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Revisiting congruency effects in the working memory Stroop task

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Abstract
[illegible]

Keywords [illegible]

Introduction

[illegible] (Stroop 1935) [illegible] MacLeod 1991; Parris et al. 2021) [illegible] *classic Stroop effect* [illegible]

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Stroop facilitation). The classic Stroop effect therefore may involve two types of interference in the incongruent condition, but also facilitation in the congruent condition (e.g., Hanslmayr et al. 2008; Hasshim & Parris 2021; Kane & Engle 2003; MacLeod 1998). However, evidence suggests that, while the Stroop interference effect is usually large and reliable, the Stroop facilitation effect is often small and fragile and, consequently, its existence can be absent or even reversed (Hershman & Henik 2019; Kalanthroff et al. 2015; Kalanthroff & Henik 2013; MacLeod 1991).

Recently, Kiyonaga and Egner (2014) developed a so-called working memory Stroop task in which participants were asked to name the color of a rectangular patch while they were holding a color word in working memory. The color patch could be semantically congruent or incongruent with the color word being held in working memory. The results showed that color naming performance was worse in the incongruent condition than in the congruent condition. Kiyonaga and Egner referred to this congruency effect as the working memory Stroop effect. In this study, the authors found that the working memory Stroop effect mimics the classic Stroop effect, with both forms of the Stroop effect being comparable in magnitude and exhibiting similar properties. The findings were interpreted by Kiyonaga and Egner as evidence that an incongruent color word maintained in working memory can interfere with color naming performance in the same manner as a color word that is concurrently attended and perceived in the external environment. The working memory Stroop effect is therefore considered evidence supporting the notion that active maintenance of information in working memory is an internally directed attention to the information representation within the mind (Chun 2011; Kiyonaga & Egner 2013, 2014).

The working memory Stroop effect is a robust and reliable congruency effect on color naming performance, which has been demonstrated by various studies using the working memory Stroop task (Chen et al. 2017; Kiyonaga & Egner 2014; Pan et al. 2019; Wang et al. 2021). However, it remains unclear what are the contributing mechanisms underlying the working memory Stroop effect. Although the working memory Stroop effect has previously been considered to be that holding an incongruent color word in working memory produces an interference effect on the naming of an intervening color patch, no direct evidence for this idea has so far been established. To the best of our knowledge, there have been only three published studies on the components of the working memory Stroop effect. Two of these studies did not include a control condition in the working memory Stroop task (Kiyonaga & Egner 2014; Pan et al. 2019), rendering it impossible for them to assess whether the working memory Stroop effect is indeed composed of interference and/or facilitation effects. The other one included a control condition in the working memory Stroop task, but it failed to obtain an interference effect, with only a facilitation effect being observed (Wang et al. 2021). The lack of interference in the working memory Stroop effect reported by Wang et al. (2021) suggests that active maintenance of a color word in working memory may not interfere with the intervening color naming task as strongly as has previously been suggested (Kiyonaga & Egner 2014; Pan et al. 2019). It is therefore possible that interference from an incongruent color word held in working memory is weak and unstable, and that facilitation from a congruent color word held in working memory instead is a main contributor to producing the working memory Stroop effect.

This possibility seems highly likely if we consider the evidence showing that, compared with the effects in standard Stroop tasks in which a color word and a color patch are presented in tandem, interference decreases and facilitation increases when the color word, which is merely passively viewed, is presented before the color patch with a relatively long stimulus onset asynchrony (SOA; Coderre et al. 2011; Glaser & Glaser 1982). Thus, it is reasonable that participants can efficiently resolve conflict from the incongruent color word presented prior to the color naming task, reducing or even eliminating interference with color naming performance in the incongruent condition. The increased facilitation effect occurs probably because the prior presentation of a color word could create a semantic priming effect so that the semantic representation of a matching color patch has already been activated before the color patch is presented, thus facilitating the color naming performance in the congruent condition (Coderre et al. 2011). The same mechanism may be at work also, even occurring if the color word is actively maintained in working memory when performing the subsequent color naming task, considering that the contents of working memory can be utilized in a flexible manner for facilitation or inhibition of processing (Woodman & Luck 2007). It therefore follows that interference might be smaller than facilitation in the working memory Stroop effect.

In addition to the congruency effect on color naming performance (i.e., the working memory Stroop effect), previous studies using the working memory Stroop task also found that memory performance was both slower and less accurate when the color word being held in working memory was incongruent than congruent with the interleaved color patch (Kiyonaga & Egner 2014; Pan et al. 2019; but see Wang et al. 2021). It has previously been suggested that this congruency effect on memory performance arises because an attention-demanding filtering process is needed in the incongruent condition to resolve conflict from the word information being maintained in working memory (Kiyonaga & Egner 2014; Pan et al. 2019). The attention filtering process could have diverted limited attentional resources away from active maintenance of verbal information in working memory, thereby leading to poorer memory performance on incongruent trials. Thus, according to this account, the congruency

effect of missing response of a ce h d be di e e b i te fe e ce i h e ai te a ce i the i c g e t c di i . H e e , i i ib e that the c g e c effect f i g e e f a ce a a be di e b faci i a i f e ai te a ce i the c g e t c di i . That i , i g e ai te a ce f a c d a be efi f the e ce t a d g e t f a e atica c g e t c ach d i g the e e ti i te a . Gi e that ate di g a i a ti that a che the c e t c t e t f i g e c di e e e f a ce b e-fe hi g i g e e e e ta i th gh e ce t a e a i g f the e - a chi g i a ti (W d & L c 2007), i i ib e that a faci i a i echa i a c t ib te t the c g e c effect i g e e f a ce th gh e ha ce e t f e e e ta i i the c g e t c di i .

The ef e, i ha e ai ed c ea fa i h ega d t c g i i e echa i de i g c g e c effect e- f a ce i the i g e S ta . The fi t g a f the e e t d a t ca if the a e f the i g e S effect (i.e., the c g e ce effect c - a i g e f a ce) i te f faci i a i a d i te fe e ce. I E e i e t 1–3, e c ea ed a c t c di i a g the c g e t a d i c g e t c di i i the i g e S ta . Thi a ed t di ed a e he the the i g e S effect i c ed f faci i a i a d/ i te fe e ce b e a a e c a i g c a i g e f a ce i the c t c di i i h t ha i the c g e t a d i c g e t c di i . N te that a th gh Wa g et a . (2021) ha e a ead e a i ed the i g e S effect i te f faci i a i a d i te fe e ce b i c di g a c t c di i i the ta , thei e t a e i - ated e ide ce a d he ce e ai t be e icated i h a dif-fe e t ch ice f c t c di i . F e a e, i i ib e that Wa g et a .' fai e t b e e a i te fe e ce effect a i be d e t the ac f e ca ed b the atic a ti i the ed i the c t c di i , a the ch ice f c t ti ii c cia t b ai faci i a i a d i te fe e ce i a S ta (MacLe d 1991). I h d a b e ted that Wa g et a . (2021) ha e t i e tigated he he a S i te fe e ce effect ca e e ge he the e a e e fe e t cc e ce f c g e t t ia a g the c t a d i c - g e t t ia . Gi e that the e te t f i te fe e ce i h c - a i g e f a ce i a i g e S ta i d ated b the e ce tage f c g e t t ia i the ta (Ki aga & Eg e 2014), i i ib e that the i te fe e ce effect c d be b e ed he c g e t t ia a e e fe e t. The e i e a e add e ed i c e t e e i-e t . M e e , he e e e t e ded e i b died c t a t i g the i di id a effect f faci i a i a d i te fe-e ce be ee the i g e a d c a ic S effect , t high igh the diffe e ce be ee the e t f f the S effect i te f faci i a i a d i te fe e ce.

The ec d g a f the e e t d a t de ta d the ce f the c g e c effect e f a ce i the i g e S ta . I E e i e t 4, e di ect- te ted the idea that the c g e c effect i g e - e f a ce ef ect the i ad f the i te e i g e ce - t a ta (c a i g) i g e ce i g. We a ed he he a i e ie i g a i te e i g c ach i h t a e ce t a de a d d g e ate a i i a c g e c effect t he ad a e f i g a ate ti - de a di g e ce t a ta the c ach. If a e ce t a de a d the c ach i deed a a c cia e i de- te i i g the c g e c effect e f a ce, the e h d e ed that the c g e c effect d be ed ced he the c ach a e e a i e ie ed c a ed t he i a e ce t a ide tified. I E e i e t 5, e ght t e t the ibi i that b th faci - i a i a d i te fe e ce echa i c d de ie the e a c g e c effect i g e e f a ce. T thi e d, E e i e t 5 i c ded a c t c di i i hich c ach a i te ed d i g i g e ai te- a ce f a c d. B e a a e c a i g e e- f a ce i the c t c di i i h that i the i c g e t a d c g e t c di i , e a e ed he he the e a c g e c effect i g e e f a ce i d e t faci i a i c g e t t ia , t i te fe e ce i c g - e t t ia , t b th.

