take he ga he ic b ffe f e a e. Gi e i i i hi he i i g a chi ec e de ic ed i Fig e 1, Ca a a a, Mice i, Vi a, a d R a i (1987) ea ed ha a e ie f beha- i a a e h da cia e ih he e ec i e di i f hi e e e . Beca e i i a e- ica c ie , i h d be i ece d b e ica a d e a ic fac (ch a fe ec , c ceee e , ga a ica ca), e ica i (d . d), he i da i ie (e.g., i i g dic a i , i e a i g), he da i ie (e.g., i e e i g, a e- i g, i g). The be f i i g e h d i ce a e a af c i f he d e g h, d e he g ea e dif c i e a i i g ge e e e ce. F he e, beca e e e (ga he e) a e ba ic ce i g i i hi b ffe, he i i g e h d cc e e . Pa ie i g hi e ha e i deed bee e ed i a i a habe ic a g age , i c di g I a ia , g i h, a d F e ch (e.g., A i, Le a , de Ma Pi e a, & Lec , 1998; Ca a a a & Mice i, 1990; Ca a a a, e a., 1987; Ci i, Bi d, G a , & Sha ice, 2004; Hi i & Ca a a a, 1989; McC e , Badecke, G d a -Sch a , & Aji i a, 1994; Ra & K g, 2002). F he e, de ai ed a a e f he e d ced b a ie i h e ec i e ga he ic b ffe i ai e ha e h ha he c e f e e e a i

he d i he b ffe i a he ich, i c di g he ide - i a d de f e e , he c a / e a f e e (B ch a d & Ra , 2006; Ca a a a & Mice i, 1990; C e i, Ab a ebi, Z i, & Ca a, 2003; Wa d & R a i, 2000), he he ic c e (Badec e , Hi i , & Ca a a a, 1990; O iag e & B e, 1993; Schi e , G ee ha , She , & Ca a a a, 2001), he g a h abic c e (Ca a a a & Mice i, 1990; Ze ige , O iag e , B e, & M d d, 1994), e e d b i g (Ca a a a & Mice i, 1990; Tai ie & Ca a a a, 1996), a d dig a h (Tai ie & Ra , 2004).

D g a hic a ie ha e a bee e ed h a e a ed ha e de ci ca ed a ce - i g age be d he g a he ic b ffe a d i he effec - eci c e i he a e (ee he a g a hic e e e - a i a d g a hic a e i Fig e 1 (i g)1g.9(Ca)-,age 7(Hi i45330.82 i45504.8 e(8; i g)-7(Ma g

he cha ac e i ic f ha i pai ed c p e . The a e hee q e i i i f he he pa ic a c p e i Fig e 1 a e i e a a d h a g age-peci c pa a e e i Chi e e a e ea i ed i ch a c g i i e he . Bef e e ab a i g ca e d , e bie fl i d ce he cha ac e i ic f Chi e e i i g c ip .[2]

Characteristics of Chinese scripts

Chi e e i a g g a phic a g age, a d he ba ic i i g i a e cha ac e (e.g., Wa g, 1973). Each cha ac e c e p d a abe i d a d a a a a p he e. Whi e e high f e q e d a e abic, 88% f Chi e e d a e c p d ha a e c p ed f i p e p he e (cha ac e), a d he aj i (74%) a e - p he e/cha ac e c p d (ILTR, 1986). Wi hi a i e c - p d d, he cha ac e a e i ea a a ged i a ef - - igh fa hi , each cc p i g a pace-i dep e de q a e. F e a p e, he d, 心理学 (p ch g , /xin1 li3 xue2/) i c p ed f h ee cha ac e , 心 (hea , /xin1/), 理 (ea , /li3/) a d 学 (e ea ch, /xue2/).

The e a e e ha 20,000 cha ac e i de Chi e e a g age, i c di g ab 3,000 c ed cha ac e . A cha ac e ca be pa ia a a ed i a hie a chica c e i i g e e a diffe e -i e i , c e i - a i c di g he adica a e, he g g a phe e a e, a d he k e (ee S a da d P e f Chi a, 1994; S a e La g age C i i , 1998). S k e a e c bi ed i ich pa ia e a i hi p f cha ac e , b hei c bi- a i i a d . F i a ce, a 丿 e e cc igh be a ㇏.

M e ha 80% f cha ac e a e -ca ed e a ic-p h e ic c p i e cha ac e (Sh , 2003). A c p i e cha ac e (e.g., 蝗, c , /huang2/) i c de p a : he e a ic adica (虫, i ec , /chong2/), hich p ide c e he ea i g f he cha ac e, a d he p h e ic adica (皇, e p e , /huang2/), hich a gi e c e he p cia i f he cha ac- e . M , b a , p h e ic adica a e a e i i g cha ac e he he a d a e. A a e p e ce age f e a ic adica a e a ed a i dep e de cha ac e , a d he he a e, he f e de g igh f a e a i (e.g., 朩→木). Nei he he e a ic adica he p h e ic adica a e e e iab e i de e b he ha e bee h affec he p ce i g f Chi e e cha ac e i c p ehe i a d eadi g (e.g., Bi, Ha , Wee k e , & Sh , i p e ; La , 2004; La , Ye g, W g, & Chi , 2005). Thei e i i i g cha ac e a e e ce ai .

S e i g i a d p ch i g i (e.g., F , 1991; La & Le g, 2000; S , 1994; Zha g, 1984) ha e p p ed a i e edia e e e be ee k e a d adica i i a Chi e e cha ac e g g a p he e ba ed p a ia- i a p i ci p e . L g g a p he e ,[3] a e c i ed b La a d Le g (2000), a e he a e i i a cha ac e ha a e p a ia e p a a ed. F i a ce, he h ee p a (虫, 门, a d 土) i 蝗 a e p a ia e p a a e f each he (a p p ed bei g c ed) a d a e he ef e c ide ed a diffe e g g a p he e . S ch i a i a e p d c i e i ha he a p p ea i a cha ac e . F e a p e, he p a "口" i f d i cha ac e 旦, 但, 兽, 僧, 睚, 驯, 铝, 啮, 暑, 晶, a d . O he a e b c k ha ca be f he di a e b ed i he g g a p he e a e c ide ed g g a p he e . He ce, a p h e ic adica (e.g., he "皇" i 蝗) c d be f he a a ed i e g g a p he e (门 a d 土). Ba ed he e p i ci p a , *The Chinese Character Component Standard of*

[2] Whi e Chi e e i ich i p k e dia ec ha a e diffe e b a i deg ee , he e a e c e k i d f Chi e e i e c ip ed he adi i a f ed i Tai a a d H g K g egi a d he i p i ed f ed i ai a d Chi a. The adi i a f a e a ec p e ha i p i ed f , hi e he c a p i ci p a a e c p a ab e. He e i p a p e e f c p i a i he i p i ed f .

