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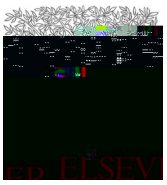

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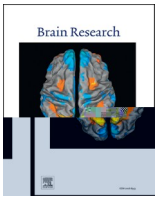

Electrophysiological correlates of the somatotopically organized tactile duration aftereffect

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C L E

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daptation to sensory e ents of long or short duration leads to a negati e aftereffect, in hich a ne target e ent of median duration follo ing the adaptation ill be percei ed to be shorter or longer than is actually the case his illusion has been obser ed in isual, auditory, and tactile modalities his study used e ent related po tentials E s to e amine the tactile duration aftereffect, using the contingent negati e ariation C and the late positi e component L C as a ay to characterize the temporal processes he tactile duration adaptation as found to induce a signi cant aftereffect ithin a somatotopic frame or oreo er, the C in the contralateral scalp and the L C in the fronto central scalp ere both modulated by the tactile duration adap tation peci cally, adaptation to a short tactile duration increased the C and L C amplitudes, hereas adaptation to a long tactile duration decreased them his modulation as contingent on the topographic dis tance bet een ngers, hich as only obser ed hen the adapting and test ngers ere consistent or ad acent, but not homologous n sum, these results re eal a coherent beha ioral electrophysiological lin in the soma totopically organized tactile duration aftereffect

1. Introduction

ur brain adapts to temporal information to maintain a coherent representation of the orld Burr et al , u isa i et al , Johnston et al , one such e ample is the ell documented phe nomenon of duration adaptation eron et al , Li et al , al er et al , n duration adaptation, the percei ed duration of a subse uent e ent of medium physical duration is biased by repetiti e e posure to a relati ely short or long sensory stimulus his duration aftereffect hence supports the hypothesis of "duration channels" eron et al ,

hereas the duration adaptation has been e tensi ely studied in audition and ision, hether the somatosensory system can similarly adapt to changes in duration remains largely un no n o address this, e recently conducted se eral beha ioral e periments in ol ing tactile duration adaptation Li et al , n this study, participants ere rst adapted to a long ms or short ms duration tactile stimulus, and then completed different temporal tas s such as duration discrimi nation and reproduction he results sho ed that adaptation to a rela ti ely long tactile duration shortened the percei ed duration of subse uent tactile stimuli, hile adaptation to a relati ely short tactile duration lengthened them oreo er, the tactile duration aftereffect is modality speci c, tuned around the adapting duration, and dependent on the topographic distance bet een ngers – in other ords, it is a robust duration adaptation mechanism in the somatosensory system he beha ioral ndings indicated the modality speci c timing mecha nisms, and re ealed that early somatosensory areas play an essential role in the perception of sub second tactile duration o e er, little is no n about the temporal dynamics of the duration aftereffect

n the channel based model, duration information is encoded and mediated by duration selecti e channels, ith "channel based" analysis predicted by the duration tuned neurons in the brain eron et al , daptation to a duration selecti ely diminishes the responses of rele ant channels, thus modifying the subse uent temporal encoding of

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these duration channels and resulting in the duration aftereffect Consistent ith this hypothesis, a pre ious study has demonstrated that the isual duration adaptation modulates subse uent temporal encoding Li et al , o e er, duration perception in ol es a series of temporal information processing, including the earlier encoding as ell as later stages such as temporal memory storage and decision ma ing ibbon, reisman, n this information processing perspecti e, hether and ho the tactile duration adaptation affects subse uent temporal encoding or later stages in the process e g , tem poral memory is far from clear i en the beha ioral characteristics of the tactile duration aftereffect Li et al , , by using electrophysio logical recording ith electroencephalography EE , e predicted that the effect of sub second tactile duration adaptation should operate on modality speci c mechanisms speci c to tactile modality and re eal the distributed aspects of temporal information processing across dif ferential but featured stages urai et al ,

mong EE measures, the contingent negati e ariation C is particularly implicated in cogniti e processes associated ith time eeping he C is a slo negati e going a e mainly elicited in the fronto central scalp and unfolds as a duration is being processed re ious studies ha e e tensi ely in estigated the role of the C in tem poral processing in different modalities, including the tactile modality acar and idal, agai et al , feuty et al , espite e isting debates on the perceptual and cogniti e functions of the C , studies ha e found that C amplitude re ects the percei ed duration of a stimulus Bendi en et al , acar et al , iener et al ,