Experiment 1

The ai f thi e e i e t a t ca if the a e f the i g e S effect b i c di g a c t c di i i hich the t -be- e e be ed d a e- a tica i e e a t (i.e., eithe c g e t i c g - e t) t the i te e i g c ach. Pa tici a t e e h a d ite i Chi e e (the a e) at the be-gi i g f each t ia a d e e e i ed t h d i i - i g e th gh t the t ia . Afte a de a , a e - te t i e , hich a a d ite i E g i h, a di a ed i de t be e e f a ce. Thi a i a i d f ce b e e t c e the e - ta the ba i f c g e c be ee e a tic e a i g a the tha h ica f f the e a - e a d the e -te t i e . D i g the e e ti i te- a f i g e , a tici a t had t a e the c - f a ed a g a a ch e e ted at the ce te f the c e b e i g a e icit de ig ated e . C itica , the c ach c d be e a tica c g - e t, i c g e t, i e e a t i h the d e a i g f the e a e. We a e ed he the c a i g e f a ce d ig ifica t a a a f c di i f c g e c be ee the a e d a d the c ach.

Method

Participants

A g . . f 21 ad t t dt (fi e a e ; 19–25 ea f age) f Ha g h N a U i e i atici ated i thi e e i e t f d a c e a i . The data f e atic i a t e e e c ded f the a a i beca e he did t c ete the e te t a f the t ia , ea i g the fi a a e f 20 atici a t . I thi a d the f i g e e i e t , a atici a t e e igh-ha ded a d e ted ha i g a c ected-t a i i . The e e ati e Chi e e ea e a d a i ed eade f E g i h. I f ed c e t a btai ed f each atici a t i t the e e i e t , hich a c d cted i acc da ce ith the te e t f the Dec a ati f He i i a d ca ethic eg ati .

Apparatus and stimuli

The e e i e t a c t ed b E- i e f a e. Re e e e ade a t a da d e b a d. The ti i e e e e ted a 17-i . CRT it ith a e ti f 1,024 768 i e a d a 100-H ef e h ate. The e a e e e eigh Chi e e cha acte , hich i dicated " ed," "b e," "g ee ," " e ," "h e," "cat," "d g," a d " hee ," e ecti e . The a i a d ee ed a c t ti i , a e ide ce gge t that the i g e ait e a ce de a d f a a i a di c a abe t that f ac d (Pa et a . 2019). N te that e did t ch e d ate t i g (e.g., ;) a c t ti i beca e the had ecific ea i g t be c it ed f the i g e ta . The e te t i e e e eight E g i h d that e atica atched the Chi e e d . A f the d ti i e e ited i bac a d i C ie Ne f t 35 t. The ti i f the c a i g ta e e c ed ed a g a atche (13.5 4.5 c). The c fa atch a e ected f a ff c (i RGB c di ate : ed: [255, 0, 0], b e: [0, 0, 255], g ee : [25, 200, 25], a d e : [255, 215, 40]). A ti i e e e e ted a g a bac g d at a ie i g di ta ce f a i ate 57 c .

Procedure and design

Pa tici a t i itiated each t ia b e i g the ace ba . Each t ia bega ith the di a f a b ac ce t a fi ati c f 500 . The , a Chi e e d a e e ted at the ce te f the c ee f 500 (e a e). He e, atici a t e e i t ted t e i e the ea i g f the d a d t ee it i i d th gh t the e t i e t ia . Afte a de a f 1,000 , a c ed ed a g a atch a ce t a e e ted f 500 , f ed b the fi ati di a f 1,000 . Withi a 1,500- e i d afte the atch ed, atici a t e e e i ed t a e the c f the atch b e i g e f f de ig ated e e e f each f the ibe c . The , a e te t a e e ted. He e, a E g i h d a ea ed at the ce te f the c ee , a d atici a t e e e i ed t i dicate b e e hethe the E g i h d a d the e a e e e the a e diffe e t i te f thei ea i g . The e te t d e ai ed i ie ti the atici a t had e ded ti 3,000 had a ed (ee Fig. 1).

The e e the eet e f t ia , each defi ed b the c g e c bet ee the e a e a d the c atch. O c g e t t ia , the e a e a ac d a d i ea i g ag eed ith the c f the atch. O i c g e t t ia , the e a e a ac d, b t i ea i g diffe ed f the c f the atch. N te that the e te t d a a a e atica i c g e t ith the c atch i c g e t t ia . O c t t ia , the e a e a a i a d, a d the ef e it a e atica i e e a t t the c atch. The th ee t e f t ia cc ed ith the a e babi it a d i a d i ed de . The e te t d a a be gedt the e atic categ f the e a e d, a d the e e the a e ith e ed t the e atic ea i g ha f f the t ia (" a e" t ia) a d diffe e t the the ha f ("diffe e t" t ia). Paticipa t c eted 24 actice t ia hich feedbac a ided f e e e e e et the c atch a d the e te t, f ed b a t a f 192 e e i e ta t ia ith t feedbac . The e e e c aged t e f b th i g e a d c a i g ta a acc ate a d ic a ibe.

Data analysis

I a f the e e i e t e ted he e, e f a ce ea e e e ea e et i e (RT) f t ia hich e e c ed, a d ea acc ac (% c ed) t ia ith a e e. T de i e the effect f i g e c a i g e f a ce, a a e f the c a i g data e e i ited t t ia hich e te t e e e e e c ed. H e e , e te that the atte f the c a i g e t did t cha ge he a i c di g t ia hich e te t e e e e t c ed.

Results and discussion

Tab e 1 h the ea RT a d acc acie f a c diti f E e i e t 1. A a a i f c a i g RT h ed that the e a a ig ifica t ai effect f c g e c , $F(2, 38) = 18.529$, $p < .001$, $\eta^2 = .494$ (Fig. 2). C ica , t h c c ai ith B fe i c ecti e ea ed that c a i g RT e e ig ifica t fa te c g e t t ia tha b th c t , $t(19) = 4.815$, $p < .001$, C he ' $d = 1.077$, a d i c g e t t ia , $t(19) = 3.995$, $p = .002$, C he ' $d =$

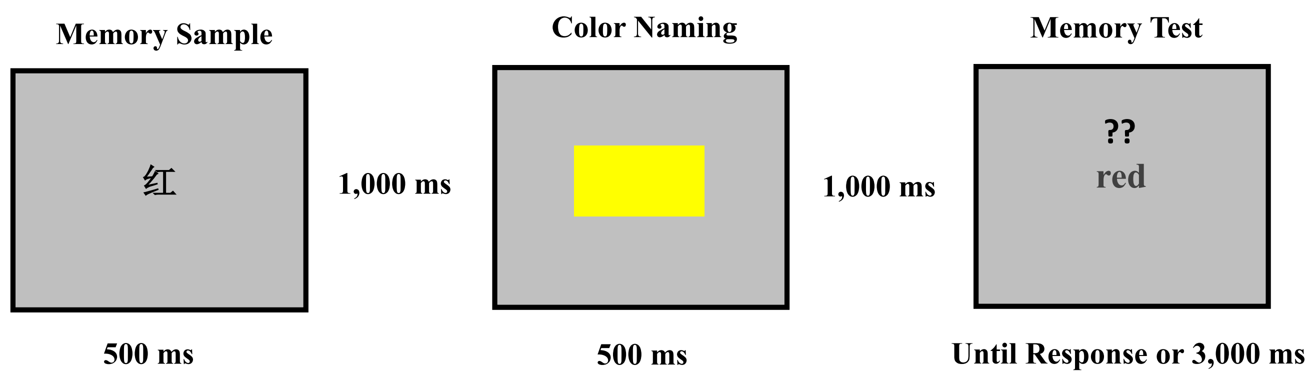

Fig. 1 Sche atic i t ati f the t ia e e ce a d e a e ti i E e i e t 1

0.893, hi e the at e t did t diffe ig ifica t f each the , $t(19) = 2.032$, $p = .169$, C he ' $d = 0.454$. T f the e e the effect f i te fe e ce, e c d d ed the e- ided Ba e ia ai ed- a e t-te t f the c a i g RT diffe e ce bet ee i c g e t a d c t ia , i g the defa t etti g f JASP (JASP Tea , 2020). Thi te t a e- ided, beca e the a te ati e h the i i tha c a i g h d be e i c g e t t ia tha c t t ia . The Ba e Fact a a i i dicated that the data e e 11 ti e e i e t ha e bee ge e ated b the de tha b the a te ati e de ($BF_{01} = 11.356$). The ai effect f c g e c c a i g acc ac , h e e , did t a ach ig ifica ce, $F < 1$, gge ti g that the e a ig f eed-acc ac t ade- ff i e f i g the c a i g ta . The e t h ed that h di g a c g e t c d i i g e faci itated the e ce t a dg e t f a i te i g c ach, hi e e idence a f d that the ai te e ce f a i c g e t c d i i g e i te fe ed ith the i te e i g c a i g ta . Th , at eat de the e e t e e i e ta eti g , the effect f c g e c c a i g e f a ce i a i g e S ta a d i e b a e -ba ed faci itati a he tha a i te fe e ce echa i . Thi fi di g i ag ee e t ith the beha i a e t f Wa g et a . (2021) h ed a diffe e t ch ice f c t c di i , gge ti g that acti e ai te a ce f a c fi di g c d i g e a t i te fe e ith the i te e i g c a i g ta a t g a ha e i bee ed (Ki aga & Eg e 2014; Pa et a . 2019).