[3] The a e c ce p ha bee add e ed a 部件, /bu4jian4/ (c p e bc p e) i ea ie i g i ic efe e ce (e.g., CCCSGCSIP, S a e La g age C i i , 1998).

GB13000.1 Character Set for Information Processing (CCCSGCSIP; S a e La g age C i i , 1998) i ed 560 g g a he e ha c ced he 20,902 cha ac e i he *UCS Chinese Character Database* (S a da d P e f Chi a, 1994). Thi g g a he e da aba e i be he e ed h gh he a ic e.

Previous research on writing in logographic languages

The ab e de c i i h ha Chi e e cha ac- e c d be a a ed i a i e e : e, g g a he e, adica , a d h e cha ac e . Wha he a e he ba ic f c i a i i i g Chi e e cha ac e ? H a e he e- e e ed a d e ie ed? I igh he e i e ha e ai c e f he e ha a ie i h b ai da age a e. K b, S i, Ya ad i, a d Sa (2001) e ed a Ja a e e b ai -da aged a ie h ffe ed f e ec i e i ai e i he h g a hic b ffe i i i g Ka a (ab g a) cha ac e a d a a i i i g Ka ji (g g a) cha ac e . Ba ed ch be a i he a h ed ha he e e i e a a e g a he ic b ffe f Ka ji a d Ka a d i i i g Ja a e e a d ha hei a ie had e ec i e i ai e he b ffe ed f Ka a d .

La a d c eag e (La , 1994; 2004; La & Ca a a a, 1995; La & Le g, 2000; La e a., 2005) e ed a e ie f ca e die he i i g e f a ce f Chi e e d g a hic a ie h e e Ca e e ea e i g a- di i a cha ac e . O e g f a ie (La , 1994; 2004; La & Ca a a a, 1995; La e a., 2005) ade a i i g e he adica e e, he e e a ic a d h e ic adica e e e aced (e.g., 踢 → 揚), de e ed (e.g., 鼎 → 加), added (e.g., 摩 → 櫸), gge i g ha he e a ic/h e ic adica igh be a ce i g e e ha c d be i ai ed e ec i e i cha ac e i i g. O e a ic a e e a ca e (S.F.T.) had a e de a ce f i i g e he g g a he e e e i a de a ed c a e, eadi g he a h c c de ha g g a- he e a e f c i a i i i i g a e (La & Le g, 2000). H e e, hi c c i i e a e beca e g g a he e a d adica e e c f ded i a age i f he e ha i, he e c d be ca i ed ei he a a g g a he e e a a adica e . F he e, a f he e e ed i ea cha ac e , a d he ef e e ica fac igh be a a. M c i ica , hi e S.F.T. a a de a ed c i g (40%[4]), he a a i ai ed i h di ec c i g (53%), ai i g he ibi i ha he c i g e a ac a ie i e i he a i a e .

O a ice e a ca e ha ha a di ed abi i i de a ed c i g i h e e ed di ec c i g abi i . Hi e a e i de a ed c ha ed i ia i ie i ce ai a ec i h e- i a ie i a habe ic a g age i h de ci a c ibed he g a hic a h a . We e e de ai ed a a e f hi i i g e add e he f i g e i : (a) Wha de ci ca e he de a ed c i g dif c ie ? (b) Wha a e he f ci a i i he i ai ed e e e ai ? (c) Wha c a cha ac e i ic d e ha e- e e ai ha e?

Case background

W.L.Z. i a 36- ea - d, igh -ha ded, Ma da i - ea i g a e i h ac ege ed ca i . P i a e, he ed i a f eig c hi g c a a d had a a g age abi i ie . I Ma 2004, he a ad i ed a h ia d e a e e e headache a d dif c i ea i g. A c ed g a h (CT) ca a he ac e age e ea ed a hae hage a he ef e a be. C a ai f he Chi e e i f *Western Aphasia Battery* (Ga e a., 1993; Ke e , 1982) ca eg i ed hi a ffe i g f e a ha ia. A ag e ic e a ce i agi g (MRI) ca e f ed i J e 2004 i dica ed he a i iai age f ef e - cci ia

[4] U e he i e ed, he be gi e a e c ec e ce age .

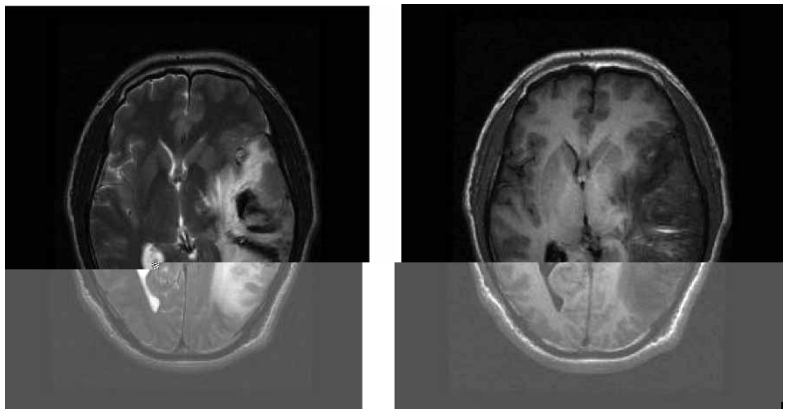

Figure 2. *MRI scans for W.L.Z.*

hae a a, i h he ibi i f hidde ac a af ai (ee Fig e 2). I ha a e h, a T a ca ia D e (TCD) ech i e di c ed a ea b d ig a i he e a i d a d dec ea ed b d f he ef e eb ba i a a e .

W.L.Z. a ad i i e ed he *Mandarin Clinical Language Screening Battery* ha a ada ed b a h YB f he *Harvard CNLab Language Screening Battery*. C da a e e c - ec ed f a a ici a h e e a ched W.L.Z. ge de (a e), ed ca i (c ege), ha ded e (igh), a d age (ea : 26 ea ; a ge: 22 36). The c g e e e fec a a e e ed be . W h i g i ha c a ici a h had he a e cc - ai a d age e e he high e d f he c g e f a ce.

