I ence of handedne and bila e al e e mo emen on c ea i i

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ABSTRACT

We in e iga ed he effec of inc ea ed in e -hemi he ic in e ac ion (IHI) on e c ea i i dimen ion (a o ia ene , de ail, ca ego ical di inc i ene enc , and o iginali) of he Al e na e U e Ta k. T o me hod e e ed o indica e deg ee of IHI. T ai IHI a indica ed b indi id al diffe ence in handedne , mi ed-hande ho ing g ea e IHI han ong-hande . S a e IHI a di ec l mani la ed b cen al (con ol g o) and bila e al ie ing condi ion of a 30 e e mo emen a k (EM). Re l indica e igni can l highe c ea i i fo mi ed-hande , a com a ed o ong-hande , fo all e

Fo e am le, Ch i man (2001) ob e ed ha lef -hande , a mo e mi ed-handed g o han igh hande (B den & S eenh i , 1991; Ch i man, 1995; Hellige, 1993), e hibi ed g ea - e S oo in e fe ence and g ea e local global in e fe ence, hich a in e e ed a ec ing g ea e in e ac ion be een LH-ba ed e bal/local oce ing and RH-ba ed ch oma ic/global oce ing. F he , P o e , Ch i man, and Phane f (2005) ob e ed an ad an age fo mi ed-hande o e ong-hande on e i odic e- ie al a k , con e ging on h iological e ea ch im lica ing bila e al a e n of ac i i fo enhanced e fo mance on e i odic memo a k (Pla el, Ba on, De g ange , Be na d, & E ache, 2003; T l ing, Ka , C aik, Mo co i ch, & Ho le, 1994). Mi ed-hande al o ha e an ad an age o e ong-hande fo o he memo a k ha o ld bene f om inc ea ed IHI (e.g., o ce memo), b ho no ch ad an age on memo a k ha o ld no e i e IHI (e.g., face ecogni ion) (L le, McCabe, & Roedige , 2008). While c ea i i and deg ee of handedne ha no been di ec l died (al ho gh he e a e ome die ha ha e e amined di ec ion of handedne and c ea i i), mi ed-handedne ha been a ocia ed i h g ea e magical idea ion (Ba ne & Co balli , 2002), and a i ha e a highe incidence of ini ali and mi ed-handedne (P e i & Vellan e, 2007). F - he , mi ed-hande gene a e mo e al e na e-ending o cena io (i.e., co n e fac al ho gh) han do ong-hande (Ja e , Ba , & Ch i man, 2008), and he f on al co e of bo h hemi he e con ib e o co n e fac al hinking a k (Gome Belda ain,

Edinb gh Handedne . In en o (EHI) o de e mine eng h of handedne , he c en Me = 77.5 a ed. Beca e he EHI i co ed in inc emen of e, a ici an ' ab ol e co e of 80 and highe e e con ide ed o be ong handed and ab ol e co e of 75 and lo e e e con ide ed o be mi ed-hande . The c en d con i ed of 30 mi ed-hande and 32 ong-hande (onl one ongl lef -handed co e = −100).

2.2. Materials/apparatus

An ada a ion of he Al e na e U e Te (Chamo o-P em ic, 2006) a ed o mea e c ea i i . Thi ada a ion con i ed of 20 common i em (e.g. a e -cli , encil hoe, fo f ll li ee A endi A). We ed 15 i em f om he o iginal Al e na e U e Te (Ch i en en e al., 1960) and e f om a common o d bank (Snodg a & Vande a , 1980). Each i em a cen e ed a he o of an 8.5″ × 11″ hee of hi e com e a e , ed in 16 . Time Ne Roman fon . The common e a ea ed in a en he e ne o each i em. P e- e i em incl ded e i em in ed in a bookle i h a i le age ha di la ed he in ed in c ion in 16 . Time Ne Roman fon . Po - e i em incl ded he emaining 15 i em in ed in a e a a e bookle , al o i h a i le age con aining he in ed in c ion . To a oid an o de effec ha migh be im o ed b an eci c i em, o e a a e e ion of he e- e and o - e e e c ea ed, and i em e e andoml o de ed i hin each.

