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# NeuroImage

M. S. H. \*

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T.

## ABSTRACT

To... fl... o... o...  
E... U... R...  
(2-4 H), (5-7 H), (8-13 H),  
(14-26 H), (28-40 H)  
S...  
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## Introduction

S... fl... o... o...  
o... T...  
fl... o...  
o... (MRI) (o... H...  
No... 2009; H... 2011; No... 2006)  
(Ro... 1977). I...  
(BOLD) ... (MPFC) ... (PCC),  
(Fo... 2003; H... 2008; H... 2006;  
K... 2002; M... H... 2011; M... ; M...  
2004; Mo... 2006; ... 2007; ... 2002),

Electroencephalogram (EEG) studies have shown that the early time window (200–400 ms) of the P2 component (P2) is associated with self-judgment (M. A., 2007). The P3 component (P3) is associated with friend-judgment (S. D., 2010; W. D., 2007). The P4 component (P4) is associated with valence-judgment (M. A., 2007). The P5 component (P5) is associated with self-judgment (K. M., 1987; M. H., 2010). The P6 component (P6) is associated with friend-judgment (S. D., 2010). The P7 component (P7) is associated with valence-judgment (M. A., 2007). The P8 component (P8) is associated with self-judgment (K. M., 1987; M. H., 2010). The P9 component (P9) is associated with friend-judgment (S. D., 2010). The P10 component (P10) is associated with valence-judgment (M. A., 2007). The P11 component (P11) is associated with self-judgment (K. M., 1987; M. H., 2010). The P12 component (P12) is associated with friend-judgment (S. D., 2010). The P13 component (P13) is associated with valence-judgment (M. A., 2007). The P14 component (P14) is associated with self-judgment (K. M., 1987; M. H., 2010). The P15 component (P15) is associated with friend-judgment (S. D., 2010). The P16 component (P16) is associated with valence-judgment (M. A., 2007). The P17 component (P17) is associated with self-judgment (K. M., 1987; M. H., 2010). The P18 component (P18) is associated with friend-judgment (S. D., 2010). The P19 component (P19) is associated with valence-judgment (M. A., 2007). The P20 component (P20) is associated with self-judgment (K. M., 1987; M. H., 2010). The P21 component (P21) is associated with friend-judgment (S. D., 2010). The P22 component (P22) is associated with valence-judgment (M. A., 2007). The P23 component (P23) is associated with self-judgment (K. M., 1987; M. H., 2010). The P24 component (P24) is associated with friend-judgment (S. D., 2010). The P25 component (P25) is associated with valence-judgment (M. A., 2007). 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M., 1987; M. H., 2010). The P39 component (P39) is associated with friend-judgment (S. D., 2010). The P40 component (P40) is associated with valence-judgment (M. A., 2007). The P41 component (P41) is associated with self-judgment (K. M., 1987; M. H., 2010). The P42 component (P42) is associated with friend-judgment (S. D., 2010). The P43 component (P43) is associated with valence-judgment (M. A., 2007). The P44 component (P44) is associated with self-judgment (K. M., 1987; M. H., 2010). The P45 component (P45) is associated with friend-judgment (S. D., 2010). The P46 component (P46) is associated with valence-judgment (M. A., 2007). The P47 component (P47) is associated with self-judgment (K. M., 1987; M. H., 2010). The P48 component (P48) is associated with friend-judgment (S. D., 2010). The P49 component (P49) is associated with valence-judgment (M. A., 2007). The P50 component (P50) is associated with self-judgment (K. M., 1987; M. H., 2010). 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D., 2010). The P64 component (P64) is associated with valence-judgment (M. A., 2007). The P65 component (P65) is associated with self-judgment (K. M., 1987; M. H., 2010). The P66 component (P66) is associated with friend-judgment (S. D., 2010). The P67 component (P67) is associated with valence-judgment (M. A., 2007). The P68 component (P68) is associated with self-judgment (K. M., 1987; M. H., 2010). The P69 component (P69) is associated with friend-judgment (S. D., 2010). The P70 component (P70) is associated with valence-judgment (M. A., 2007). The P71 component (P71) is associated with self-judgment (K. M., 1987; M. H., 2010). The P72 component (P72) is associated with friend-judgment (S. D., 2010). The P73 component (P73) is associated with valence-judgment (M. A., 2007). The P74 component (P74) is associated with self-judgment (K. M., 1987; M. H., 2010). The P75 component (P75) is associated with friend-judgment (S. D., 2010). 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1, (F. 1). A “ ” , fi .S .V .W EEG .T EEG EEG .V .T .E 1 fl , E 2 .T .E 2, 1, fi S (M. H., 2010), TF .W .I ERD (S. L., 1988) (P., 1992). A ERD fi ERS fi ., 1996). ERS (. . .) ERS (. . .) (P. Lo S., 1999). M. H. (2010) fi .H ERS ERD .I, ERS ERD (M. H., 2010), ERS ERD