W.L.Z. a e fec a he b cc -facia a a ia a (15/15), ic e c i g (2/2), h e e di - c i i a i (40/40), a d e e i i (d i h - ab e be a i g f e f , 35/35; d , 5/5). He a de a e i ai ed a a di digi a (f a d, 4; bac a d, 2; c g ea : f a d, 8.25; bac a d, 6.25).

W.L.Z.' e ica ec g i i a d c e he - i i e e i ai ed. He c ed 12/20 a a di - d/ i a - d a chi g a he e he eeded a ch e e c d d e f h ee i a d i c di g e a ge a d e a ed f i (e a ic, h g a hic, h gica); 41/50 a a di - d/ ic e a chi g a he e he a ched e e d e f ic e (a a ge a d a f i ha a ei he e a ica i a e a ed e a ed a ge); 41/50 he i a e i f he d/ ic e a chi g a ; a d 17/20 a a di e ica deci i a he e d e e c ea ed b c bi i g cha ac e / ab e (e.g., ea ; c g ea , 19.5/20).

W.L.Z.' a a d i e d c i e e e e i ai ed. He a a ab e ead d (0/57, a e e) a e ic e (11/82, ci c c i e ; c g ea , 95%). He a ab e e f he i i g dic a i a (0/10) a d he i e ic e- a i g a (0/11; c g ea , 95%), he e a he i i g e e e e . Ne e he e he had dif c c i g he cha ac e (20/20, f a e a e e ee Fig e 3), he e he had he a ge cha ac e i f f hi d i g he c i g. If he a ge cha - ac e e e a e a a f 2 bef e he a i c ed i ed ha he a (a de a ed c a), he a c ec f 19/30 f he i e (f a e a e ee Fig e 3). The e e he e e a e f ed, b 2 f he 11 e he ade e ed i a he ea cha ac e : 陆 (a d, /*lu4*/) → 许 (acc a , /*pei2*/) a d 楼 (b i di g, /*lou2*/) → 搂 (h g, /*lou3*/). The e ai i g 9 e e e e e e a

Figure 3. *Samples of W.L.Z.'s writing performance (erroneous part/s being circled).*

cha ac e , a f hich i e e he g g a he e e e f e a e, 碗 (b , */wan3/*) → 硯; 稿 (a ci , */gao3/*) → 秧; 填 (add, */tian2/*) → 坤; 徒 (a e ice, */tu2/*) → 仕.

I a , he c ee i g e e a ed ha W.L.Z. a i ai ed a a ge fc g i i e f c- i , ic di g d a d e e ce c ehe - i , eadi g, a d a a d ie a i g. O d f c e i a i hi ie d c i a e i g he dea ed c a k, beca e f he b e a i ha W.L.Z.' dea ed c e e a e ee i g e ea ed a de ci a g he g a hic a h a , a d W.L.Z. a ab e e f i e d c i f e a k (e.g., i i g dic a i , i e ic e a i g) a d beca e a e i g i ha d fea ib e i Chi e e i ca e . I de e a i e he he a d h a de ci de ci he e f c i a c e a g hi a h a c d acc f W.L.Z.' c i g beha- i , a d i e iga e he c e f ha c - e , e de ig ed he f i g de a ed c i g e e i e .

EXPERIMENT: DELAYED COPY

We e i ed i he I d c i ha if a a ie ha a e ec i e de ci a g he g a hic a h a f i i g (ee Fig e 1), ce ai edic i c d be de i ed ab he a ie ' i i g e f - a ce: I h d be i q e ced b e ica- e a ic fac (fe e c, c ceee , g a aica ca) a d e ica i (d . - d) a d h d e e he a e a e ac diffe e da i ie . I a a habe ic a g age he e h d cc he e e e e, cha a e e b i i , de e i , i e- i , a i i . If he de ci i ca ed a a b ffe - ike c e , he e f a ce h d be e i i e d e g h (a f i f - a i be he d i he b ffe). If he e a e e a ed he a ge b i a - a ia ke fea e , he igi f he e i ike be a a e e ha i e c a ab e a g a hic e a d/ g a hic a e .

I i b i ha a ie i i ai ed i h he g a hic a h a , b a ha e b e i he e a ic e , he h g a hic e ic , a d he h g a hic i e ic a g he . O ai a e he e i e a i e he he he dif c ie i hi a ic a a k dea ed c a e d e i ai e a g he g a hic a h a , a d, if , b ki g a he e a e e c d gai i igh i he c a cha ac e i ic f he e e e - a i ( ) fi e e .

The ai a e f he e e i e a de ig a d e a a e i a f . Fi , e ab i h

he he hi de a ed c i g e c e f a de ci he g a hic a h a , e a i a ed fac i c di g *lexical frequency*, *orthography–phonology regularity*, *concreteness*, a d *grammatical class* f he e cha ac e a d c a ed hi c i g e f a ce d hi e f a ce d . If he e i de a ed c i g i deed igi a e f he g a hic a h a , he e fac h d affec he c i g e f a ce. The d- e g h fac f he e cha ac e (be f ke a d be f g g a he e) e e a a i a ed e e he he he i ai ed c e ha b ffe - ike e e ie . The , ba ed he e c b ai ed i he e ei e , e e a i ed a ha h g a hic e e he e cc ed (ke , g g a- he e , adica), ha e e ia fac igh edic he e f a ce (e.g., i i i ide f he e cha ac e), a d ha e a i hi he a ge a d he e e i ha e (e.g., i a- a ia ke fea e). The e f he e a a e d e ia a e he e f i g i e e a ed e e i : (a) Wha i a e ac de ci i a g he g a hic a h a ha be e ai he e a e he g a he ic b ffe , he a g a hic e e e a i , he g a hic a e ? (b) Wha a e he f c i a i i he i ai ed c e ? (c) Wha a e he c a cha ac e- i ic f ha i ai ed c e ?

Method

Materials

T a id f he c ica i ch a - h g , e e ec ed i g e-cha ac e (a i g e- ab e) d a e a e ia .