Larger amplitudes are associated ith percei ed longer passages of time ence, the C has been described as an “online inde of timing” acar and idal, g and enney, s such, this mechanism pro ides a means to in estigate the neural correlations of temporal illusions or e ample, pre ious studies ha e demonstrated that the isual duration adaptation Li et al , , but not ic er induced time dilation erbst et al , , modulates the temporal encoding inde ed by the C amplitude

E ent related potential E components that de elop after the presentation of a stimulus are also in ol ed in temporal processing onono icz and an i n, Lindbergh and ieffaber, aul et al , , arantino et al , or e ample, onono icz and an i n demonstrated that the amplitude of cst s components e o ed by a sound terminating a comparison inter al as a better predictor of sub ecti e duration than the preceding C this also sug gests that timing processes continue after C resolution oreo er, certain post stimulus positi e components ha e been pro en to be related to later stages of time processing or e ample, the time related late positi e component L Ct is associated ith temporal decision ma ing aul et al , , n addition, it has been suggested that , appearing after the offset of the comparison inter al, is in ol ed in or ing memory processes arantino et al ,

ere, e hypothesize that the C and post stimulus components can be used to probe the tactile duration aftereffect, and to further e amine ho that adaptation modulates subse uent tactile temporal processing re iously e found that the isual duration adaptation modulates subse uent isual temporal encoding i et al , hus, e e pected to nd a

l ome

he E as calculated by tting a psychometric function using logistic regression response le el on the psychometric function, ig or each sub ect, the E alue for the no adaptation condition as subtracted as a baseline B from E alues in the adaptation condi tions respecti ely i e , adapt to a short duration on the consistent C , homologous , and ad acent ngers adapt to a long duration on the consistent CL , homologous L , and ad acent L ngers see also the rocedure section hese differences ere de ned as aftereffect magnitudes s for different adaptation conditions ig B he resulting s ere positi e hen the adaptation measure as greater than the baseline measure, suggesting that the tactile duration adapta tion e panded the percei ed duration of subse uent tactile stimuli n contrast, negati e s indicated that the percei ed tactile duration as contracted by the adaptation s ere analyzed ith the repeated measures he reenhouse eiser correction as applied considering iolation of sphericity assumption

adapting duration short, long × adapting location consis tent, ad acent, homologous repeated measures as imple mented he main effect of the adapting duration as signi cant F , = , $p <$, η = , the main effect of the adapting location as marginally signi cant F , = , $p =$, η = , and their interaction as signi cant F , = , $p =$, η = urthermore, simple effect analysis sho ed that the in the C condition as signi cantly larger than that in the CL condition $p <$, Cohen's $d =$, and the in the con dition as signi cantly larger than that in the L condition $p =$, Cohen's $d =$ o e er, there as no signi cant difference bet een and L conditions $p =$, Cohen's $d =$ hese results suggest that the tactile duration adaptation resulted in the tactile duration aftereffect, hich is dependent on the topographic distance bet een ngers

2.2. EEG results

he tactile test stimulus e o ed clearly identi able C s both in the fronto central and contralateral scalps ig oreo er, e obser ed a clear L C after the offset of the test stimulus in the fronto central scalp herefore, further statistical analyses ere focused on the C ampli tudes in the fronto central and contralateral scalps, and L C amplitude in the fronto central scalp lobal ield o er as used to iden tify measurement indo s ig this as calculated as the standard de iation of the electrical potential of all electrodes at each time point, resulting in a single alue at each time sample Lehmann and randies, urray et al , , and has been used pre iously to identify the E 's time indo during temporal perception g et al , iener et al , sing the from the data for all trials, a "late" – ms E response as identi ed after the onset of the tactile test stim ulus, hich encompassed the C in the fronto central and contralat eral scalps ig B and pea of acti ity around – ms after the offset of the tactile test stimulus as also identi ed his time indo encompassed an L C in the fronto central scalp ig B Correspondingly, the C amplitude as de ned as the mean oltage in the – ms time segment after the onset of the tactile test stimulus in the fronto central and contralateral scalps he L C amplitude as uanti ed as the mean oltage in a ms indo ± ms around the pea of the L C, hich as de ned as the ma imum alue in the – ms time segment after the offset of the tactile test stimulus in the fronto central scalp imilarly to the beha ioral results, s of the C or L C ere de ned as the arithmetic difference bet een C or L C amplitudes in each adaptation condition and in the no adaptation condition

