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H - fi DCS -

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Introduction

I - fi . B (SV) . P - - (. . ; A , 1975; F ., 2002; K G , 2009; R , 2003). R , . M fi SV -

(PFC) (B K , 2009; C ., 2011; K G , 2007, 2009; P B , 2009). T (PFC) (B K , 2009; B ., 2009; H ., 2014; J ., 2011; J M , 2012; K ., 2008; M C ., 2004; B ., 2014). T PFC (M C ., 2004); PFC - . A PFC - fi . E MRI (H ., 2009; L ., 2009) (TMS; F ., 2010) PFC fi - .

I PFC - fi (C ., 2010, 2012; E ., 2012; F ., 2010; H ., 2013). F , TMS PFC

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(C ., 2010, 2012; E ., 2012; F ., 2010). S - (DCS) (H ., 2013; K ., 2014). T PFC fl fi - fi DCS (HD- DCS) DCS W DCS, HD- DCS HD- DCS . S . O DCS (H ., 2013). I - (PFC) ( ) HD- DCS, fi PFC ITC. W PFC . D ( ) ( ) ( ) (F ., 2014; J ., 2012). F DCS . L PFC . I - G PFC - ITC (F ., 2010), PFC .

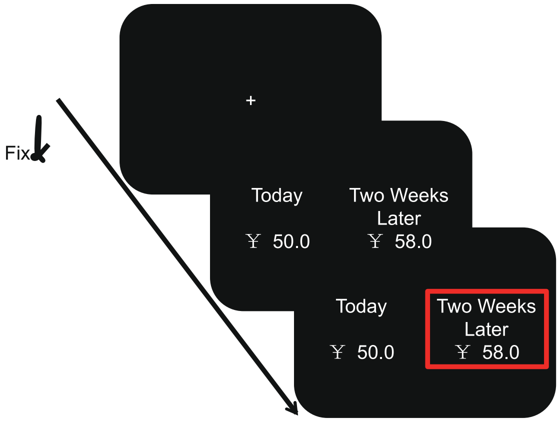
Materials and methods

Participants

117 3 DCS - (39 ; E . 1: 24 22.1 ± 2.0 ; E . 2A: 18 21.1 ± 1.8 ; E . 2B: 21 21.4 ± 2.0). A DCS (HD). N . A . P ( ). T P E C S C S , P U .

Intertemporal choice (ITC) task

T - ; (F . 1A) DCS PFC. E 24 . F 144 (12 12). D (SS) (LL) . T - 5 . A . I 5 , , "P " (< 2%). T ITC SS . T fi " - ", SS fi " ". T " " SS fi 30 . T LL SS (1, 3, 7, 14, 30, 90 ; F . 1B). F) . T SS - fi 50 C ($8 USD). T - LL - : LL - SS . W (SV) LL (D) - :



$SV = LL\ Amount/(1 + kD)$

T | ` | k | 0.005
0.015 | | | (

(~24) (N ., 2015). HD- DCS E 2A 2B - ITC . T - E . 2A: (1) (F3+), (2) (F4+), (3) . S E . 2B (1) (F3−), (2) (F4−), (3) . A E . 2A 2B E . 1.

Conventional tDCS

C DCS - - (S M , M 1300-A, N) 5 × 7 - (S ., 2014). P PFC : / , / . F / F3, F4 (F3+F4−); / F4, F3 (F3−F4+; F . 2A). F 2.0 A ~20 . S 8 (~12) 30 - 30 - . P (0.057 A/ ^{2}) (~0.0063 C/ ^{2}) (B ." 2012; M ., 2010; V ., 2013). T . H , 30 - 30 - (D ., 2015; G - ., 2006).

HD-tDCS

HD - - (S M , 4 × 1-C3, N) DCS. F A -A C fi - EEG . E ~4 2 . T 4 × 1 fi (E ., 2013; V ., 2013). T ~7.5 - HD- DCS (V ., 2013 , 2013). F PFC C3, FT7, F 1, F , F3 (F . 2B). F PFC C4, FT8, F 2, F , F4. T . W HD- DCS (F ., 2014). T 2.0 A ~0.5 A/ ^{2} ~0.125 A/ ^{2} . P HD- DCS DCS . T DCS HD- DCS (B ., 2012; D ., 2015; G ., 2006; G ., 2016; H ., 2015; N ., 2015). T

DCS , DCS HD- DCS . HD- DCS - DCS, fi (C -D ., 2012; D ., 2009; D ., 2015; K ., 2013) (F . 2C D). A HD- DCS DCS, 2.0 A 20 (B ., 2012; K ., 2013; M ., 2010). A DCS HD- DCS , .

Behavioral data analysis

I R (R C T , 2014) R (S D T , 2016). W - DCS . F fi LL LL

$$logit\,P(chooseLL) = \beta_1\,LL\ amount + \beta_0$$

A , SS LL . T LL SV SS :

$$logit(0.5) = \beta_1 indifference\ point + \beta_0$$

T , β_1 β_0 fi :

$$indifference\ point = -\beta_0/\beta_1$$

H SS . W fi β_1 β_0 (“ 4” R; B ., 2014). F , LL . T fi β_1 β_0, β_1 β_0 .