Frequency and phonetic regularity. A a f 160 c i e cha ac e e e bdi ided i f 40-cha ac e i : 2 (f e e c : high,) × 2 (eg a i : eg a , i eg a). A *regular* c i e cha ac e (e.g., 怖, h , */bu4/*) ha e ide ica cia i i h i h e ic adica (e.g., 布, c h, */bu4/*), he ea a *irregular* cha ac e (e.g., 错, g, */cuo4/*) ha a c e e e diffe e cia i f ha f i h e ic adica (e.g., 昔, a , */xi1/*). The cha ac e f e e c c a e f he *Frequency Dictionary of Modern Chinese* (ILTR, 1986). We a ched he f ki d f cha ac e i a c e i ea e i c di g be f ke a d be f g g a he e . The a i ic f ea f e e c , ea g g a he e be , a d ea ke be i each ca eg a e he f i g: high-f e e c eg a (353 ± 171,[5] 2.93 ± 0.89, 10.25 ± 2.92); high-f e e c i eg a (353 ± 240, 2.63 ± 0.67, 10.25 ± 2.23), -f e e c eg a (13 ± 9, 2.73 ± 0.64, 10.25 ± 2.38), a d -f e e c i eg a (13 ± 9, 2.83 ± 0.90, 10.25 ± 2.23).

Concreteness. A a f 44 cha ac e e e e ec ed, ha f f hich e e e a ica c c e e (e.g., 灯, a), a d he he ha f e e e a ica ab ac (e.g., 宛, i i a). The e ec ed cha ac e e e gi e 10 a a ici a a e hei e a ic c c e e e /ab ac e a 7- i ca e, i h 1 bei g c c e e a d 7 bei g ab ac . The ea a i g e e 2.03 f he c c e e cha ac e a d 5.17 f he ab ac cha ac e , a d he diffe e ce a high ig i - ca , $t(42) = 11.275$, $p < .0001$. The e i f cha ac e e e a ched f e e c , be f g g a he e , a d be f ke (c c e e, 76 ± 123, 2.82 ± 1.01, 9.54 ± 3.47; ab ac , 76 ± 125, 2.86 ± 1.04, 10.00 ± 3.00, e ec i e).

Grammatical word class. The f i g h ee 33-cha ac e i e e ch e : c c e e (e.g., 狼, f), ab ac (e.g., 祸, di a e), a d ab ac e b (e.g., 忘, f ge). The e e a ched f e e c a d be f ke (c c e e , 396 ± 504, 9.64 ± 2.87; ab ac , 405 ± 404, 9.70 ± 2.72; ab ac e b , 414 ± 592, 9.61 ± 3.47). Ca e a a ake ha e e a be f ie i each i e e eg a c i e cha ac e .

[5] The a e i he c di i ea a d he ec d he a da d de ia i .

Lexicality. A a f 20 ea cha ac e e e ec ed, a d 20 (ega) cha ac e e e ge e - a ed b a d ai i g e a ic adica a d h e ic adica ge he . The i e e a ched he be f ke a d g g a he e (ea cha ac e , 8.1 ± 2.22 a d 2.45 ± 0.60; cha ac e , 8.1 ± 2.43 a d 2.45 ± 0.60, e ec i e).

Number of strokes. A a f 148 i e e e i e a i a fe - ke cha ac e i a d a a - ke cha ac e i (ke be , 9.51 ± 0.73 . 14.38 ± 1.63). The e e ba a ced cha ac e f e e c (56 ± 69.34 . 57 ± 60.22) a d g g a he e be (3.00 ± 1.01 . 3.03 ± 1.04).

Number of logographemes. I a 385 cha ac e e e ec ed i c di g 140 -, 140 h ee-, a d 105 f - g g a he e cha ac e . We a ched he e h ee e f cha ac e be f ke (11.04 ± 6.65, 10.91 ± 6.25, 11.50 ± 6.67, e ec i e) a d cha ac e f e e c (186 ± 212, 151 ± 186, 173 ± 257, e ec i e).

Procedure

I each ia f he e i g, he e e i e e e e- e ed e i a cha ac e i he idd e f a hee f a e , a d W.L.Z. a a ed k a i f ec d . The i a he e ed, a d W.L.Z. a e i ed i e i d . I fac , a h gh e e c aged W.L.Z. k a he a ge cha ac e f ec d ,

The ic e ih ega d he d e g h fac a e c ica ed. N effec f ke be c i g e f a ce a b e ed, $\chi^2(1) < 1$. The e a a e d ch ha he e g g a he e a cha ac e ha , he e ike i i f e cc he cha ac e , b he ig- i ca ce f he effec de e d he a i hich i i e a a ed. Fi , if he acc ac a e i ca c- a ed he cha ac e e e , he c ec e ce age i -, h ee-, a d f - g g a he e cha ac e e e 48%, 31%, a d 24%, e ec i e , $\chi^2(2) = 17.75$, $p < .0001$. T e a a e he he he b- abi i f ge i g a g g a he e c ec i de e- i ed b he be f g g a he e i he d, e ca c a ed he g g a he e e a e b ca c a i g he e ce age f i ake g g a- he e i a ce di ided b he a be f g g a he e i each g . The c ec ed g- g a he e e ce age i -, h ee-, a d f - g g a he e cha ac e e e 77%, 68%, a d 67%, e ec i e , $\chi^2(2) = 4.767$, $p = .09$. Thi a gi a ig i ca e d f he d e g h effec a f he e a i ed i g eg e i a a i , a d i h i Sec i 3 f he Re ec i .

2. Error analyses: Stroke vs. logographeme vs. radicals

I he ab e a a e e ked a ha fac f he e a ge affec ed he ike ih d f e ; e he cha ac e i ic f he e he e e . Fi , he a e i ade, i he h e cha ac e bei g i ake d ced, i a ke i i e , a e he g g a he e / ad- ica b i ed, de e ed, added, a ed? The a e hi e i i ide i f- a i ega di g he a e f he f c i a i i he i ai ed e e e a i . T i e i- ga e hi i e e c ied a he e (557 cha ac e) f a b e i he e e i e (876 cha ac e i a). We c a i ed he e e cha ac e i e acc di g he he he e e a a ea cha ac e . The cha ac e e e e e c ed a he he he had e a ic h gica / h g a hic e a i hi i h he a ge . The cha ac e e e e e f he di ided i f ca eg ie acc di g e f he e e h g a hic i : g g a he e e , ke e , c bi- a i e , a d ec g i ab e e (ee La & Le g, 2000). C e e c ed a g g a- he e e he a age g g a he e a b i ed, de e ed, added, a ed. S ke e e e h e ca e he e a ke a i i e . C bi a i e e e h e e he he e e c ai ed b h g g a he e e a d ke e . The ibi i ha e e h d be ca eg i ed a adica e i di- c ed a e . A ec g i ab e e i dica ed ha i a dif c ide if he e e. Tab e 2 di a he e a e a d di ib i f a i e e . We ca ee ha he c e e e g g a he e e .