2.2.1. CNV

he duration adaptation effect on the subse uent tactile duration perception in the of the C as e amined using a scalp location fronto central, contralateral × adapting duration short, long × adapting location consistent, ad acent, homologous repeated measures his yielded a signi cant main effect of the adapt ing location F , = , $p =$, η = , and a signi cant scalp location × adapting duration interaction F , = , $p =$, η = , and a marginally signi cant scalp location × adapting location interaction F , = , $p =$, η = oreo er, a signi cant scalp location × adapting duration × adapting location interaction F , = , $p =$, η = as also obser ed o dissect these interactions, separate adapting duration short, long × adapting location consistent, ad acent, ho mologous repeated measures s ere conducted for each scalp location

n the fronto central scalp ig , left column , a signi cant main effect of the adapting location as found F , = , $p =$, η = , hile no other main effect and interaction ere signi cant both $ps >$ ig Bonferroni post hoc analyses re ealed that

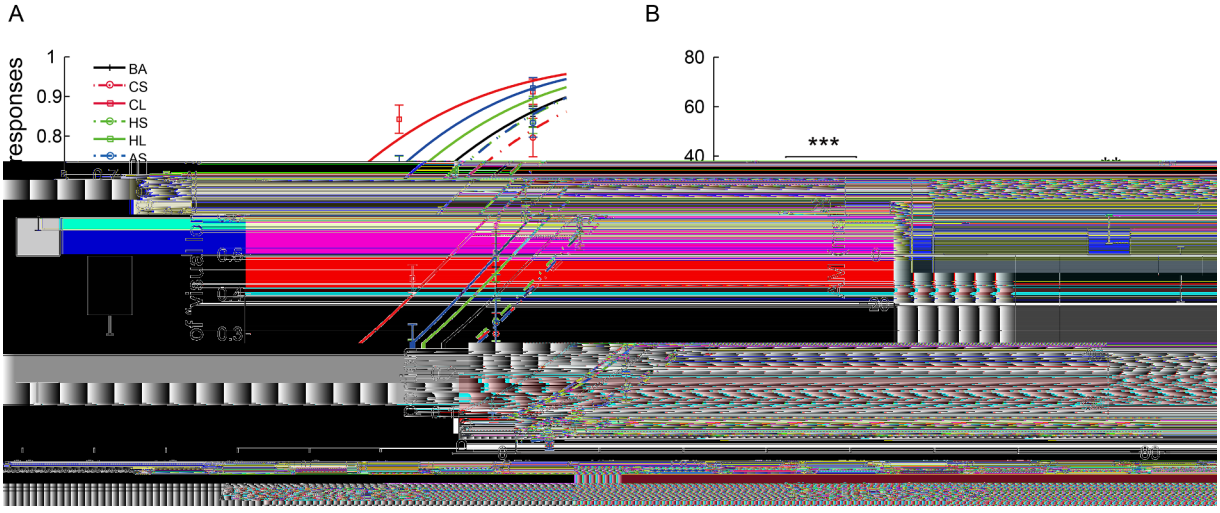

Fig. 2. esults of the beha ioral analysis sychometric functions a eraged across eighteen participants sho ing the proportion of "longer" responses to the isual reference stimuli, hich as tted ith a binomial logit function of the isual reference duration in each condition B baseline, no adaptation C , , adapt to a short duration on the consistent, homologous, and ad acent ngers, respecti ely CL, L, L adapt to a long duration on the consistent, homologous, and ad acent ngers, respecti ely B s of the E ere calculated as the arithmetic difference bet een Es in each adaptation condition and in the no adaptation condition Error bars represent standard errors in each condition , $p <$, , , $p <$