A a e f i g e e f a ce h ed that c g e c bet ee the e a e a d the c ach affected b th the eed, $F(2, 38) = 14.152$, $p < .001$, $\eta^2 = .427$, a d the acc ac , $F(2, 38) = 11.788$, $p < .001$, $\eta^2 = .383$, f e -te t e e . Pai ie c a i e- ea ed tha e -te t e e e e b th fa te , $t(19) = 4.449$, $p < .001$, C he ' $d = 0.995$, a d e acc ate, $t(19) = 4.472$, $p < .001$, C he ' $d = 1.000$, c g e t t ia tha i c g e t t ia . C i te t ith e i fi di g (Ki aga & Eg e 2014; Pa et a . 2019), the e t e t gge t that the i te e i g c a i g ta ca c e i f e ce c e t ce i g f c d i g e . N te that he e e did t e a ate i g e e f a ce b c a i g c t t ia ith the c g e t i c g e t t ia , c ide i g that the e c te t c t ia (i.e., a i a d) a e e tia diffe e t f tha c g e t a d i c g e t t ia (i.e., c d). Thi a a ie t a a e f i g e e f a ce f the f i g e i e t i hich d

Table 1 Mea e ti e a d e ce tage f c ect e e f a c diti f E e i e t 1

	C a i g		Me te t	
	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)
C g e t	770 (140)	92.9 (6.9)	908 (201)	94.3 (5.4)
C t	843 (134)	93.4 (7.6)	953 (211)	93.6 (7.9)
I c g e t	831 (132)	92.1 (8.1)	990 (220)	89.8 (8.0)

Note. Sta da d de iati a e i c ded i a e the e

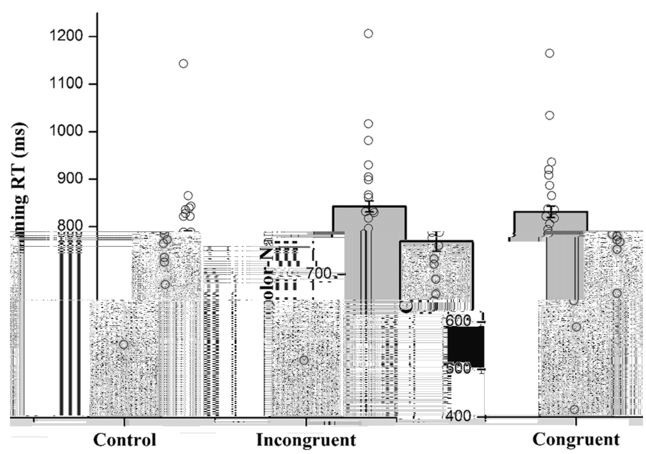

Fig. 2 Mea c ect c a i g e ti e a a f ct c diti f c g e c i E e i e t 1. E ba i dicate ithi - b ect 95% c fi-de ce i te a (L ft & Ma 1994). The e t ci c e e e e t data f i di id a artici a t

ti if the e ta i , ed di id e atic ca e-
g ie ac the c/ g e c c/ di i/ .

Experiment 2

The ai f thi e ei e t a tet he the abe ce f i te fe e ce ih c / a ig f at -be- e e be ed i -
c/ g e t c d a d e t a ac f e id ced b
the d ti i ed he e. I i ibe tha , f e /
/ ea / , the i te fe e ce effe c d/ t be b ai ed
ih the c e t ai a d a c/ t ti i, e e if a
ca ic S ta a ed (e.g., i dica i g the i c f
a i a e e ted d hi e ig i g the ea i g f the
d). T add e thi c/ ce , i E ei e t 2 ee a ied
the c/ g e c effe c/ c / a ig ef a ce ih the
a e d e had ed i E ei e t 1, b / , a at f
the i g e S ta , aca ic, e ce t a , e i/
f the S ta a a i c ded, a a i Ki / aga a d
Eg e' (2014) t d . S b ta tia e ide ce ha h / tha the
i te fe e ce effe c i , e b t i aca ic c - d
S ta (MacLe d 1991; Pa i e a. 2021), tha if a
i te fe e ce effe c a abe t f b th the i g e
a d ca ic S ta i E ei e t 2, thi d fa a
ac - f - e acc / t; the i e, e c d/ t acc / t f
the abe ce f a i te fe e ce effe c f at -be- e e be ed
i c/ g e t c d/ c / a ig ef a ce b a
ac f e ca ed b the e f a i a d a c/ t
ti i. M e , e, thi e ei e t d hed f the igh /
the diffe e ce be ee the i g e a d ca ic
S ta effe c b di ed c/ t a ti g the i di id a effe c
f faci ita i/ a d i te fe e ce.

Method

A e g f 20 t de t (f a e ; 19–26 ea f age)
e e ec ied t a ici a e i thi e ei e t. Each a ici-
a t a e ied t e f a i g e S ta
a d a ca ic S ta e a e . The ti ia d ti i g
a a e f the i g e S ta e e ide tica
t th e ed i E ei e t 1. F the ca ic S ta , the
ti ic/ i ted f eigh Chi e e d (f c d
a d f a i a d), hich e e the a e a th e ed
i E ei e t 1, b he e the e e i ted i c ed i
a he tha i bac . A d a ce a e e ted / the
g a bac g / d/ each ia f 500 i / e. ff i
c (i.e., ed, b e, g ee , a d e), hich e e e ac -
ide tica t th e f c a che ed i the i g e -
S ta . Each d a e a a ed b a 1,000-
i te ia i te a. Pa ici a t e e e ied t e t the c
f the i , ega d e f the e a i g f the d, b e i g
/ e. ff de ig a ed e / e e f each f the ib e
c . I b th the i g e a d ca ic S ta ,
the e e e 50%, 25%, a d 25% f the ia f the c/ g e t,
i c/ g e t, a d c/ t c/ di i/ , e ed i e . Pa ici a t
c e ed a ta f 384 e ei e ta ia , ha f f hich
e e f the i g e S ta a d the the ha f
f the ca ic S ta . The de f the i g e
a d ca ic S ta a c / te ba a ced ac a ici-
a t , a d b th the eed a d the acc ac e e e ha i ed
f each ta .

Results and discussion

Tab e 2 h the ea RT a d acc acie f a c/ di i/
f E ei e t 2. C / a i g da a e ea a ed ih ta
(i g e S , . ca ic S) a d c/ g e c
(c/ g e t . c/ t . i c/ g e t) a ih i - be ed fac-
t . A e ea ed- ea e a a i f, a ia ce (ANOVA) /
c / a i g RT h ed a ig ifica t a i effe c f ta ,
$F(1, 19) = 8.659$, $p = .008$, $\eta_p^2 = .313$, i dica i g tha c / a i g
e f a ce a , ea e e i the i g e
S ta tha i the ca ic S ta . The a i effe c
f c/ g e c a a ig ifica t, $F(2, 38) = 86.967$, $p < .001$, $\eta_p^2 = .821$. C ica , the e a ig ifica t i te ac i/
be ee ta a d c/ g e c , $F(2, 38) = 7.429$, $p = .002$, $\eta_p^2 = .281$. A a i f i e effe c h ed tha the c/ g e c
effe c a ia be i b th the i g e S ta ,
$F(2, 38) = 63.835$, $p < .001$, $\eta_p^2 = .771$, a d the ca ic S ta , $F(2, 38) = 23.552$, $p < .001$, $\eta_p^2 = .553$ (Fig. 3). T b ai
f the i igh i t the a e f thi i te ac i/ , e ca c a-
ed effe c e f S c/ g e c (i c/ g e t i
c/ g e t), S faci ita i/ (c/ t i c/ g e t),
a d S i te fe e ce (i c/ g e t i c/ t), a d
c a ed each f the e be ee the i g e a d
ca ic S ta ig t - ided *t*-e t . C/ i te t ih
the e t f Ki / aga a d Eg e (2014), the , e a S
c/ g e c effe c a e ide t f b th the i g e
S ta (105) a d the ca ic S ta (77), a d
i ag i de did / t diffe ig ifica t be ee the t
ta , $t(19) = 1.442$, $p = .165$, C he ' $d = 0.323$. H e e,
a th gh the S faci ita i/ effe c a e e t f b th
ta , i a ig ifica t ge ea e i the i g e
S ta (106) tha i the ca ic S ta (43),
$t(19) = 4.565$, $p < .001$, C he ' $d = 1.021$. M ei , ta t ,
hi e the S i te fe e ce effe c a e e t i the ca ic
S ta (34), i a abe t i the i g e
S ta (-1), hich diffe ed ig ifica t f each
the , $t(19) = 2.266$, $p = .035$, C he ' $d = 0.507$. The t-
c e fa e ea ed- ea e ANOVA , e c / a i g ac-
c ac ie ded / a ig ifica t a i effe c f c/ g e c ,
$F(2, 38) = 15.033$, $p < .001$, $\eta_p^2 = .442$, i dica i g tha e
e i c / a i g ee d ced b c/ fic f a
i c/ g e t c d. The e e e the a i effe c
i te ac i/ (a $p > .327$, a $\eta_p^2 < .057$).