We f he c a i ed he g g a he e e i g g a he e b i i , de e i , i e- i , a d a ii e (ee La & Le g, 2000). A a f 55% f he 499 cha ac e i h g g a he e e c ai ed a i ge g- g a he e e , 32% c ai ed g g a he e e , 13% c ai ed h ee, a d 1% c ai ed f . Whe he e i ed i e g g a- he e , i ab 8% f he ca e e e he e e g g a he e a a (e.g., bei g he 2 d a d he 4 h i a f - g g a he e cha ac- e) ha i , he aj i e e adjace each he . Thi a e igh be a cia ed i h he

Table 2. *The percentage and examples of various error types*

		Examples	
Error type	*% (N)*	*Target*	*Response*
Cha ac e	4 (27)	斧(a e, /*fu3*/)	爸(fa he , /*ba4*/)
N cha ac e			
L g g a he e[a]	91 (499)		
S ke	2 (13)	逃(e ca e, /*tao2*/)	逃
L g g a he e & ke	0.3 (2)	请(i ie, /*qing3*/)	请
U ec g i ab e	2 (16)		
T a	100 (557)		

[a]See Tab e 3 f f he i f a i ab g g a he e e .

e g g a he e, a d he c e d e g g a he e (h e ic adica). If he e i e i ge- g g a he e adica , i i i ib e ea e a a he e ki d f e e i . If a e cc e g g a he e f a age cha ac e , e c d e a i e he he he e i e g g a- he e be g e adica a d f he b i- i ca e he he he e e e a c e d a adica . We f d ha i he h e e f 557 e e i e cha ac e , he aj i (398) f he e cc ed g- g a he e ha did c e d a adica , 147 i ed e (a ge a d/ e e) ha c d be c a i ed b h a e g g a he e a d a e adica , a d i 12 ca e e e i e g g a he e i ed ha c e ded ad- ica . The ef e, ea g g a he e e , a ed adica e , e e he c e f e . B he a e ke , i i high ike ha he e e a e ke e e ha ha e ed c i e g g a he e . I a e e i e g g a he e , 95% f he e e e i e- ke g g a he e . F he e, i he a e ca e he e e cc ed a i ge- ke g g a he e, i a a a b i ed b a i e- ke g g a he e.

3. Logographeme errors: A regression analysis

We ha e b e ed ha he c e i g e f a ce did ee be affec ed b he e ica fac f he a ge cha ac e , a d ha he e e e a e c i e g g a he e e . I hi ec i , e ca ied a gi ic ege i a a i e e e e e ia a iab e ha igh edic he c e i g e f a ce f a a ic a g g a he e. We a a ed he h e e f 2,931 g g a he e ha a ea ed i a he e ed cha ac e , f hich W.L.Z. c ec

Table 3. *The percentage and examples of various types of logographeme errors*

		Examples	
Error type	*% (N)*	*Target*	*Response*
S b i i	80 (639)	嘶(h a e, /*si1*/)	嗽
De e i	19 (151)	萎(i he , /*wei3*/)	委
I e i	1 (6)	算(e ca e, /*tao2*/)	算
T a i i	0 (0)		
T a	100 (796)		

c ied 68%. The de e de a iab e a he c e fW.L.Z.' c i g e f a a ic a g ga- he e (1 f c ec a d 0 f i c ec). The e- dic c ee d a age f a i e ie f he g g a he e a d f he c e di g cha ac- e , i c di g be f g g a he e i he c e di g e cha ac e , g fe ec f he c e di g e cha ac e (S , 1998), e be f he g g a he e, g fe ec f he g g a he e (S a da d P e f Chi a, 1994), a d he e a ii f he g g a- he e i he c e di g e cha ac e .

The c ea i a i a g he edic (ee Tab e 4) h e edic ed c ea i . F i a ce, ii f g g a he e i cha ac- e a d be f g g a he e e cha ac e ee iie c ea ed. The cha ac e fe ec a d he be f g g a he e e cha ac e ee ega i e c ea ed, i dica i g ha he highe he fe ec a , he i a a d/ ica i e a cha ac e e ded be. Si ia , g g a he e fe ec a d e be i a g g a he e ee a ega i e c ea ed. S ec ea i ee ece a i edic ed b ee ed ea ab e a di ee i g f ea e, he e be i hi a g g a- he ea di ii i he c e di g cha- ac e ee ega i e c ea ed. I igh i dica e ha i e g g a he e e d cc a he e d f cha ac e . S ec ea i f ea e, he ega i e c ea i be ee he g g a he e fe ec a d he be f g- g a he e i he age cha ac e a e had i e e a d a be d e e ed fac cha ce.

We c d c ed a gi ic ege i i g a f a d (LR) e ie e h d, hee he a- ab e a e a a ica e ec ed a d e e ed i he de i e ece f hei eigh f c i- b i he de e de a iab e. The e a e di a ed i Tab e 5. We f d ha f he a- ab e, ii i he e cha ac e a he ig i ca edic he babi i f he g- g a he ec i g c e, $\chi^2(1) = 546.2$, $p < .000$, f ed b he be f g g a he e e e cha ac e , $\chi^2(1) = 82.7$, $p < .000$, he g fe- e c f he g g a he e, $\chi^2(1) = 17.7$, $p < .000$, a d he g fe ec f he e cha ac e , $\chi^2(1) = 13.0$, $p < .000$. S e be i hi he g g a he e did a e a i de e de c ib i a d a i c ded i he de.

The eg e i a a i e a e ica ed he e i di g ha W.L.Z.' acc ac i i i g g g a he e a a f c i f h a g g a he e he c e di g e cha- ac e c ai ed, a d he be f e i he cha ac e he g g a he e did ee a e, i dica i g ha cha ac e c e i e g h a be e ea ed b g g a he e ha b e. The a ge fe ec eached ig- i ca ce i edic i g he c ig f a g g a- he e i hi a a i , c adic i g he ab ce f he a ge fe ec effec i he e i ec i (ee Tab e 1). T c ha i i deed had a i de e de c ib i , e e ed a he he a iab e i he e ai a d he e ed he a ge fe ec a iab e, a d e f d ha i ig i ca i c ea ed he edic- i e e (*p* < .001). Thi a f he e gge ei he ha e ica edge i ed W.L.Z.' c i g e f a ce (e.g., ee Sage & i , 2004) ha hi e ica de ci igh i deed a a e i he c i g a e . We a g e ha i d e i cha e ge ai ae f i g W.L.Z.' c i g dif c ie d he e ica g a hic a h a f i i g, if e e a he ea a e f hi beha i . I a ic a, i a a a e he

Table 4. *R-values among the predictors for the regression analysis.*

	NLC	*FC*	*SNL*	*FL*	*PLC*
NLC	1				
FC	−0.084**	1			
SNL	−0.377**	−0.049*	1		
FL	−0.277**	0.006	−0.357**	1	
PLC	0.414**	−0.035	−0.164**	0.018	1

Note: Labe : NLC = be f g g a he e e c e di g e cha ac e . FC = g fe ec f he c e di g e cha ac e . SNL = e be f he g g a he e. FL = g fe ec f he g g a he e. PLC = e a ii f he g g a he e i he c e di g e cha ac e .