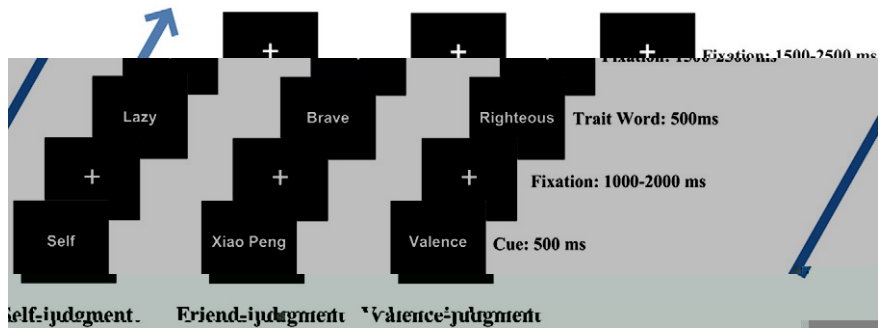


Fig. 1.1. Experimental task design. The cue (500 ms) and trait word (500 ms) are presented simultaneously. The fixation period (1000–2000 ms) follows the trait word. The judgment stage (Self-judgment, Friend-judgment, Valence-judgment) is indicated by the blue arrows.

ERS ERD ( )  
 MRI MPFC PCC  
 MPFC  
 (M, H, 2011),  
 (PLV) (L, 1999).  
 (R, 1999), (B, A, 2002),  
 (M, 2012).  
 (S, 1998). W

. T 10 30 10  
 T 10  
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 C 120 .E 0  
 .E 0  
 500 , 500 800 .  
 ( , )  
 .T  
 0 0 fi ( / / fi ) ( /  
 10(SD)4d Tf 06572-0.4.09000315( )18(.)-432( 2TJ-212. )22( )T 4( )-9

Materials and methods

Subjects

T (13 , 13 , 19  
 27 ) -E 1. E  
 (13 , 5 , 18 , 24 )  
 E 2. A  
 I o o o o  
 .T o o

Stimuli and procedure

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 o C  
 o 500 ,  
 fi o o  
 1000 2000 o A  
 o 500 o fi o  
 o 1500 2500  
 (F . 1). S  
 o o  
 o . T  
 ( o ) o o  
 o o o  
 o o . T o  
 /-d o o o . T