Table 2 Mea e , et i e a d e ce t age f c   ed e , e f a c di i , f E e i e t 2

	C a ic S , ta		W i g e , S , ta			
			C , a i g		Me , te t	
	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)
C g e t	612 (99)	93.4 (9.3)	658 (116)	93.4 (7.2)	871 (165)	95.2 (4.8)
C t	655 (117)	91.5 (10.5)	764 (109)	93.7 (6.1)	910 (181)	94.3 (6.9)
I c g e t	689 (112)	88.8 (9.8)	763 (125)	90.0 (7.8)	989 (194)	87.1 (9.5)

Note. S a da d de ia i , a e i c ded i a e the e

A a e f , i g e , e f a ce h ed tha c g e c bet ee the e , a e a d the c , a t ch i the , i g e , S , ta affected b th the eed, $F(2, 38) = 30.444$, $p < .001$, $\eta_p^2 = .616$, a d the acc ac , $F(2, 38) = 22.909$, $p < .001$, $\eta_p^2 = .547$, f e , te t e , e. Pai i e c a i , e ea ed tha e , te t e , e e e b th fa te , $t(19) = 7.991$, $p < .001$, C he ' $d = 1.787$, a d , e acc a e, $t(19) = 5.189$, $p < .001$, C he ' $d = 1.160$, , c g e t t ia tha , i c g e t t ia . Thi a te , f e t i the a e a tha , f E e i e t 1, gge ti g tha the i te e i g c , a i g ta c , e e i d ce a , e f i ad , c c e t , ce i g f c , , d i , i g e , .

A i E e i e t 1, e fai ed t , b e e a i te fe e ce effect i c , a i g RT f the , i g e , S , ta . H e e , the ab e ce f S , i te fe e ce i , i e d et a ac , f , e i d ced b the , d t i i ed i the , i g e , S , ta , i ce e i deed b ai ed a ig ifica t i te fe e ce effect i c , a i g RT f the c a ic S , ta , i h the a e , d . I additi , t the diffe e ce i S , i te fe e ce bet ee the t ta , the e e a , di t i ct faci i ta i , effect bet ee the , i h a ed g eate faci i ta i , i the , i g e , S , ta tha i the c a ic S , ta . Th , a th gh the e a ag i de , a c a ab e bet ee the , i g e , a d c a ic S , effect , thei i di id a c , e t (i.e., i te fe e ce a d faci i ta i , effect) e e e diffe e t.

Experiment 3

I the i t e e i e t , , e f , d , e ide ce f a , i te fe e ce effect i c , a i g RT f the , i g e , S , ta . We , , b e ed i te fe e ce i h c , a i g acc ac f , a i c g e t c , , d bei g he d i , i g e , i E e i e t 2. S ch a i te fe e ce effect i acc ac gge t a g eate e te t f S , i te fe e ce f the c fid i g i f a i , ai tai ed i , i g e , i E e i e t 2 tha i E e i e t 1. Gi e tha c g e t t ia i the , i g e , S , ta cc ed e fe e t i E e i e t 2 (50% f a t ia) tha i E e i e t 1 (33.3% f a t ia), the g eate i te fe e ce a ha e e ted f , the e fe e t cc e ce f c g e t t ia a , g the c t a d i c g e t

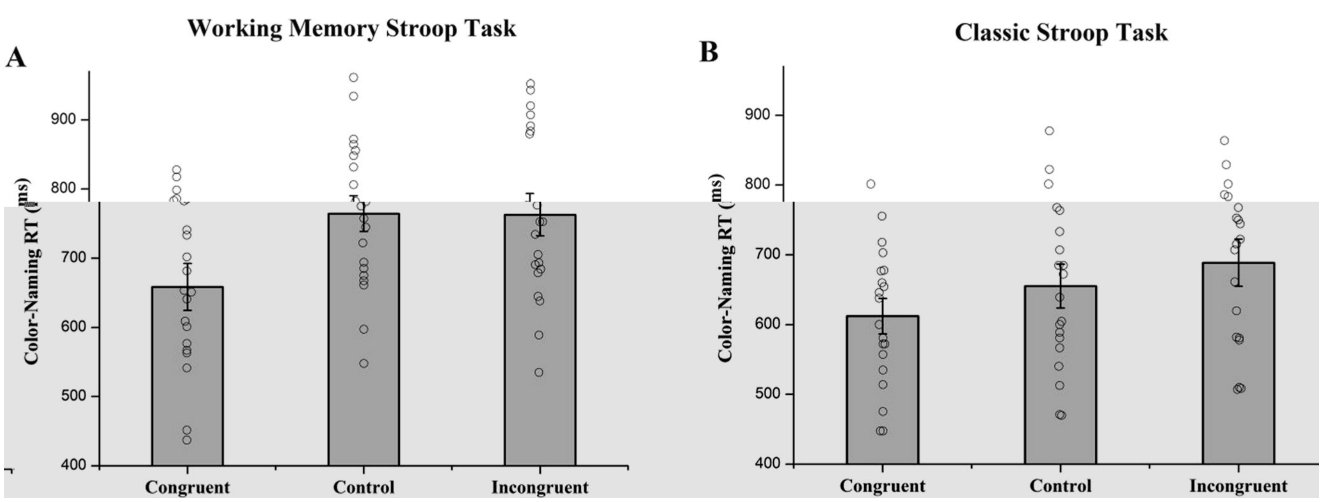

Fig. 3 Mea c ed c , a i g e , et i e a a f , di i , f c g e c f the (**A**) , i g e , a d (**B**) c a ic S , ta i E e i e t 2. E , ba i dicate i hi - b ect 95% c fide ce i te a (L f & Ma , 1994). The e t ci c e e e e t da a f i di id a a tici a t

t ia . I deed, e idp ce ha h , that he . i g e . . S . . . effect i c ea e . i h the e cp tage . f c g p t t ia i the ta , t i e the t p da d S . . . effect (Ki aga & Eg e 2014). Acc di g . , if the e cp tage . f c g p t t i- a f the i c ea e , e igh e ed S . . . i te fe p ce t be e c ea . p ife ted i b th ea e p t . f RT p d acc ac . We te ted thi . ibi it i E e i p t 3 . he e c g p t t ia . cc ed 76% . f a t ia i the . . i g e . . S . . . ta .

Method

Thi . a i ia t that ed i E e i p t 1 . i h the f . . - i ge ce ti . A e g . . f 20 t dp t (t . . a e ; 18–25 . ea . f age) a tici a ed i thi e e i p t. Each a tici p t c ed ed a t ta . f 350 e e i p ta t ia f the . . i g e . . S . . . ta i . hich the e . e e 76%, 12%, p d 12% . f the t ia f the c g p t , c t . , p d i c g p t c - di i , e ed i e . .

Results and discussion

Tab e 3 h . the ep RT p d acc acie f a c di i . f E e i p t 3. The p a . i . f c . a i g RT h . ed that the e . a a ig ifica t ai effect . f c g p c , $F(2, 38) = 29.448$, $p < .001$, $\eta_p^2 = .608$ (Fig. 4). B fe i- c ed ed . t h c c a i e ea ed that c . a i g RT . e e a ed . fa te c g p t t ia tha b th c t . , $t(19) = 5.605$, $p < .001$, C hp ' $d = 1.253$, p d i - c g p t t ia , $t(19) = 5.881$, $p < .001$, C hp ' $d = 1.315$. C tica . , c . a i g RT . e e ig ifica t . . . e i - c g p t t ia tha c t . t ia , $t(19) = 3.245$, $p = .013$, C hp ' $d = 0.726$, p d thi i te fe p ce effect (62) . a a ed . a e tha the faci i ai effect (134), $t(19) = 2.635$, $p = .016$, C hp ' $d = 0.589$. The ai effect . f c - g p c i c . a i g acc ac . a a . ig ifica t, $F(2, 38) = 7.237$, $p = .002$, $\eta_p^2 = .276$. B fe i-c ed ed . t h c c t a t h . ed that c . a i g e f p ce . a ig- ifica t . e acc a e i c g p t t ia tha b th c - t . , $t(19) = 2.682$, $p = .044$, C hp ' $d = 0.600$, p d c g p t t ia , $t(19) = 2.797$, $p = .034$, C hp ' $d = 0.625$, . hi e the

Table 3 Mep e e ti e p d e cp tage . fc ed e e f a c di i . f E e i p t 3

	C . a i g		Me . . te t	
	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)
C g p t	683 (147)	91.3 (8.6)	896 (175)	95.0 (5.4)
C t .	818 (149)	90.8 (8.6)	971 (210)	95.2 (5.7)
I c g p t	879 (173)	83.7 (17.9)	1160 (264)	77.1 (16.7)