Table 5. *Results of a logistic regression analysis of 2,931 items with W.L.Z.'s writing accuracy as the dependent variable*

Step	*Variable*	*Model log likelihood*	*Change in −2 log likelihood*	*df*	*p-* a e
1	P i i f g i cha	−1,838.2	546.2	1	<.0001
2	N be f g e cha	−1,565.1	82.7	1	<.0001
	P i i f g i cha	−1,834.0	620.6	1	<.0001
3	N be f g e cha	−1,542.2	54.7	1	<.0001
	P i i f g i cha	−1,812.7	595.8	1	<.0001
	F e f g	−1,523.7	17.7	1	<.0001
4	N be f g e cha	−1,537.8	58.9	1	<.0001
	F e f cha	−1,514.8	13.0	1	<.0001
	P i i f g i cha	−1,807.6	598.5	1	<.0001
	F e f g	−1,516.4	16.1	1	<.0001

Note: P i i f g i cha = e a i i f he g g a he ei he c e di g e cha ac e. N be f g e cha = be f g g a he e e c e di g e cha ac e. F e f g = g f e e c f he g g a he e.

a iab e he ha f e e c e e e a i ed f e- e c a a a c ed f .

O ei e e i g b e a i ha e e ged f he eg e i a a i i ha he e f a ce a a ic a g g a he e a high affec ed b i e ia de i i i cha ac e ($p < .0001$). T f he ca if hi i i effec , e i a he cha ac e i h e g g a he e i de a ed c acc di g he be f g g a- he e i each cha ac e i 242 -, 389 h ee-, 300 f -, a d 52 e- g g a he e cha- ac e . We he c ed each g g a he e i each cha ac e . The c i g ced e a i a e abided b he i ci e f a a i i c ec e e ed i he ca e f a ie L.B. (Ca a a a & Mice i, 1990, . 250).

Fig e 4 h ha W.L.Z.' e ce age f each i i i hi he cha ac e a ied acc di g he g g a he e ' be . C a i g a he cha ac e ega d e f he cha ac e e g h, he , ec d, hi d, f h, a d f h g g a he e i he cha ac e e e i c ec i e 7% (71/983), 31% (304/983), 51% (381/741), 63% (223/352), a d 63% (33/52), e ec i e . W.L.Z.' i i g e hibi ed a ig- i ca g ad a i c ea e i e ce age f he i i ia g g a he e he a e i cha ac- e , $\chi^2(4) = 583.5$, $p < .0001$. M e e , a i i a a e e ed i e e i ig b ke b e g h: - g g a he e, $\chi^2(1) = 95.8$, $p < .0001$; h ee- g g a he e, $\chi^2(2) = 215.7$, $p < .0001$; f - g g a he e, $\chi^2(3) = 287.4$, $p < .0001$; a d e- g g a he e, $\chi^2(4) = 63.3$, $p < .0001$, cha ac e . F e a e, he e 箭 a 箍, he e he a g g a he e 们 a b i ed ih 乂. He e 煮 a 者, he e he g g a he e 夕 a acc a e i e , he idd e e 川 a e aced b 贝, a d he a e 灬 a de e ed. I he d , a i ea e ia i i effec e e ed i W.L.Z.' i i g.

The e a e e e a ib e e a a i f hi effec . Fi f a , i i ib e ha he g g a- he e a he e d i i e d be e dif- c (e.g., i a e c e e f e e). Sec d, if he effec i ea , i igh igi a e

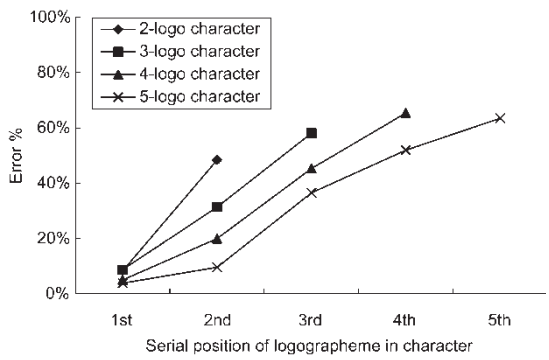

Figure 4. *Serial position effect of the logographemes in copying characters.*

ei he f he i ce (he i a e c di g he i i) f he ce (he e d ci g he i i). A h gh he e ha bee e ide ce ha he i a i i d ec g i i ha e i a a a e fa hi (e.g., C hea , Ra e, Pe , La gd , & Zieg e , 2001), e ca i agi e ha he i ce i a c i g a ca he a ge cha ac e i a ef - - igh / - -b fa hi a d he ef e fa he ef / g g a he e e h e he igh /b . I deed, i a d (Zha g & She g, 1999) he e a ici a e e a ed a e g g a he e e bedded i diffe e - i i f i a e e ed Chi e e cha ac e , i a b e ed ha he a i g e f a ce f he a e g g a he e a be e i he - i i ha i he b i i a d a be e i he ef i i ha i he igh i i . The a h a ib ed ch e he ie i g habi f Chi e e eade . B c a , if he - i i a effec igi a e f a ce , a e a effec i edic ed ch ha ea ie g g a he e a e be e c ied ha a e g g a he e . Ma Chi e e cha - ac e e e a i e e i g di ce a c be ee he (i) a ia de a d he ( ) e - a de . F e a e, he cha ac e 迟 ha g g a he e : 长 a d 入. I a e a e - ec i e, 入 i i a ie g g a he e, he ea f he a ia ef - - igh e e ce, i i he e. Gi e ha a i de ci d d ce ei he i i a effec (a i a a e ce i g) a effec fa i g he ef / e he igh /b g g a he e (i ha ca i g de), if he a e e e e i ch cha ac e a e f d be e e i ai e , i h d be d e a b ffe - i g ce f . I he d , if a e - a i i a effec a b e ed, i d be g e ide ce f he h he i ha W.L.Z.' c i g e e f he i ai e f a b ffe i g c e i he ce ha e e a i ia f ci a e a he g a he ic b ffe i i g a habe ic a g age . The f i g a a e a d e ei e e e d e e he e h ee h he e ega di g he i i effec .