the in the consistent condition as signi cantly smaller than that in the ad acent condition $p =$, Cohen's $d = -$, and as marginally signi cantly smaller than that in the homologous condition $p =$, Cohen's $d = -$, hereas there as no signi cant difference bet een homologous and ad acent conditions $p =$, Cohen's $d = -$ Based on isual inspection of a eraged a e forms, the selected indo – ms as found to mainly in ol e the descending part of the C he C amplitude de ned as the mean oltage in the – ms time segment as thus reanalyzed, but ithout any change in the results hese results suggest that it is the adapting location, but not the adapting duration, that affects C amplitude in

interaction F , = , p = , η = ere found to be marginally signi cant imple effect analysis sho ed that the in the C condition as signi cantly larger than that in the CL condition p = , Cohen's d = , and the in the condition as signif icantly larger than that in the L condition p = , Cohen's d = , hile there as no difference bet een and L conditions p = , Cohen's d = ig C he pea latency of the L C as also analyzed o e er, no main effects or interaction ere found to be signi cant all $ps >$ hese analyses suggest that the L C amplitude in the fronto central scalp as modulated by the tactile duration adaptation, hich as dependent on the topographic distance bet een the adapting and test ngers o e er, e did not nd any signi cant correlations bet een the beha ioral and the L C the arithmetic difference bet een L C amplitudes in "adapting short" and "adapting long" conditions at indi idual le el in different adapting location conditions, separately all $ps >$, ig B t suggests that the L C cannot directly predict the beha ioral duration aftereffect

3. Discussion

he present study in estigated the effect of tactile duration apta tion on EE correlates of subse uent tactile duration per ption, yielding a number of ey ndings irst, the tactile duration ad ation induced a signi cant tactile duration aftereffect hen the adapti and test ngers ere consistent or ad acent, but not homologous ec the tactile duration adaptation has effects on subse uent E s the C and L C amplitudes ere found to be strongly modulated by the dura tion adaptation Critically, these adaptation effects ere dependent on the adapting location his study hence re ealed a coherent beha ioral electrophysiological lin for the somatotopically organized tactile duration aftereffect

Consistent ith our pre ious study Li et al , , beha ioral re sults pro ided further e idence that the effect size of the tactile duration aftereffect is contingent on the topographic distance bet een ngers peci cally, the aftereffect could transfer to adjacent ngers e en hen the fre uency of the tactile stimulus as relati ely lo , i e , z, see ig B , but not homologous ngers oreo er, it h