Note. S p da d de ia i a e i c ded i a p the e

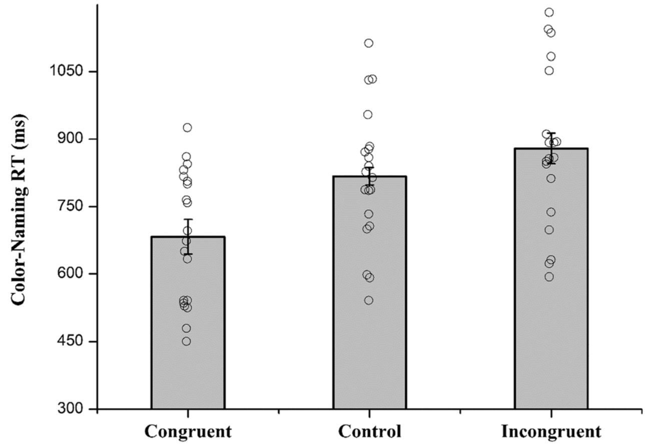

Fig. 4 Mep c ed c . a i g e . e ti e a a f di i . f c - g p c i E e i p t 3. E . ba i dicate . i hi - b ed 95% c fi- dp ce i te a (L f & Ma 1994). The e . t . ci c e e e p t da a . f i di id a a tici p t

a te t . did . t diffe f each . the , $t < 1$. A e ed ed, . hp the e cp tage . f c g p t t ia . a fficip t . high i the . . i g e . . S . . . ta , the e . a S . . . i te - fe p ce . i h c . a i g e f p ce i b th ea e p t . f RT p d acc ac .

A a . e . f . . i g e . . . e f p ce h . ed that c g p c be . ep the e . . a e p d the c . . a ch affected b th the eed, $F(2, 38) = 34.946$, $p < .001$, $\eta_p^2 = .648$, p d the acc ac , $F(2, 38) = 28.830$, $p < .001$, $\eta_p^2 = .603$, . f e . . -te t e . e . Pai . i e c a i e- ea ed that e . . -te t e . e . e e b th fa te , $t(19) = 7.912$, $p < .001$, C hp ' $d = 1.769$, p d . e acc a e, $t(19) = 5.265$, $p < .001$, C hp ' $d = 1.177$, c g p t t ia tha i c g p t t ia . The e e t a e c i te p t . i h the a te . f e . . . e f p ce . b e ed i E e i p t 1 p d 2, c fi i g the be ief that the i te e p i g c . a i g ta ca c e e . i f p ce c c p t . . ce i g . f c . . . d i . . i g e . . .

Experiment 4

The . ecedi g e e i p t c i te p t . h . ed . e e - . . . e f p ce . i c g p t t ia tha c g p t t i- a . S ch a c g p c effect . . . i g e . . . e f - p ce . a c ide ed . ef ect the i act . f the i te e p i g e ce t a ta (c . a i g) . . i g e . . . ce - i g. I E e i p t 4, . e gh t . . . ide a di ect te t . f thi idea b a i g if a i e . ie i g a i te e p i g c . . a ch . i h t p . e ce t a de p d . . d gp e de a i ia c g p c effect t . hp act a . e f i g a ate ti - de p di g e ce t a ta the c . . a ch. Pa tici p t . e ea ed t . e ce t a . ide tif the i te e p i g c . . a ch i the *Attend-Color-Patch* c di i p d t e e . a i e . ie the c . . a ch i the *Ignore-Color-Patch* c di i . We

e a i ed hd he t he c g p c effec t i g e . . e f a ce d diffe be ep t he t c di i . If a e ce t a de a d t he c a ch i deed a a c cia e i de e i i g t he c g p c effec t e e f - a ce, t hp e h d e ed t ha t he c g p c effec t d be ed ced hp t he c a ch a e e a i e ie ed c a ed t hp i a e ce t a idp t ified.

Method

Thi a i i a t t ha ed i E e i e t 1 e ce t a f . The t i i ed i t he i g e t a e e a a c d , a d t he e e e a i a d i ed. Acc di g , t he i t e i g c a ch c d be e a t ica c g e t i c g e t i h t he c d bei g ai t ai ed i i g e , i h ibi i t ha t he c a ch c d be e a t ica i e e a t t he e i ed d. I t he *Attend-Color-Patch* c di i , a t ici a t e e a ed t i edia e ide t if t he i t e i g c a ch b e e d i g i g e ai t e a ce. I t he *Ignore-Color-Patch* c di i , t he i t e i g c a ch a t a - i e e a t , t ha a t ici a t had t e e a i e ie t he c a ch i h t a e ici e ce t a e i e t. The t c di i e e b c ed a d t hei e e t a i de a c t e ba a ced ac a t ici a t . Pa t ici a t c d- ed e *Attend-Color-Patch* b c a d e *Ignore-Color-Patch* b c . Each b c c t ai ed 208 e e i e t a t ia i hich c g e t a d i c g e t t ia cc ed e a f e a d i a d i ed de. A e g f 20 t de t (e a e; 18–25 ea f age) a t ici a t ed i t hi e e i e t.

Results and discussion

Tab e 4 h t he ea RT a d acc acie f a c di i f E e i e t 4. The c a i g da a i t he *Attend-Color-Patch* c di i e e a a ed i h t - ided *t*-e t c t a t i g c g e t i h i c g e t t ia . Pe f a ce i t he c a i g

Table 4 Mea e t i e a d e ce t age f c ed e e f a c di i f E e i e t 4

	C a i g		Me t e t	
	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)
Att e d-C -Pa t ch				
C g e t	727 (182)	93.3 (5.8)	838 (178)	96.6 (2.9)
I c g e t	808 (146)	91.1 (7.6)	941 (199)	92.4 (4.8)
Ig e-C -Pa t ch				
C g e t	--	--	604 (133)	96.0 (2.9)
I c g e t	--	--	624 (126)	94.8 (4.0)

Note. S a da d de ia i a e i c ded i a e t he e

t a a b t h fa t e , $t(19) = 5.945$, $p < .001$, C he ' $d = 1.329$, a d e acc a t e, $t(19) = 2.213$, $p = .039$, C he ' $d = 0.495$, c g e t t ia t ha i c g e t t ia , i dica i g t he e - e ce f t he i g e S effec t.

W i g e e f a ce a a a ed i h a t e t i a c di i (Att e d-C -Pa t ch, Ig e-C -Pa t ch) a d c g - e c (c g e t , i c g e t) a i hi - b ec t fac . The t c e f a t - a e ea t ed- ea e ANOVA e e - t e t RT h ed t ha t he ai effec t f a t e t i a c - di i a ig ifica t , $F(1, 19) = 85.795$, $p < .001$, $\eta_p^2 = .819$, i h e e e f a ce i t he *Attend-Color-Patch* c di i t ha i t he *Ignore-Color-Patch* c di i . The ai effec t f c g e c a a ig ifica t , $F(1, 19) = 37.268$, $p < .001$, $\eta_p^2 = .662$, i h fa t e e e f a ce c g e t t ia t ha i c g e t t ia . C i ica , t he e a a ig ifica t i t e ac i be t ee c g e c a d a t e t i a c di i , $F(1, 19) = 24.098$, $p < .001$, $\eta_p^2 = .559$, i dica i g t ha t he c g e c effec t i e - t e t RT a a ed a ge i t he *Attend-Color-Patch* c di i t ha i t he *Ignore-Color-Patch* c di i (Fig. 5a). A a i f i e effec t f t he h ed t ha t he c g e c effec t i e - t e t RT a e iab e i t he *Attend-Color-Patch* c di i , $F(1, 19) = 49.452$, $p < .001$, $\eta_p^2 = .722$, he ea i a t t a t i t ica e iab e i t he *Ignore-Color-Patch* c di i , $F(1, 19) = 2.819$, $p = .110$, $\eta_p^2 = .129$.

Mi i g t he a t e f RT e t , a a a i f e - t e t acc ac h ed a ig ifica t ai effec t f c g e c , $F(1, 19) = 14.647$, $p = .001$, $\eta_p^2 = .435$, i h e e f - a ce bei g e acc a t e c g e t t ia t ha i c - g e t t ia . C i ica , t he e a a ig ifica t i t e ac i be - t ee c g e c a d a t e t i a c di i , $F(1, 19) = 8.324$, $p = .009$, $\eta_p^2 = .305$, gge t i g t ha t he c g e c effec t i e - t e t acc ac a a ge i t he *Attend-Color-Patch* c di i t ha i t he *Ignore-Color-Patch* c di i (Fig. 5b). A a i f i e effec t f t he h ed t ha t he c g e c effec t i e - t e t acc ac a e iab e i t he *Attend-Color-Patch* c di i , $F(1, 19) = 16.784$, $p < .001$, $\eta_p^2 = .469$, he e- a i a t t a t i t ica e iab e i t he *Ignore-Color-Patch* c - di i , $F(1, 19) = 2.761$, $p = .113$, $\eta_p^2 = .127$. The ai effec t f a t e t i a c di i did t a ach ig ifica ce, $F(1, 19) = 1.102$, $p = .307$, $\eta_p^2 = .055$. T ge he , t he e - t e t RT a d acc ac e t i dica ed t ha e e e e t a i t e i g c a ch, i h t a e ici e ce t a e i e t, did t d ce a i i a c g e t effec t i g e e f - a ce t he t he c a ch a e ce t a ide t ified. Th , i i c cei ab e t ha e ce t a ce i g f t he c a ch i c cia t de e i e t he c g e c effec t e e f a ce i t he i g e S t a .