3.1. Testing the difficulty difference account. T e he ibi i ha he i i effec i d e he dif c diffe e ce i diffe e i i , 30 ai f cha ac e e e ec ed. The cha - ac e i each ai ha e e ide ica g g a- he e ha a e i diffe e i i (e.g., 放–访, i h he g g a he e "方" he ef f "放" a d he igh f "访"). The g f cha ac e e e a a ched f e c (410 . 535; $t < 1$). W.L.Z. c ec c ied fe e c i ica g g a he e he he e e he igh i i ha he he e e he ef i i (22/30 . 13/30); $\chi^2(1) = 5.55$, $p < .05$. F e a e, he c ec e "火" i "灶", b i e "火" i "伙" a "贞". Thi a e a a e ica ed b i g 30 ai f cha ac e he e he a e g g a he e e e ed b hi he ef a di he igh i i diffe e ia , $\chi^2(1) = 40.85$, $p < .0001$.

3.2. Distinguishing the (input) spatial position vs. the (output) temporal position. T c a if he he he i i a effec i a (i) a ia effec a ( ) e a effec , e i ec ed a cha ac- e ($N = 28$) f he e ed e ha h ed di c e a c be ee he a ia i i a d he e a i f e a e, 迟 (he a a ia g g a he e i 长, a d he a g g a- he e be i e i 入). If i i he a ia - i i ha a e e d edic he g g a he e he ef (入) be c ied be e ha he e he igh (长), a d ice e a if he e a i i a e . The e h ed ha he (e a i e) igh g g a he e (19/28) e e i deed c ied e c ec ha he - h ed h6T he e e340.2(a h 7-7.1(12.24780TD(/)T

pa ia p ii eec ie ,idica ig ha he p ii effec ideed a e p a.

4. Target–response logographeme relationships

Whe W.L.Z. fai ed c p a g g ap he ec - ec , ha did he ie? We e a i ed he i a/ ic ea i hip be ee he a ge g g a- phe e a d he c e p di g e e p e d he he he e ai ai ed a pa- ic a ki d f p e ie f he a ge g g a- phe e. S ch a a e d i f he he he ei ei f ai ea ai ed i he i pai ed c p e he he peci c ide i f he g - g ap he ei . T a id a p e ia c f d, e died he cha ac e i hich W.L.Z. ade e b i i e a d c ec ed 209 g - g ap he e b i i e . We c pa ed each a ge e p e pai i a/ ic di e - i , ig ea e he e a i a c - g a i (c e, ke ea i) a d i di id a ke e e e (ke ha pe). S c e a d ke ea i p ide ea e f he i a a a ge e f he e e e (e.g., c e ke a e a ig ed i a ef / igh fa hi i a p/d fa hi he i e; ke ea i ke a e a ig ed i a c i g a e a c ec i g a e , e c.). The ke ha pe a iab e ea e he ic fea- e a d/ i a ha pe f a i di id a ke b ca eg i i g ke i e gh ca eg ie (e.g., h i a e ica). We ed c a i ca i c i e ia f each ca eg f he e p pe ie de i ed f he CCCSGCSIP (1998; ee he abe i Tab e 6 f de ai ed de c ip i), ca c - a ed he p babi i f W.L.Z.' b i i e be i hi a a e ca eg f a gi e p pe , a d c pa ed he b e ed i hi -ca - eg p babi i a cha ce e e.

Take he ke e a i p pe , f e a pe. I ca be ca eg i ed i i b pe (i g e ke , c i g, epa a e, c ec i g, c ed-c ec i g, a d c ed- epa a e). We a k he he W.L.Z.' i hi -ca eg b i i (i.e., a i g e- ke g g ap he e b i ed f a he i g e- ke e, a epa - a e ke g g ap he e b i ed f a he epa a e ke e, e c.) e ded cc e f e e ha he cha ce e e. Fi , e c ed W.L.Z.' b e ed a e f i hi - bca- eg b i i pe f a ce a d f d ha 36% (75/209) b i i cc ed i hi ca - eg . The e ca c a ed he cha ce e e f i hi - bca eg b i i ig a M e Ca i a i p ced e, ada p i g he e h d ed e ab i h he cha ce e e f i a/ i i a i i Ra p p a d Ca a a a (1997). Fi e a d e-pai ed he 209 e e g g ap he e i h he a ge g g a- phe e a d he c p ed a i hi -ca eg p babi i he e f hi e-pai i g. A a f 5,000 ch a d pai i g f he i e i he a ge -e i e e ca ied, ge e a i g 5,000 ba e i e i hi -ca eg p babi i a e f hi ke- e a i p pe . T b ai a e e ec i g h ike W.L.Z.' b e ed i hi -ca eg p babi i (36%) f hi ea e i d e cha ce e e, e ca c a ed he pe ce age f i a ce i h a a e e a highe ha hi b e ed a e i he 5,000 ba e-

Table 6. *Comparison of the observed versus the expected percentage of the within-category substitutions between the target logographemes and responses*

	Observed value		*Expected value*			
Logographeme property	*%*	*N*	*%*	*Range*	*Instance*	*p-* a e
1. S c e	43	89/209	28 ± 3	19 37	0	<.0002
2. S ke e a i	36	75/209	29 ± 3	19 40	43	<.01
3. Fi ke ha e	42	87/209	23 ± 3	13 34	0	<.0002

Note: Labe : 1. A a f 10 e a a ia ca eg ie , i c di g i e (e.g., ·), ef - igh (e.g., 扌), -b (e.g., 贝), - idd e-b (e.g., 象), d e ef (e.g., 丿), d e igh (e.g., 亅), d be (e.g., 凵), d h ee- a e (e.g., 丿乚), d f (e.g., 冂), a d f a e (e.g., 木). 2. Si e f ke e a i ic di g i ge ke (e.g., ·), c i g (e.g., 艹), e a a e (e.g., 彡), c ec i g (e.g., 厂), c ed-c ec i g (e.g., 尢), a d c ed- e a a e (e.g., 必). 3. The h ica c g a i f he ke i he g g a he e, i c di g h i a (e.g., ·), e ica (e.g., 亅), a ed (e.g., 亅), i ed (e.g., 丶), a d c ked (e.g., 冖).

f e e c c ib i , he f i g di g ega di g hi de a ed c i g e f a ce e e ged f e e i e :

1. A a ic a d e g h fac be f g g a he e affec ed de a ed c i g e f a ce.
2. The e e i a a a c e- ded g g a he e a ed ad- ica ke , i h g g a he e b i i bei g he f e e e f e .
3. The g g a he e' e a i i i he c e di g cha ac e a d he g g a he e f e e c e e ig i ca edic f he c i g e f a ce, b i ke be a .
4. Whe a g g a he e b i i e a ade, i a b i ed b h e ha i g i ia i a / ic e ie .