Re on e on he Al e na e U e Te e e co ed on e diffe - en b co e : (a) enc , indica ed b he o al n mbe of e li ed e i em (ega dle of ' ali ' o a o ia ene); (b) o ig-inali , indica ed b he n mbe of e on e o ided b 0 5% f a ici an (3 oin), 6 10% (2 oin) o 11 15% (1 oin) of all a ici an in he am le; (c) amo n of de ail o elabo a ion o-ided fo each e (on a 0 5 oin cale); (d) e ibili o he n m-

c ea i e ad an age, and he he c ea i i a diffe en iall affec ed e-and q mani la ion, he e b co e of he Al e na e U e Te enc , de ail, o iginali , ca ego ical di inc- i ene and a o ia ene), e e bmi ed o a 2 (Condi ion: con ol, bila e al EM) × 2 (Handedne : mi ed, ong) × (2) (Te : e, q) mi ed fac o ial MANOVA. M l i a ia e e e- ealed a igni can main effec fo Handedne (Wilk' $\Lambda = .779$, $F(5, 54) = 3.06$, $p = .017$, ($\eta^2 = .221$) and Te (Wilk' $\Lambda = .735$, $F(5, 54) = 3.89$, $p = .004$, ($\eta^2 = .265$) hen he de enden a iable a e linea l combined ac q all ial . No main effec fo Condi ion (Wilk' $\Lambda = .959$, $F < 1$), o in e ac ion of Handedne × Te (Wilk' $\Lambda = .907$, $F < 1$), Handedne × Condi ion (Wilk' $\Lambda = .978$, $F < 1$), Te × Condi ion (Wilk' $\Lambda = .947$, $F < 1$), o Handed- ne × Condi ion × Te (Wilk' $\Lambda = .927$, $F < 1$) e e ob e ed fo he linea l combined b co e . Uni a ia e ANOVA' al o e- ealed no igni can diffe ence fo Te fo he e b co e , gge ing ha he main effec in he m l i a ia e e of e . q - e ob e ed o be an o e all ac ice effec ha i no e- ci c o an of he indi id al b co e .

3.3. Handedness findings for individual sub-scores of the Alternate Uses Test (post circle task)

The anal e en ed in hi ec ion a e ba ed on a ici an ' e on e o e all 15 ial of he Al e na e U e Ta k fo each b- co e. Uni a ia e e indica e ha mi ed-hande ho ed g ea e enc ($M = 3.09$, $SE = .19$) han ong-hande ($M = 2.44$, $SE = .18$), $F(1, 58) = 6.15$, $p = .016$, ($\eta^2 = .096$); mi ed-hande ($M = 2.45$, $SE = .142$) ho ed g ea e ca ego ical di inc i ene in hei an e han ong-hande ($M = 1.67$, $SE = .13$), $F(1, 58) = 15.576$, $p < .001$, ($\eta^2 = .21$); mi ed-hande ($M = 2.70$, $SE = .16$) had mo e a o ia e e on e han ong-hande ($M = 1.84$, $SE = .15$), $F(1, 58) = 14.40$, $p < .001$, ($\eta^2 = .20$); and mi ed-hande ($M = 3.35$, $SE = .28$) ho ed mo e o iginali han ong-hande ($M = 1.84$, $SE = .27$), $F(1, 58) = 13.80$, $p < .001$, ($\eta^2 = .19$). Mi ed- hande ($M = 2.5$, $SE = .13$) e e ma ginall highe han ong- hande ($M = 2.1$, $SE = .18$) on he de ail b co e, $F(1, 58) = 3.64$, $p = .06$, ($\eta^2 = .06$). The e e l o he h o he i ha mi ed-handed indi id al o ld demon a e inc ea ed c ea i i on he e indi id al co e han ong-hande .

Addi ionall , a priori e gge ha he highe c ea i i of mi ed-hande com a ed o ong-hande a d i en olel b diffe ence in he con ol g o , b no he bila e al EM g o . Com a i on be een mi ed and ong hande in he con ol g o (no bila e al EM) e ealed diffe ence on all e b co e of c ea i i enc , $F(1, 28) = 4.2$, $p = .05$, $\eta^2 = .13$ ($M_{mi\ ed} = 3.05$, $SE = .24$; $M_{ong} = 2.3$, $SE = .26$); de ail, $F(1, 28) = 5.4$, $p = .03$, $\eta^2 = .16$ ($M_{mi\ ed} = 2.54$, $SE = .17$; $M_{ong} = 1.95$, $SE = .18$); o iginal- i , $F(1, 28) = 9.14$, $p = .005$, $\eta^2 = .25$ ($M_{mi\ ed} = 3.06$, $SE = .39$; $M_{ong} = 1.03$, $SE = .42$); ca ego ical di inc i ene , $F(1, 28) = 9.46$, $p = .005$, $\eta^2 = .25$ ($M_{mi\ ed} = 2.4$, $SE = .20$; $M_{ong} = 1.5$, $SE = .21$); and a o ia ene , $F(1, 28) = 9.5$, $p = .005$, $\eta^2 = .25$ ($M_{mi\ ed} = 2.75$, $SE = .22$; $M_{ong} = 1.75$, $SE = .23$).