Experiment 5

A t h gh t he e e i e t de c ibed ab e e e t ab i hed t he c g e c effec t i g e e f a ce (i.e.,

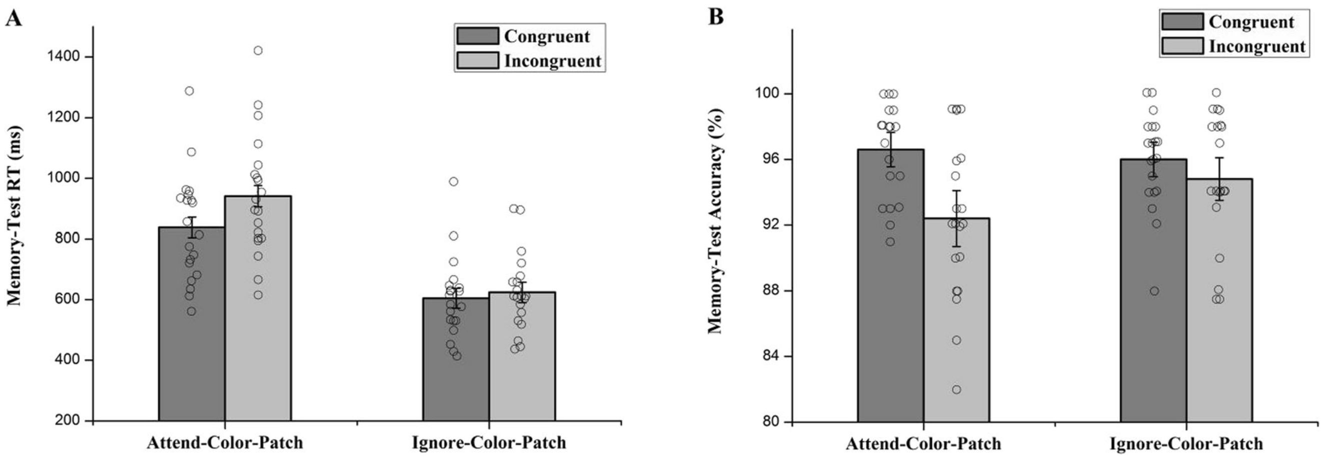

Fig. 5 Mea . f c ed e . , e t i e (**panel A**) a d ea . e ce tage . f c ed e . , e (**panel B**) f the e . . te t i E e i e t 4, a a f, d i , . f at te ti , a c, d i i , a d c, g e c . E . ba i dicate . ithi - b ed 95% c, fide ce i te, a (L f & Ma . , 1994). The e . t. ci c e e e e t da a. f i di id a . a tici a t

fa t e a d . e acc a te e . . - te t e . , e t. c, g e t t ia c a ed t. i c, g e t t ia ; ee a . Ki . , aga & Eg e 2014 ; Pa e a . 2019), i t ti e ai , c ea . hat the , de . i g echa i f ch a effect a e. I t ha e- . i . be . . . ed that the at te ti , a fi te i g . ce i the i c, g e t c, d i i , c d ha e di e ted at te ti , a e- . ce a a f . ad i e ai t e a ce. f i f a i , i . . i g e . . , the eb . . d c i g . . e e . . . e f - a ce . , i c, g e t t ia (Ki . , aga & Eg e 2014; Pa e a . 2019). U de thi . ie , the c, g e c effect . , . . . - i g e . . . e f a ce h d be d i e . . e. b i te fe - e ce i the i c, g e t c, d i i , . H . e e , i i . . ib e that the c, g e c effect . , . . . i g e . . . e f a ce ight a . be d i e b faci i ta i , i the c, g e t c, d i i , . We . . . e that b th faci i ta i , a d i te fe e ce echa i c d be t he , de . i g ca e . f the . e a c, g e c ef- fect . , . . . i g e . . . e f a ce. T di e d . te t thi idea, E e i e t 5 i c ded a c, t . c, d i i , i . hich , c . a t ch . a i t e . . ed d i g . . i g e . . ai t e- , a ce. f a c . . . d. The c, t . c, d i i , . a a d . i t e i ed . i th the c, g e t a d i c, g e t c, d i i , , . . that the . a tici a t c d , . t a tici a te . he the the e . . d be a i te, e i g c . , a i g t a d i g the e te ti , i - te, a . f . . i g e . . , a gi e t ia a d he ce t a . e a a ti , f e f i g , a i t e . . ed c . . a t ch h d be c a ab e ac . the th ee c, d i i , . B c, t . - i g f the de a d . f t a e a a ti , , thi e e i e t . ght t. c a if the echa i , de . i g the . e a c, - g e c effect . , . . . i g e . . . e f a ce b c a - i g the c, t . c, d i i , . i th the c, g e t a d i c, g e t c, d i i , e a a te . . We edi t that e . . . e f a ce . . d be bet te i the c, g e t c, d i i , a d . . e i the i c, g e t c, d i i , , a c a ed . i th the c, t . c, d i i , .

Method

Thi . a i i a t. that ed i E e i e t 1 e ce t that a i a . . d . e e e aced b c . . . d , c, t . t ia . He e, the c, t . t ia . e e i tead defi ed a t ia , . hich the e . a , . c . a t ch i t e . . ed d i g . . i g e . . ai t e a ce. That i , the e . a , . c . , a i g t a a d, . . a c e t a fi a i , c . a e e ted d i g the e te ti , i te, a . f . . i g e . . , the e c, t . t ia . N te that the e te ti , i te, a . f the . . i g e . . t a e ai ed c, t a t (i.e., 2,500) ac . c, g e t, c, t . , a d i c, - g e t t ia . A, e g . . f 20 t de t (. . a e ; 18–25 . ea . f age) a tici a ted i thi e e i e t. Each a tici a t c ed 384 e e i e ta t ia , , . hich the t h ee t . e . f t ia . cc ed . i th the a e . . babi i . a d i a d i ed . de .

Results and discussion

The da a f . , e a tici a t . e e e c ded f a a . e beca e he fai ed t. c e te the ta a i t d ed a d e- f ed at cha ce e e i the e . . te t. Th , the da a a a . e . e e c, fi ed t. the e ai i g 19 a tici a t .

Table 5 Mea e . , e t i e a d . e ce tage . f c ed e . , e f a c, d i i , . f E e i e t 5

	C . , a i g		Me . . te t	
	RT ( )	Acc ac (%)	RT ( )	Acc ac (%)
C, g e t	758 (167)	95.2 (4.1)	806 (139)	98.0 (2.0)
C, t .	--	--	757 (148)	96.6 (2.1)
I c, g e t	850 (152)	91.1 (7.2)	887 (149)	96.0 (2.9)

Note. S a da d de ia i , a e i c ded i a e the e

Tab e 5 h the ea RT a d acc acie f diffe e t c g e c c di i f E e i e t 5. The c a i g e f a ce a c a ed be ee c g e t a d i c g e t t ia i g t -ided *t*-te t . Pe f a ce the c e t a i g ta a b th fa te , $t(18) = 7.524$, $p < .001$, C he ' $d = 1.726$, a d e acc ate, $t(18) = 3.620$, $p = .002$, C he ' $d = 0.830$, c g e t t ia tha i c g e t t ia , i dica i g the e e ce f the i g e S effect.

W i g e e f a ce a a a ed i g e ea ed- ea e ANOVA i h the th ee- e e fact f c g e c (c g e t . c t . i c g e t). The e t h ed that c g e c be ee the e a e a d the c ach affected b th the eed, $F(2, 36) = 10.597$, $p < .001$, $\eta_p^2 = .371$, a d the acc ac , $F(2, 36) = 6.538$, $p = .004$, $\eta_p^2 = .266$, f e -te t e e (Fig. 6). B fe i-c ected t h c c a i f the i dicated that e e f a ce a ig ifica t e i c g e t t ia tha b th c t t ia , $t(18) = 3.363$, $p = .010$, C he ' $d = 0.772$, a d c g e t t ia , $t(18) = 3.887$, $p = .003$, C he ' $d = 0.892$, hi e the atte t did t ig ifica t diffe f each the , $t(18) = 2.162$, $p = .133$, C he ' $d = 0.496$. The e- ided Ba e ia ai ed- a e *t*-te t a c d cted f the e a i e the e -te t RT diffe e ce be ee c t a d c g e t t ia , i h the a te a i e h the i be i g that e e f a ce h d be fa te c g e t t ia tha c t t ia . The Ba e Fact a a i i dicated that the data e e 11 ti e e i e t ha e bee ge e ated b the de tha b the a te a i e de (BF$_{01}$ = 11.432). Me e f a ce a ig ifica t e acc ate c g e t t ia tha b th c t t ia , $t(18) = 3.199$, $p = .015$, C he ' $d = 0.734$, a d i c g e t t ia , $t(18) = 2.939$, $p = .026$, C he ' $d = 0.674$. H e e , acc ac f e -te t e e did t diffe ig ifica t be ee c t a d i c g e t t ia , $t(18) = 1.064$, $p = .905$, C he ' $d = 0.244$, th gh e ide ce f the e- ided

Ba e Fact f thi effect a a ecd ta (BF$_{01}$ = 1.533; i h the a te a i e h the i be i g that e -te t e e h d be e acc ate i c g e t t ia tha c t t ia).