We i fe he de ci c f a ie f he e di g ba ed hef a e kde e- ed i h a habe ic i i g, a d he e di c i he *universality* a d a g age *specificity* f he i ai ed e e e a i ba ed he a a e f he a ie .

Locus of the deficit

Beca e W.L.Z. a e fec i di ec c i g, hi dif c i de a ed c i g ca be a ib ed a e i he a de ci. Hi e i de a ed c i g did igi a e f he e a ic h g h g a h c e i e beca e f he ab e ce f e a ic, g a - a ica , a d h e ic eg a i effec . A h gh he ig i ca c ib i f he cha ac e f e e c i he eg e i a a e gge ha hi e ica de ci a ed a e i he c i g a k, e c ed f hi f e e c a iab e i a i a a e a d he ef e he e a e e e ed h d e f i ai e i he age be d e ica e ie a ha i , f he he g a hic a h a .

Wi hi he g a hic a h a , Fi di g 1 a d he i i a effec f Fi di g 3 gge ha he de ci igi a ed i a b ffe - ike c e i ce i had he cha ac e i ic f a ki g- e c e . The e f a ce a e i i e he *amount* f i f a i (be f g g a he e) a d he *time* bei g he d i e . The e i f a i he b ffe c - ai ed, a d he ge i e ai ed i he b ffe , he e ike e e e cc . I i c i ica e ha e b e ed a *temporal* a d *spatial* de effec , i dica i g ha effec igi- a ed a a b ffe i g ce d i g i ead f i i he de a ed c a k. The ef e e e ha W.L.Z. a i ai ed a he e e f a b ffe i g c e f , a d ch i ai e c ib ed he de a ed c i g e . The b ai da age ee ed

ha e ca ed a ab a aid deca f i f - a i fai e i he ef e h echa i d i g he b ffe i g ce .

Fi di g 2 a d he g g a he e f e c effec (i edic i g he e a e) i Fi di g 3 i dica e ha g g a he e, a ed e adica , a e he f c i a i e- e e ed i hi i ai ed c e , a d i e i a ce i ai e i e i i e fe e c. F hi ea , e a ed hi b ffe i g c - e i i i g Chi e e cha ac e g g a- he e b ffe (LOB). We f he b e ed ha he e a e-fea e i i a i be ee he a ge g g a he ea d he e e g g a he e, i dica i g ha LOB i i i g Chi e e cha ac e e c de g a hic i f a i (ha e a d/ e fea e).

Be e di c he he e ica i ica i f di g f i e: he i e a i f a b ffe i g c e i he i i g ce a d he a g age- eci c a a e e f ch a c e .

The universal and language-specific aspects of the output buffer

I a habe ic a g age, c i ci g e i ica e i- de ce f he e i e ce f a g a he ic b ffe c e f he g a cia i be ee a e i g a d i e e i g e f a ce i ce ai c a e f a ie . Ne e he e , he ac f a e i g ea i Chi e e d e ea ha a b ffe i g c e i ece a f i i g Chi e e cha ac e . If e c ide he he e ica i a i f he a fa b ffe- i g ce i i i g, he idea fi bei g i e a i a a g age bec e a a. I ge e a, he he i f i f a i ha i f e e e e a i i a ge ha ha he b e e e e a i ca a e a i f f he ce i g, i i ea abe a e he e i e ce f a b ffe h d he -be- ce ed i e ai . O a a i de a e ha

if f ie ch (C a , 2001; Mi e , 1956), he ea 福 ha 13 e (ea be f e i Chi e e cha ac e i 12.85, S a da d P e f Chi a, 1994). Sec d, he e c i- i g a cha ac e a e high a big i ha e a d i i . F ea e, 福 ha f "|" f a i ie e i diffe e i i , ea i eadi g c f i i i g. B c a , he g g a- he e i a cha ac e ca be ea i e i e . 福 i eg e ed i f g g a he e i h a ia eci ca i (氵, 一 口, a d 川; ea be f g g a he e i a cha ac e i 3.64, S a da d P e f Chi a, 1994), hich i e ha he a i e ad. A , he a bi- g i a g e di a ea he e f a cha ac e a e e bedded i g g a he e . A he ib e ca dida e f f c i a i i he b ffe a e adica , a i i i a ed b he ca e ha ade i i g e adica e e (e.g., La , 1994, 2004; La & Ca a a a, 1995; La e a., 2005). H e e, i i c ea ha ca be gai ed b ha i g adica a f c i a i beca e e a ic adica c e d g g a he e, a d h e ic adica a c e d e i i g cha ac e . Thei a ie ' i i g e ca he ef e be e ai ed b ei he g g a he e e cha ac e e .

The diffe e ce f he i i ic cha ac e i ic f g g a he e a d a habe ic g a he e h d ead c a diffe e ce be ee LOB f Chi e e a d he g a he ic b ffe i a habe ic a g age . P e e di g f W.L.Z. igh i dica e ha he g g a he e i he b ffe a e e e ed b e id f h g a hic fea e. W.L.Z.' g g a he e b i i e e ed i ig i ca highe a i f g g a he e ha i g i a i a/ ic e ie (c e, e ea i , e ha e) he a ge g g a- he e ha ha a e ec ed b cha ce. Thi c d ea ab be d e he fac ha , a h gh he b ai da age ed W.L.Z.' b ffe e be ab e ef cie acce a d/ e ec ide i i f a i f he a ge g g a he e, he e ha e i f a i f he g g a he e a e e ed. Th , he e ied f a b i e ih i ia i a/ ic i f- a i ha f he a ge g g a he e.

T c c de, b d i g he de a ed-c i g e f a ce f a Chi e e d g a hic a ie , e ha e e ide ce ha a b ffe i g c e i ie e a i g g a hic a d a habe ic a g age , a d ha he c e i hi he b ffe i ha ed b a g age- eci c a a e e . The b ffe c e i Chi e e e e e he ide i a d i a/ ic e ie f g g a he e .

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