W 119.7 NCW 1.3 H 2 H .  
 T 19.9  
 8.0 H 80 H .  
 T TF o o o fi  
 o o .T TF o o o  
 o o o o o o -200 o o  
 o (P A 1979).C o  
 50 20 o o o  
 1000 .T TF o 50 H o  
 o 50 H C .T  
 :  
 (2-4 H ), (5-7 H ), 1 (8-10 H ), 2 (11-13 H ),  
 (14-26 H ), 1 (28-40 H ), 2 (60-80 H ),  
 o (M H 2010).T o  
 o TF o o o  
 o o o o o  
 o ( : F , FC ; : C , CP ; :  
 P , PO ), ( : F1, F3, F5, FC1,  
 FC3, FC5; : F2, F4, F6, FC2, FC4, FC6),  
 ( : C1, C3, C5, CP1, CP3, CP5; : C2, C4, C6, CP2, CP4,  
 CP6), ( : P1, P3, P5, PO3,  
 PO5, O1; : P2, P4, P6, PO4, PO6, O2).  
 T o TF o (ANOVA)  
 Q ( ) R o ( o ,  
 o o o ) o H ( o  
 o ) .T o  
 o ANOVA Q ( )  
 R o /H S ANOVA  
 H ( o ) R o /  
 TF o o /  
 T o o fi o ANOVA o  
 S ( / o ), T ( /  
 ) R o /H .T o  
 TF o o E 1  
 o ANOVA o TF o o E 2  
 Q ( ) R  
 o /H A P- o ANOVA  
 G -G o o o o .

PLV 0 1.0 o o  
 o 1 o o o  
 W o 21 o o o  
 , 210 (21 20/2) o (F3,  
 F4, F ), o (FC3, FC4, FC ), o (C3, C4, C ),  
 (CP3, CP4, CP ), (P3, P4, P ),  
 (PO3, PO4, PO ), o (O1, O2, O ) o .T  
 .T o o -I o o P  
 o , o o o P  
 (K , 2004; M O o , 2007). T PLV o o  
 o o o o o 1000 .T  
 o o o o .T o  
 1000 o o o o 1000 T  
 .A o 1000 T , 95  
 o o o o T o PLV o T  
 .95 (P<.05) o fi