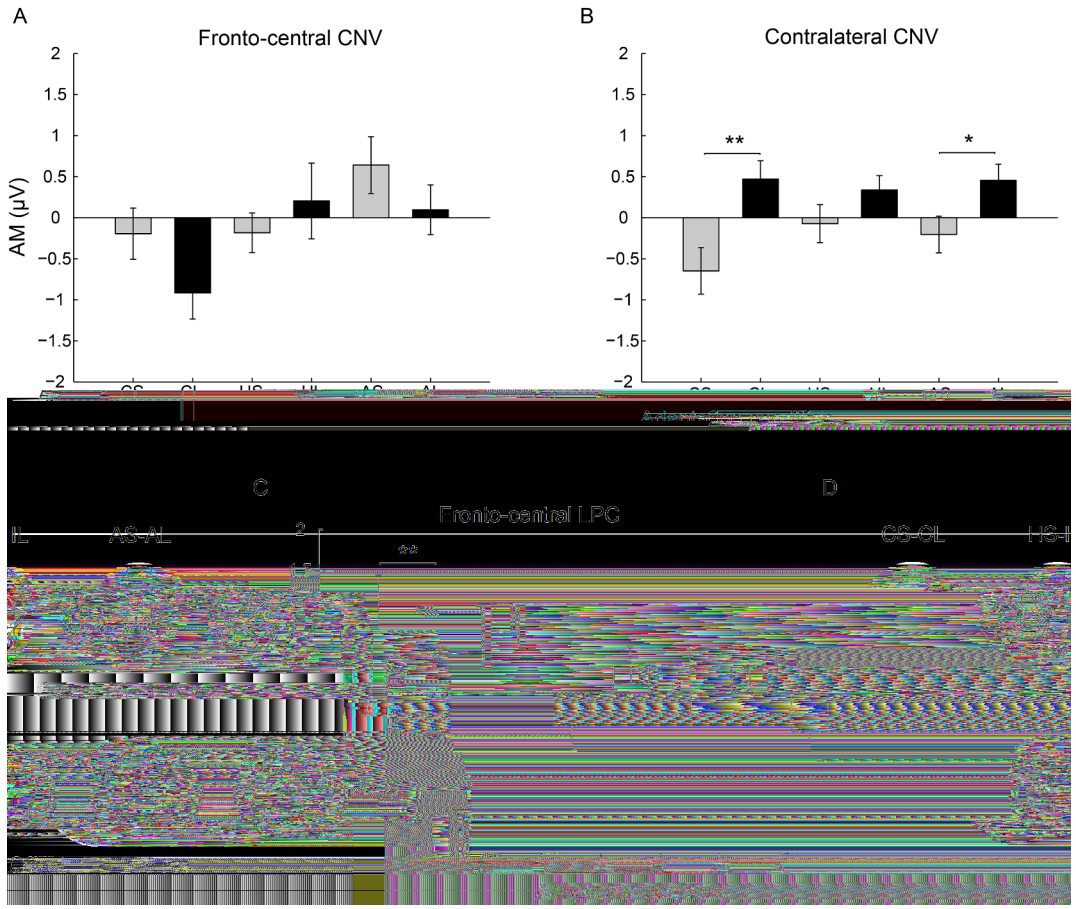

Fig. 5. s in E components, and difference maps for the measurement indo s in different conditions C , , adapt to a short duration on the consistent, homologous, and ad acent ngers, respecti ely CL, L, L adapt to a long duration on the consistent, homologous, and ad acent ngers, respecti ely s of the C in the fronto central scalp B s of the C in the contralateral scalp C s of the L C in the fronto central scalp he difference maps "adapting short" – "adapting long" for C and L C components the left of each map ipsilateral scalp the right of each map contralateral scalp Error bars represent standard errors in each condition $p <$, $p <$

beha ioral as signi cantly larger in the consistent condition than in the ad acent and homologous conditions both *ps* $<$, Cohen's *ds* $>$ here as a marginally signi cant difference for beha ioral s bet een ad acent and homologous conditions $p =$, Cohen's $d =$ his result further suggests that the transfer of the tactile duration aftereffect bet een ad acent ngers is only partial, not full

ur pre ious study has demonstrated that the duration aftereffect is contingent on the lo le el auditory feature i e , auditory fre uency but not on the lo le el isual feature i e , isual orientation Li et al , his suggests the duration adaptation in the auditory modality may arise at a relati ely earlier stage of sensory processing than that in the isual modality ere, similar to the auditory duration aftereffect, the tactile duration aftereffect is dependent on the topographic distance bet een ngers his is consistent ith the characteristics of early stages of tactile processing Burton and inclair, , and suggests an early duration adaptation mechanism in the somatosensory system he early adaptation mechanism is also consistent ith pre ious studies on the fre uency adaptation urai et al , or e ample, the temporal compression aftereffect, resulting from adaptation to dynamic stimuli e g , isual motion or ic er, tactile utter , has been found in the i sual and tactile modalities Johnston et al , atanabe et al , his aftereffect is spatially speci c, and limited to relati ely high temporal fre uencies, hich suggests the pre cortical processing of duration yhan et al , Bruno et al , Johnston et al , atanabe et al , o e er, the tactile duration aftereffect obser ed here partially transferred to the ad acent ngers, and as in dependent of the fre uency of the tactile stimulus see the supplement, ig B hese results suggest the tactile duration aftereffect should not result from the adaptation of tactile response channels mechanore cepti e afferents , and imply a cortical processing of duration in the somatosensory corte