F - , fl : “ ” (ASAP) (K G , 2010; M , 1987). F - ASAP - , (M , 1987), . T SV *A* -

=———

. I ASAP , SV

. W

ASAP

(AIC ASAP : 35503; AIC

: 35512). F ,

ASAP

T .

k fi B

“ B DM” R (A ., 2011, 2016). W

: $(k) \sim N(\mu, \sigma)$. T

LL

:

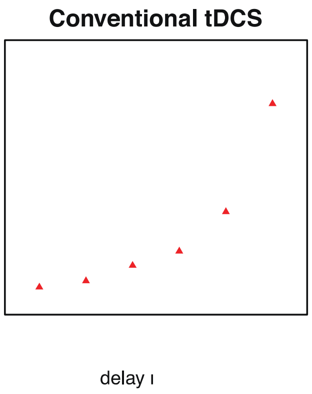
$$P(choose\ LL) = \left(1+e^{-b(SV_{LL}-SV_{SS})}\right)^{-1}$$

SV_{SS} SV_{LL} SS LL -

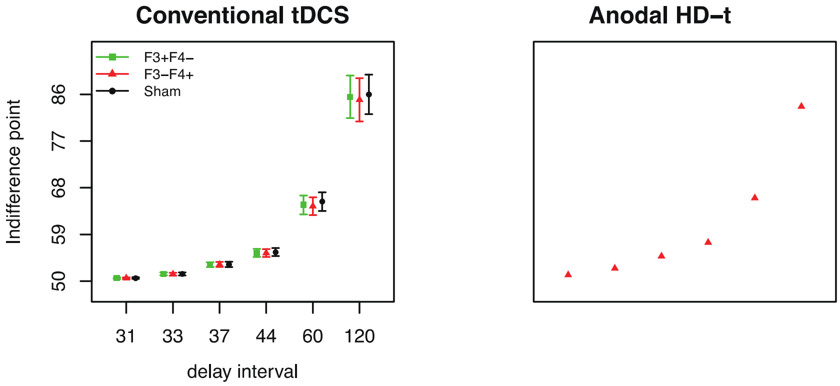
b -

. D -

fi .



Results



Delayed context

P TMS PFC fl (F ., 2010). T DCS, SS LL 30 . W ASAP (K G , 2010) . A DCS . I fi E . 1, 2 A 2B (F . 4A–C; : $F_{(2,76)}=0.91$, $\eta^2=0.02$, $p=0.41$ (E . 1); $F_{(2,76)}=1.35$, $\eta^2=0.03$, $p=0.26$ (E . 2A); $F_{(2,76)}=2.60$, $\eta^2=0.06$, $p=0.08$ (E . 2B); : $F_{(10,380)}=0.51$, $\eta^2=0.013$, $p=0.89$ (E . 1); $F_{(10,380)}=1.05$, $\eta^2=0.027$, $p=0.40$ (E . 2A); $F_{(10,380)}=1.72$, $\eta^2=0.043$, $p=0.07$ (E . 2B)). D (k) fi E . 1 2A, 2B (F . 4D–F; E . 1: $F_{(2,76)}=.70$, $\eta^2=0.018$, $p=0.50$; E . 2A: $F_{(2,76)}=2.72$, $\eta^2=0.067$, $p=0.072$; E . 2B: $F_{(2,76)}=2.86$, $\eta^2=0.070$, $p=0.063$). T DCS . A 2 × 3 × 6 ANOVA (& , F3, F4 & , 6) fi (E . 1: $p=0.88$; E . 2A: $p=0.88$; E . 2B: $p=0.98$). A 2 × 3 ANOVA ((k)) fi DCS (E . 1: $p=0.63$; E . 2A: $p=0.38$; E . 2B: $p=0.37$).

Discussion

W PFC fl . W HD- DCS . O fi (,) PFC (F3–F4, F3 , F4). I HD- DCS PFC . F , PFC fl PFC (. . , F . 3H). R (PFC,) (PFC) (B K , 2009; C ., 2011; K G , 2009; M C , 2007; M C ., 2004; P B , 2009; B M C , 2013; B ., 2014). A PFC (K G , 2010; M C , 2007; S ., 2010; B M C , 2013; W ., 2014). R TMS

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., 2010; E ., 2012; F ., 2010; H ., 2013;
K ., 2014). H
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~1 A (B ., 2015; H .,
2013; M ., 2015). R
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., 2013). A
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fi DCS
(F ., 2007; M
., 2015; N ., 2015). T
(E . 2A 2B) fi
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(F . 2C).
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E ., 2012; F ., 2010). A
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2014; J ., 2012). H
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; H ., 2010; B M C , 2013). F
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M C , 2013). E PFC
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PFC . H ,
SV

. A PFC (F ., 2010; H ., 2010).

Conclusion

W HD- DCS PFC fi . A HD- DCS , . T , PFC . O ITC PFC. T PFC PFC (O ., 2013; W ., 2004).

Acknowledgment

T M S T C (2015CB559200) N N S F C (P 31322022, 31371019, 31421003, 91224008) (J.L) N N S F G 1358507 (S.M.M). T D . H , M . H W D . P C , D . K D A . T fl .

Appendix A. Supporting information

S :// . . /10.1016/ . .2016.09.006.

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