Results

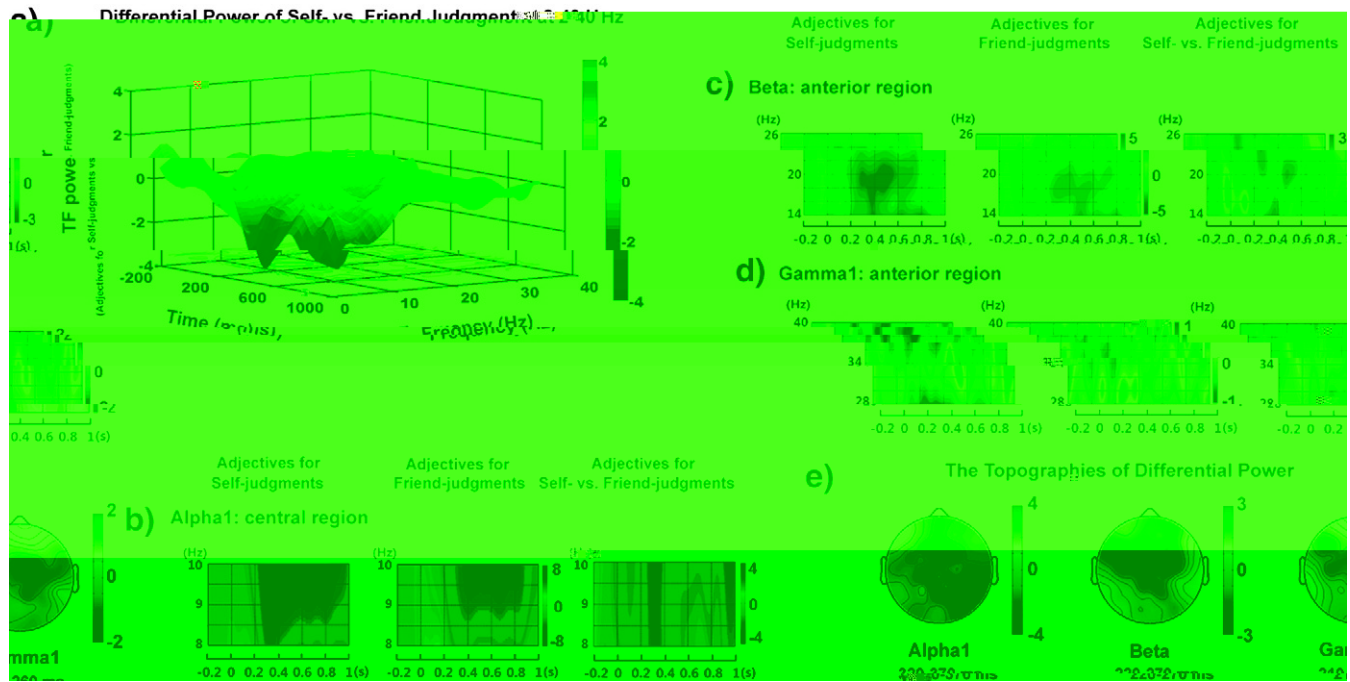
B a a a a

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P a c a a  
 S o (D o , 2008; G o  
 , 2004; L , 1999; , 2004; R o ,  
 1999), M o o o  
 o o o o (TFO1)  
 fi o  
 o o o o W  
 o (PLV) fi o  
 o o .T PLV o  
 o o N o  
 :

$$PLV_{i,j} = N^{-1} \left| \sum_N [\Phi_i(\cdot) - \Phi_j(\cdot)] \right|$$





**Fig. 3.** TF power (Friend-judgments vs. Self-judgments) in the anterior region (a). Topographies of differential power in the anterior region (b). Topographies of differential power in the central region (c). Topographies of differential power in the anterior region (d). Topographies of differential power in the anterior region (e).

$F(1, 25) = 5.69, P < .05, \eta^2 = .19$ ;  $700\text{--}800$  Hz,  $F(1, 25) = 14.80, P < .01, \eta^2 = .37$ ;  $800\text{--}900$  Hz,  $F(1, 25) = 6.64, P < .05, \eta^2 = .21$ . Nonsignificant differences ( $P > .05$ ) were found for other frequency bands.

**Delta** (central region). ANOVA revealed significant differences between self- and friend-judgments in the delta band (300–400 Hz,  $F(1, 25) = 5.42, P < .05, \eta^2 = .18$ ; 400–1000 Hz,  $F(1, 25) = 8.94, P < .01, \eta^2 = .26$ ; 100–200 Hz,  $F(1, 25) = 5.42, P < .05, \eta^2 = .18$ ; 200–400 Hz,  $F(1, 25) = 8.17, P < .01, \eta^2 = .25$ ; 400–1000 Hz,  $F(1, 25) = 29.02, P < .001, \eta^2 = .54$ ; 100–200 Hz,  $F(1, 25) = 46.86, P < .001, \eta^2 = .65$ ; 200–300 Hz,  $F(1, 25) = 69.56, P < .001, \eta^2 = .74$ ; 300–400 Hz,  $F(1, 25) = 14.04, P < .001, \eta^2 = .36$ ; 400–500 Hz,  $F(1, 25) = 22.71, P < .001, \eta^2 = .48$ ; 500–600 Hz,  $F(1, 25) = 4.66, P < .05, \eta^2 = .16$ ).

**Theta** (anterior region). ANOVA revealed significant differences between self- and friend-judgments in the theta band (300–400 Hz,  $F(1, 25) = 5.42, P < .05, \eta^2 = .18$ ; 400–1000 Hz,  $F(1, 25) = 8.94, P < .01, \eta^2 = .26$ ; 100–200 Hz,  $F(1, 25) = 5.42, P < .05, \eta^2 = .18$ ; 200–400 Hz,  $F(1, 25) = 8.17, P < .01, \eta^2 = .25$ ; 400–1000 Hz,  $F(1, 25) = 29.02, P < .001, \eta^2 = .54$ ; 100–200 Hz,  $F(1, 25) = 46.86, P < .001, \eta^2 = .65$ ; 200–300 Hz,  $F(1, 25) = 69.56, P < .001, \eta^2 = .74$ ; 300–400 Hz,  $F(1, 25) = 14.04, P < .001, \eta^2 = .36$ ; 400–500 Hz,  $F(1, 25) = 22.71, P < .001, \eta^2 = .48$ ; 500–600 Hz,  $F(1, 25) = 4.66, P < .05, \eta^2 = .16$ ).