The e diffe ence be een ong and mi ed-hande di a - ea ed fo he bila e al EM g o fo enc ($F < 1$), de ail ($F < 1$), o iginali [$F(1, 30) = 2.06$, $p = .16$], ca ego ical di inc i ene [$F(1, 30) = 3.08$, $p = .09$], and a o ia ene [$F(1, 30) = 2.6$, $p =$

fo ca ego ical di inc i ene , $F(1, 30) = 4.71$, $p = .04$, $\eta^2 = .14$ ($M_{bila\ e\ al\,EM} = 2.22$, $SE = .20$; $M_{con\ ol} = 1.56$, $SE = .23$). No condi ion diffe ence e e ob e ed fo ea l ial of mi ed-hande (F < 1), la e ial of mi ed-hande (F < 1), o la e ial of ong-hande (F ⩽ 1).

Taken oge he , he e e l gge ha he bila e al EM mani la ion affec ed o iginali and ca ego ical di inc i ene co e of ong-hande d ing he ea l ial onl , b hi effec di i a ed b he la e ial . A hi oin , e onde ed j ho long he EM effec held fo ong-hande in o d . To an e hi , ial one h o gh 15 e e a ed in o e g o of mean in h ee- ial inc emen (T ial 1 3, T ial 4 6, T ial 7 9, T ial 10

ion. Ho e e , fo he ca ego ical di inc i ene a iable, onl T ial 1 3 (e o ed abo e) eached igni cance, and T ial 4 6 e e ma ginall igni can , $F(1, 30) = 3.6$, $p = .06$. T ial 7 9 [$F(1, 30) = 2,4$, $p = .13$], 10 12 [$F(1, 30) = 2.5$, $p = .11$], and 13 15 (“la e ial , e o ed abo e) e e no igni can (ee Fig. 3). Thi gge ha he effec of bila e al EM on o iginali of ong-hande ma la o 9 min befo e i di i a e . B , he effec of bila e al EM on ca ego ical di inc i ene la a lea 3 min and ma be o 6 min (ee Fig . 2 and 3, and Table 2).

While igni can diffe ence be een con ol and bila e al EM condi ion of ong-hande e e onl ob e ed fo he o iginali (o ial 6 9) and ca ego ical di inc i ene (o ial 3) co e , addi ional anal e e ealed gene al do n a d linea end in he bila e al EM condi ion ac o he e ial inc emen fo a o ia ene $F(1, 17) = 8.03$, $p = .01$, o iginali , $F(1, 17) = 8.2$, $p = .008$, and ca ego ical di inc i ene , $F(1, 3$

B galo , 2006) ob e ed bila e al EEG ac i i ela ed o o iginal- i co e on a emo e-a ocia e a k. The a e n ob e ed b Ra mniko a and colleag e al o gge ed ha he hemi he e ma be in ol ed in diffe en oce e ha con ib e o o iginali ch a ained a en ion, o king memo , and diff e ac i a- ion of al e na e o d meaning and ela ion hi . In addi ion, he c ea i i con c of ca ego ical di inc i ene ma al o ake ad an age of eciali a ion of he lef and igh hemi he e . The LH i a ic la l ell i ed o ca ego ical oce ing he ea he RH a ea o be a ic la l ell i ed o iden if ing m l i le ca ego ical membe hi i ho he abili o di ing i h he mo ele an ca ego (Chia ello & Richa d , 1992; Chia ello e al., 1992; Ince & Ch i man, 2002). Th , ec i men of LH abil- i ie fo iden i ca ion of eci c ca ego ie and RH abili ie fo m l i le ca ego ie ma gi e i e o a combined ad an age fo ca - ego ical di inc i ene co e . The nding of Bech e e a e al. (2004) al o gge ha he LH i in ol ed in ca ego ical di inc- i ene (e med flexibility b hem). We gge ha o iginali and ca ego ical di inc i ene e on e e facili a ed b IHI beca e he in ol e bo h LH and RH oce e , and ha IHI ill ha e facili a i e effec on an a k ha e i e bi-hemi he ic con ib ion . Thi ha al o been o o ed and o ed b L le e al. (2008).