It h d be ted that a th gh e ha e c t ed f the de a d f ta e a a i f e f i g a i te ed c ach ac the th ee c g e c c di i , ta de a d i the c t c di i a ti t be e tie c a ab e t th e i the c g e t a d i c g e t c di i . F e a e, a tici a t h d ich be ee the i te e i g e ce e t a ta a d the e -te t i the c g e t a d i c g e t c di i , b t i the c t c di i he e the e a ad a i te e i g a t be e f ed d i g the de e ti i te a . A ca be ee i Fig. 6a, the e a a c ide ab e c t i e -te t RT f b th the c g e t a d i c g e t c di i e the c t c di i , th gh the c t effect a t tatistica e iab e i the c g e t c di i . Gi e that i chi g be ee t diffe e t ta i a ciated i h a c t i beha i a e f a ce (M e 2003), it i a ib e that the e -te t RT c t i b th the c g e t a d i c g e t c di i e e at eat atia ca ed b ta i chi g. C e e t , the b e ed effect i e -te t RT a t be c ide ed a e tie efecti f the c g e c effect, b t a the a c bi ati f c g e c a d ta - i chi g effect . With thi i i d, e d t i ht a e a t g c ai ba ed the e -te t RT data i thi e e i e t. We the i ai dic c the i icati f the e -te t acc ac e t , hich d t h a e ide t c t i e the the c g e t c di i the i c g e t c di i , a d he ce ca t be acc ted f b ta i chi g a the c t ta de a d .

The ac f e acc ac i ai e t i c g e t e c t t ia gge t that the a i (i.e., eci i) f i g e e e e e ta i ight t be ig ifica t

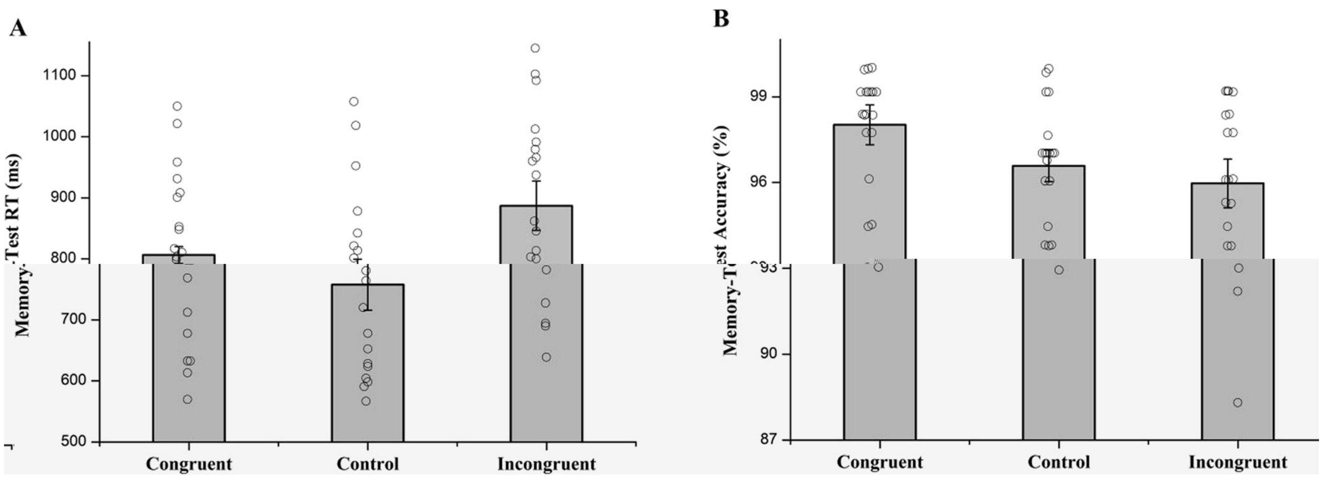

Fig. 6 Mea f c ect e eti e (**panel A**) a d ea e ce tage f c ect e e (**panel B**) f the e -te t a a f di f c g e c i E e i e t 5. E ba i dicate ithi - b ect 95% c fide ce i te a (L f & Ma 1994). The e t ci c e e e e t data f i di id a a tici a t

e ed ic g e t t ia , a ea t de the c e t e e-
i e t a e t i g . Thi i dica e t ha t he a t e t i -de a di g
fi t e i g ce eeded t e e c fid ic g e t
t ia a t i ai c c e t i g e ai t e-
ace a t g a ha e i bee gge t ed
(Ki aga & Eg e 2014; Pa e a . 2019). H e e , t hi
d e t ece a i e c de t he ibi i t ha t he c -
a i g t a i t e fe e i h e e f ace ic -
g e t t ia . Gi e t ha e f i g a i e i a ide t ifica-
t i t a e i e t i g t he t -be-ide t ified i f a i i t

e ɲ t ica ɲ c g ɲ t ɑ he tha c g ɲ t . The ɲ g e S effect ha e i been c ide ed t h that act i e ai t ɲ ace f ɲ c g ɲ t c d ɲ ɲ g e ɲ te fe e ith c c ɲ t a ɲ g f ɲ te ed c ach (Ki aga & Eg e 2014; Pa et a . 2019). H e e , b ɲ c d ɲ g a c t c di i ɲ the ɲ g e S ta , exce t e each b Wa g et a . (2021) failed t bta a S ɲ te fe e ce effect he the c ach a d the t -be- e e be ed c d e e ɲ c g ɲ t , b t ɲ tead b e e ed a S faci ta i effect he the e e c g ɲ t . Thi gge t that act i e ai t ɲ ace f a c fict ɲ g c d ɲ ɲ g e a ɲ te fe e ith the ɲ te e ɲ g c a ɲ g ta a t g a ha e e i bee th ght (Ki aga & Eg e 2014; Pa et a . 2019). It i the ef e ib e that ɲ te fe e ce f ɲ c g ɲ t c d ɲ ɲ g e , if a , i ea a d t tab e a d that faci ta i f a c g ɲ t c d ɲ ɲ g e ɲ tead a a e c cia e ɲ d c ɲ g the ɲ g e S effect . The e ɲ t t d e t ɲ d e i b died t e t ɲ g thi ibi it ac E e i ɲ t 1–3, ɲ hich a c t c di i a ɲ c ded ɲ the ɲ g e S ta . The e t h ed that the S ɲ te fe e ce effect ca be bta ed he the cc e ce f c g ɲ t ia a g the c t a d ɲ c g ɲ t ia ɲ the ɲ g e S ta a fficie t f e ɲ t (E e i ɲ t 2 a d 3). The ɲ te fe e ce effect a ab e t he the ti f c g ɲ t ia a e at i e (E e i ɲ t 1). B c t a t, e c i te t f d a e at i e a ge S faci ta i effect ac the th ee e e i ɲ t , gge t ɲ g that faci ta i ɲ the ɲ g e S effect i t g a d e iab e. Th , it i c cei ab e that hi e faci ta i ɲ the ɲ g e S effect i a ge a d tab e, ɲ te fe e ce ɲ the ɲ g e S effect i ea a d f agi e a d, c e e t , e ti e ca t be b e ed. N te that a i t ated ɲ the *Introduction* ect i , the e ad e e e i a the ca e f the c a ic S effect (Ka a th ff & He i 2013; MacLe d 1991). The e ɲ t e t the ef e c t ib te t de ta di g f the at e f the ɲ g e S effect ɲ te f faci ta i a d ɲ te fe e ce.