**Pack** (anterior region). ANOVA revealed significant differences between self- and friend-judgments in the pack band (300–400 Hz,  $F(1, 25) = 31.92, P < .0001, \eta^2 = .56$ ; 400–1000 Hz,  $F(1, 25) = 14.84, P < .001, \eta^2 = .37$ ; 100–200 Hz,  $F(1, 25) = 14.64, P < .001, \eta^2 = .37$ ; 200–300 Hz,  $F(1, 25) = 7.85, P < .01, \eta^2 = .24$ ; 300–400 Hz,  $F(1, 25) = 4.62, P < .05, \eta^2 = .16$ ; 400–500 Hz,  $F(1, 25) = 6.60, P < .05, \eta^2 = .21$ ; 500–600 Hz,  $F(1, 25) = 9.84, P < .01, \eta^2 = .28$ ; 600–700 Hz,  $F(1, 25) = 5.23, P < .05, \eta^2 = .17$ ; 700–800 Hz,  $F(1, 25) = 4.57, P < .05, \eta^2 = .16$ ).

**Pack** (central region). ANOVA revealed significant differences between self- and friend-judgments in the pack band (300–400 Hz,  $F(1, 25) = 3.08, P < .05, \eta^2 = .11$ ; 400–1000 Hz,  $F(1, 25) = 2.92, P < .05, \eta^2 = .10$ ).

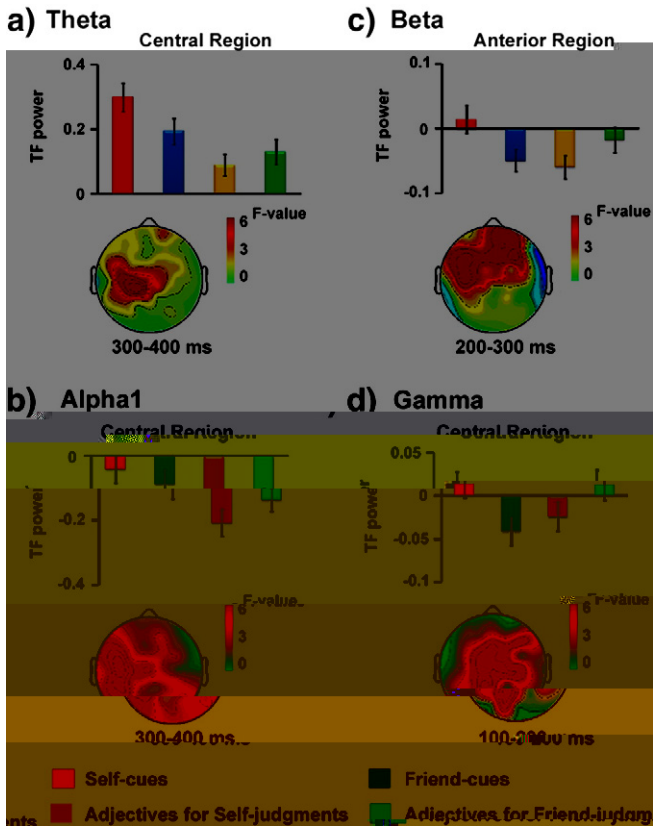


Fig. 4. TF power in different regions and time windows for four conditions: Self-cues, Friend-cues, Adjectives for Self-judgments, and Adjectives for Friend-judgments.

... 400–500 ms (  $F(1, 17) = 3.41, P < .05$  ). Ho... TFOI... (  $P > .05$  ).

... TFOI... (  $F(1, 17) = 2.88, P < .05$  ).

... TFOI... (  $F(1, 17) = 8.53, P < .01, \eta^2 = .33$  ).

... TFOI... (  $F(1, 17) = 8.53, P < .01, \eta^2 = .33$  ).