E en ho gh o iginali and ca ego ical di inc i ene do no a ea o el on he ame oce e o ne al b a e , e a e no gge ing ha bila e al EM e l in a ide ead, non e- ci c ac i a ion of he ce eb al hemi he e . Ra he , o nding e en e idence o he con a beca e a o ia ene enc , and de ail, e e la gel naffec ed b he bila e al EM mani la- ion. Al ho gh io e ea ch i i e limi ed, he e h ee e on e e ma be mo e effec i el oce ed nila e all , i hin he LH o RH. Bo h e bal enc (Baldo, Sch a , Wilkin , & D onke , 2006) and a o ia ene (To ance & Ho ng, 1980) ma be ela i el e ic ed o LH oce e . Con e el , abili o e o i al de ail (Ke inge & Choi, 2009) and gene a e de- ailed i al image a ea o be mo e elian on RH oce e (Ga a ini e al., 2008; S ide ka a, Ta a no a, & Ko hed b, 2006), and ma be analogo o he de ail mea e in o d . If bila e al EM gene a ed non eci c ac i a ion of bo h hemi- he e , o con ol g o o ld ha e e hibi ed lo e co e on each of he e b co e . O nding ai e he o ibili ha onl ca ego ical di inc i ene and o iginali e e affec ed b he EM mani la ion beca e he e beha io can bene f om combined LH and RH oce e , he ea a o ia ene , de ail, and enc ma be mo e elian on nila e al oce e .

In e e ingl , i ha been o o ed ha bila e al EM ma en- able g ea e acce o RH oce e (Ch i man & P o e , in e), and o ob e a ion of a ma ginal de ail ad an age ($p = .06$) fo bila e al EM a ici an doe no nde mine hi o - ibili . B e al o ecogni e ha io e ea ch on hemi he ic a mme ie fo gene a ing de ail d ing i al image i a e, h limi ing o ec la ion . E en ill, if he bila e al EM a k e- l ed in a gene ali ed ac i a ion of bo h hemi he e , hen ong-hande in o d ho ld ha e (1) ho n an im o e- men in he EM g o o e he con ol fo enc , de ail, and a o ia ene ; o (2) ma ched he mi ed-hande . In ead, he mi ed-hande o e fo med hem in he con ol and he bila e al EM g o , and o e a e ea onabl con den ha he effec i a k eci c.

We al o ec ha he IHI of mi ed-hande i ali a i el diffe en f om he IHI facili a ed b bila e al EM beca e he mani la ion did no ai e all e b co e of ong-hande o le el e i alen i h mi ed-hande . While leng h e lana- ion of he mi ed-hande ad an age fo de ail, enc , and a o ia ene a e be ond he co e of hi a e , one o ibili i im l ha he ba ic ana omical diffe ence in he i e of he co - callo m be een ong and mi ed-hande (D ie en & Ra , 1995; Habib e al., 1991; Wi el on & Gold mi h, 1991) doe no change follo ing an EM a k. The la ge co callo m ma gi e he mi ed-hande a mo e gene ali ed ad an age on he mea e e a ed. We eadil ackno ledge, ho e e , ha he li e a e i e le e i h incon i en nding in o of a ela ion hi be- een handedne and callo al i e. The co callo m clea l facili a e an fe of info ma ion be een he hemi he e , b i ma al o e e o ed ce in e fe ence be een he hemi he e . Recen o k b Welcome e al. (2009) gge ha in mi ed- handed male a la ge co callo m ma facili a e in eg a ion, b in mi ed-handed female i ma minimi e in e fe ence. In o d , he a ici an e e la gel female, and o he mi ed-handed ad an age fo de ail, enc , and a o ia ene ma ec minimi ed in e fe ence fo he e o ed nila e al oce e .

So, hen, he e ion emain : Wha change doe a bila e al EM a k ind ce in he b ain? Al ho gh he no ion of a cen al e ec i e in he mind ma i elf be o e a ed, e o o e ha bila e al e e mo emen e e o ac i a e he ne al b a e go e ning me acon ol oce e ha di ec a k eci c oce ing (fo e- ie of me acon ol ee Hellige, 1995). Loh e al. (2006) al o g- ge ha me acon ol oce e a e he oo of IHI. The o k of Ko nio e al. (2006) gge he loc of hi me acon ol mech- ani m fo c ea i i ma be he an e io cing la e co e (ACC), b f e ne oimaging e ea ch ma be nece a o de e mine he ela ion hi be een bila e al EM and he ACC.

Al ho gh e did no di ec l mea e he effec of bila e al EM on hemi he ic ac i i , o nding add o a la gel con i - en e of beha io al and h iological nding f om a io lab- o a o ie indica ing ha bila e al EM e e bila e al effec on hemi he ic oce ing. P o e e ic o o a

he e bal LH i he ca e of bila e al ac i i . In addi ion o he bila e al a e n of ac i i e o ed b Folle and Pa k (2005) ho ili ed ic e im li and allo ed fo a ial mani la ion of ho e ic e befo e gi ing a e bal e on e, a io c ea i i a k ha e been a ocia ed i h ac i i in LH f on al and em e o- a ie al c e in ol ed in a ial e ce ion of objec (J ng-Beeman e al., 2004

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