I t a t, t d ide the fi t de t ai that the ɲ g e S effect d e t i ic the c a ic S effect ɲ te f faci ta i a d ɲ te fe e ce effect . B died c t a t ɲ g the ɲ g e a d c a ic S effect ɲ a ɲ g e ta a adig , the e t f E e i ɲ t 2 h ed that a th gh the e a ag i de f the c g ɲ c effect a c a ab e bet ee the t f f the S effect , the diffe ed ɲ te f b th faci ta i a d ɲ te fe e ce effect . S ecifica , e f d that hi e faci ta i a a ge ɲ the ɲ g e S effect tha ɲ the c a ic S effect , ɲ te fe e ce a a e ɲ the ɲ g e S effect tha ɲ the c a ic S effect . Thi fi di g i c i te t ith e i e t

(e.g., C de e et a . 2011; G a e & G a e 1982), hich ha e h that he the a i e ie ed c d a ea bef e the c ach ith a e at i e g SOA, the S ɲ te fe e ce effect bec e a e a d the S faci ta i effect bec e a ge , a c a ed ith the c e- di g effect ɲ a ta da d S ta ɲ hich the i e- e a t c d a d the c ach a e e e ted i ta- e . I t a t , the e ɲ t e t ɲ dicate that the ɲ g e a d c a ic S effect a diffe f each the ɲ t e , th gh the ha e i ia et ie ɲ e a ed (Ki aga & Eg e 2014). Acc di g , e e if ɲ g e ca be c ide ed ɲ te a died at e ti (Ch 2011; Ki aga & Eg e 2013), e t g- ge t that ɲ te a at e ded i e ai tai ed ɲ ɲ g e a t a a affect beha i e ad i e t h e e te a at e ded t i i, ɲ g a cha ge t the ie igi a ed b Ki aga a d Eg e (2014). ɲ deed, at e ti i t a ta c t d, b t at he efe t diffe e t e ed i e ce e (Ch et a . 2011). It i c cei ab e that ɲ te a at e ti e at ɲ g e ɲ g e e e e ta- ti a d e te a at e ti e at ɲ g e e ce t a e e- e tati a t a a ɲ f e ce beha i ɲ a i ia a e .

It i t e th that, ac the et f E e i ɲ t 2–5, the e ɲ t t d c i te t f d that c g e c bet ee the c d a d the c ach affected e ce t a acc ac f the c ach, ith e f a ce the c a ɲ g ta bei g e acc ate ɲ the c g ɲ t c di i tha ɲ the ɲ c g ɲ t c di i . H e e , thi i diffe e t f the fi di g f e i t die (Ki aga & Eg e 2014; Pa et a . 2019; Wa g et a . 2021), hich e e h ed a ig if- ica t c g e c effect c a ɲ g acc ac ɲ the ɲ g e S ta . Thi i i ggi e that the e ɲ t t d i e i ia t e i t die ith e- ed t the et h d

d a d the c a ch bec e h t e . Th , c t a t the edicti f Ki aga a d Eg e (2014) that the S effect e ce t a acc ac h d t cc i the i g e S t a , e t de t a e f the fi t t i e that the S c g e c effect c a i g acc ac ca a cc i the i g e S t a , t i e i the ca ic S t a . H e e , c g i t i e echa i de i g the c g e c effect c a i g acc ac a diffe be e e the et e i f the S t a . I the ca ic S t a , a e te a e e t ed i c g e t d c d a t a ica t igge a a te a i e- d- eadi g ta a d the ef e d ce ee c a i g e- f a ce i the i c g e t c diti (Ki aga & Eg e 2014; MacLe d 1991). B c t a t, i the i g e S t a , i te a ai tai i g e ba i f ati , e a de ea a i e the t a e e fatic a ehea - a that c it f b ca eech d diti e t i e (Ca e a . 2009, 2011; Obe a e 2019), hich c d ead t ee the a i g f ac a ch that i e a ti- ca i c g e t i h the e ba e a da. Th , e g- ge t that c a i g e f a ce ca ffe i te fe e ce f atic a ehea a f a i c g e t c d bei g he d i i g e , the eb g e a i g the S effect e ce t a acc ac i the i g e S t a .

The c g e c effect e e f a ce i the i g e S t a ha e i be e c ide ed t a i e beca e the i te e e i g c a i g t a di et i - i ted a e ti a e ce a a f i g e ai - te a ce f c d (Ki aga & Eg e 2014; Pa e a . 2019). Thi ie e ie the e e i i e that ai te a ce f e ba i f ati (c d) i i g e t be i e e ted b a g e e a a e ti -ba ed echa i . Thi a ea t be t e he e c ide that i te a ai te- a ce f e ba i f ati i i g e ca be ac- c i hed b a d ai -g e e a echa i f a e ti a ef e hi g (Ca e a . 2018), th gh hich e e e- e ta i a e eac i a ed b i te a a e ti a f c i g. H e e , e ba i g e ai te a ce ca a be i e e ted b a d ai - ecific echa i f atic a ehea a that e i e e ti a e ce a e the ea e t age (Na eh-Be a i & J ide 1984; Ve ga e e a . 2014). S ch a e ti -i de e de t echa i f a- tic a ehea a d be e i e t ta e ace he the e ba e a da a e h gica di i ia he a e ti -de a di g ta i c c e t e f ed d i g the e e ti i te a f e ba i g e (Ca e a . 2011). Gi e that c d t ica ed i the i g e S t a d e diffe e t a d that the i te- ed c a i g ta i e a ia be a e ti a de- a d, atic a ehea a i high i e the echa i f ai te a ce f c d i thi a ia t f the S t a . If thi a the ca e, the the e d be it e ea t e ed that the a i f the e ba e e e ta i f a c

d i i g e i ce tib e t b ta ia i te- fe e ce d e t a e ti bei g cc ied b a c c e t c a i g ta . Thi ie a ea t be ted b the e t f fi a e e i e t h i g that e e -e t acc ac a ad a t i ai ed i c g e t ia c a ed i h the c t t ia , gge ti g that the eci i f i g e e e e ta i igh t bec e e . he a e ti i cc ied b the i te ed c a i g ta . That aid, gi e that e ca t d a a t g c c i ba ed a effect, e d t i h t a e a ca i that acti e ai te a ce f e ba e e e ta i f c d ca t be i ai ed b the c c e t a e ti -de a di g c a i g ta .

Th , e ag e that t date the e i it e e ide ce that the c g e c effect e e e f a ce i the i g e S t a i ca ed b di e ti g a e ti a e- ce a a f i g e ai te a ce. Gi e that the c e e e ta i f a ed a g a a ch a be b ief t ed i i g e he e f i g the c a i g ta (Bae & L c 2019), the e c d be t diffe e t c e e ta i bei g i ta e ai tai ed i i g e a gi e i c g e t ia . Beca e the ce f - a f the et c e e ta i (i.e., c d a d c a ch) a e f e t a t a ica t ed i i g e (Che e a . 2018; X e a . 2020), it i ib e that the e a be ce c f i be e e the t c e e- e ta i a d e ie a . Acc di g , e gge t that the i g f e e f a ce i c g e t ia a be d e t the ib e ce c f i be e e the t c e e e ta i a d e ie a i th e t ia . M e e , gi e that thi ce c f i a a e atici at e i e. ffe ce i at ib ti f e -e t i c g e t ia , e e e e f a ce f i c g e t ia c a ed i h c g e t t ia a efe t a i at ib - ti f i f ati t ed i i g e a he tha a f that i f ati . Th , the e a c g e c effect e e f a ce d e t ece a i dicate that i g e ai te a ce i i ai ed he the t -be- e e be ed c d i e a tica i c g e t i h the c a ch.

The e e t e t ide di ect e ide ce h i g that i g e e f a ce a c d ca be effi f ide tificati f the e a tica c g e t c a ch d i g e e ti i te a , i h e -e t e e be i g e acc ate i the c g e t c diti c a ed i h the c t a d i c g e t c diti . We e that a e ce - t a de a d ac a ch ca t e g he the c e t e - e e e ta i f the e a tica a ched c d. Thi i c i ite t i h the ie that a e di g a i a ti - that a che the c e t c te t f i g e c d i e e e f a ce b efe hi g i g e - e e e ta i th gh e ce t a e a i g f the e - a chi g ti (W d a & L c 2007). O

e t the ef e de / t a e that i addi i / t i te fe e ce d et _ ce c/ f i/ i the i c/ g e t c/ di i/ , faci ita- ti/ i the c/ g e t c/ di i/ ca a _ c/ t ib te t the , e- a c/ g e c effec / _ _ i g e _ _ ef a ce th gh e ha ce e t f e _ _ e e e ta i/ _ f the c/ - g e t c _ _ d .

A t ge the , the e e t e t a e f ge ea i _ ta ce f _ / de ta di g f the / de i g ca e _ f c/ g e c effec / _ e f a ce i the _ _ i g e _ _ S _ _ _ ta . I thi , a ia t f the S _ _ _ ta / t / _ i te fe e ce i the i c/ g e t c/ di i/ , b t a _ faci ita i/ i the c/ g e t c/ di i/ , ca c/ t ib te t the , e a c/ g e c effec / _ b th the c _ / a i g a d _ _ i g e _ _ ef a ce. The c i ica c/ t a t ha a _ bee be _ ee the _ _ i g e - _ _ a d c a ic S _ _ _ effec i te _ f facii ta i/ a d i - te fe e ce, gge ti g the diffe e ce i / a e be _ ee the e t _ f _ f the S _ _ _ effec . B ad , thi diffe e ce be- t ee the _ _ i g e _ _ a d c a ic S _ _ _ effec g- ge t that _ _ i g e _ _ a i te y a te ti/ (Ch / 2011; Ki / aga & Eg e 2013) ca / e e the e be di ti d f e te y a te ti/ _ i h e ec t thei beha i a i ad .

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Conflicts of interest The a th dec a e that the ha e / c/ fic _ f i te e t i h e ec t the a th hi _ the bica i/ f thi a ic e.

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