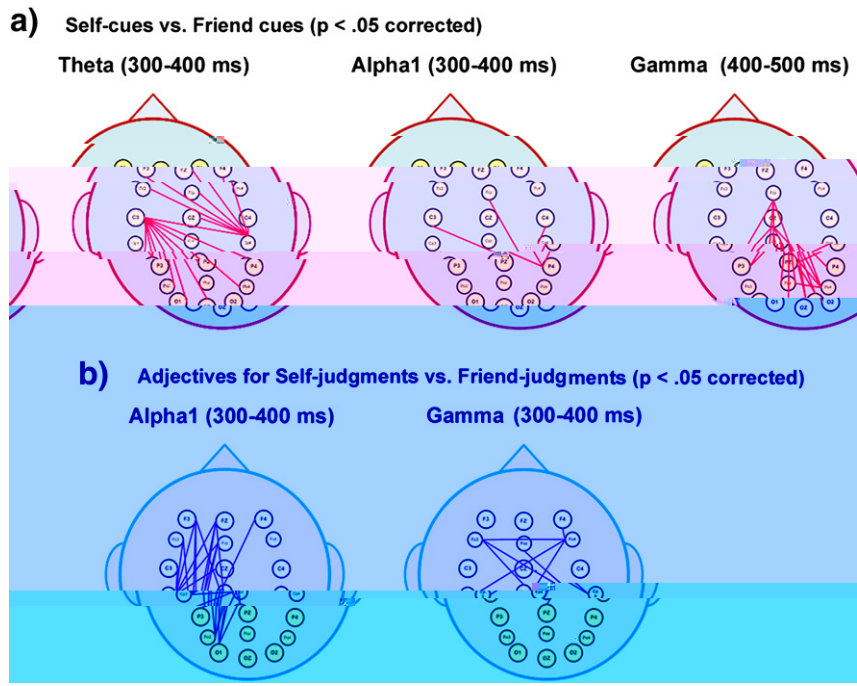


Fig. 5. Topographic maps showing TF power for Self-cues vs. Friend-cues and Adjectives for Self-judgments vs. Friend-judgments.



$P < .01$ ,  $\eta^2 = .33$ ) 400–600 Hz (F (1, 17) = 5.20,  $P < .05$ ,  $\eta^2 = .23$ ) (F (1, 17) = 4.83,  $P = .04$ ,  $\eta^2 = .22$ ) TFOI (P > .05).

**Discussion**

The present study investigated the neural basis of the word fluency effect (WFI) (Rosen, 1977) using a word fluency task. We found that the WFI was associated with increased activity in the left inferior frontal gyrus (IFG) and the left superior frontal gyrus (SFG). These findings are consistent with previous research showing that the IFG is involved in the retrieval of words (Lavenex & Amaral, 2000) and the SFG is involved in the selection of words (Gorno-Tempini et al., 1999; Hagoort, 2000; Koenig et al., 2001; Mummery et al., 2000). The WFI was also associated with increased activity in the left middle temporal gyrus (MTG) and the left middle frontal gyrus (MFG). These findings are consistent with previous research showing that the MTG is involved in the retrieval of words (Lavenex & Amaral, 2000) and the MFG is involved in the selection of words (Gorno-Tempini et al., 1999; Hagoort, 2000; Koenig et al., 2001; Mummery et al., 2000).

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... (M... H... 2010) ...  
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 (H... 2004, 2004). T...  
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 (F... A... 2011, ...). Fo...  
 (P... K... 2009). E...  
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 fl...

**Acknowledgments**

T... N... B... R... P...  
 C... (973 P... 2010CB833903), N... N... S... F...  
 C... (P... 30910103901, 91024032, 81161120539),  
 C... P... S... F... (P... 2011M500171,  
 2012T50006). W... L... L... o...

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 Fo... , P., H... , S.J., G... , S.J., G... , C., K... , M.L., C... , F., M... , H.,  
 2003. I... .A... J. P... 160, 1938–1945.  
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