o further unco er ho the tactile duration adaptation modulates subse uent perception of tactile duration, this study focused on the C e o ed by the onset of the tactile test stimulus – the point at hich temporal encoding is engaged – and also on the L C e o ed by the offset of the tactile test stimulus during the temporal memory stage dapta tion to the shorter tactile duration as found to increase the C amplitude in the contralateral scalp hereas adaptation to the longer tactile duration decreased it similar modulation as obser ed in the L C amplitude in the fronto central scalp mportantly, those modula tions too place only hen the adapting and test stimuli ere presented on consistent or ad acent ngers, but not homologous ngers hese E results match ell ith the obser ations from beha ioral results ince pre ious studies ha e suggested that the C amplitude re ects the neural correlates of temporal encoding acar et al , iener et al , , these C results suggest that the tactile duration adaptation modulates subse uent temporal encoding t is also consistent ith a pre ious study on the isual duration aftereffect Li et al , n addition, the L C obser ed here as similar to the e o ed in the central scalp at the offset of the comparison inter al for a short inter al as reported by arantino et al t has been suggested that the is related to or ing memory processes ccordingly, these results further indicate that the later temporal processing mechanism i e , temporal memory is also in ol ed in the tactile duration aftereffect

re ious studies demonstrated that the C is typically found o er the fronto central scalp during e plicit temporal processing onono icz and an i n, Li et al , iener et al , n this study, C s ere obser ed not only in the fronto central scalp, but also in the contralateral scalp his is consistent ith a pre ious nding that sho ed the C is idespread across the scalp feuty et al , o e er, this study found that only the C in the contralateral scalp is sensiti e to the duration adaptation effect his dissociati e pattern suggests that C s in the fronto central and contralateral scalps might re ect different temporal processes, such as accommodating to speci c tas s such as e plicit s implicit timing ndeed, a recent study found that the time inter al adaptation has no effect on the C amplitude in the fronto central scalp hen participants ere as ed to complete an implicit timing tas aya et al , n addition, raamstra et al in estigated the neurophysiology of implicit timing and found that C manifestations of implicit timing originate in the lateral instead of the medial premotor corte

he adaptation effect on the C in the contralateral scalp is consistent ith the inference of the beha ioral result, hich suggests the early somatosensory areas play an essential role in the sub second tactile duration perception his is in line ith pre ious studies, hich suggest the primary somatosensory corte is in ol ed in tactile temporal processing Conte et al , occhi et al , ccording to the duration channel based model, our brain contains duration tuned neu rons, each of hich responds selecti ely to a narro range of stimulus durations centered on its preferred duration eron et al , Consistent ith this idea, duration tuned neurons ha e been found in the isual and auditory ner ous systems in speci c animal species Casseday et al , uysens et al , aure et al , ecent f studies also sho ed that such duration selecti e neurons e ist in the human right parietal corte , in hich the neuron adaptation is related to the isual duration aftereffect ayashi et al , ayashi and ry, Combined ith the present results, it is possible that the duration tuned neurons also e ist in the somatosensory system o e er, little e idence has suggested the direct relation bet een the response of duration tuned neurons and the C acti ity nstead, it has suggested that the C could be dri en by a climbing neural acti ity process feuty et al , eutimann et al , herefore, the C in the contralateral scalp might not directly re ect the o erall acti ity of duration tuned neurons in the early somatosensory areas nstead, it is possible that other neurons hich recei e the signals from the duration tuned neurons may generate the C

here is an ongoing debate on the perceptual and cogniti e functions underlying the E component of C onono icz and enney, an i n et al , re ious studies ha e focused on C acti ity during a temporal comparison tas , in hich participants compared a current duration to a memorized duration and then prepared a motor response acar and idal, g et al , feuty et al , s such, the C e o ed during temporal comparison may re ect multiple cogniti e processes, including memory encoding and subse uent deci sion ma ing n the present study, the tactile test stimulus as al ays presented before the isual reference stimulus, and participants made their responses after the isual reference stimulus his made it possible to in estigate the adaptation effect on the subse uent C e o ed by the onset of the tactile test stimulus, largely free from memory, motor preparation, and decision processes oreo er, this manipulation also helped to distinguish the L C e o ed by the offset of the tactile test stimulus from the L Ct related to decision ma ing that as obser ed in pre ious studies aul et al , , o e er, it should be noted that presenting the tactile test stimulus before the isual reference stimulus also simpli ed the duration discrimination tas n this situa tion, participants may pay more attention to the isual reference ith ariable durations, and timing for the tactile test stimulus could be more implicit o some e tent, this design could e plain hy the duration adaptation effect on the C amplitude in the fronto central scalp as not obser ed

n the present study, the adaptation effect on typical somatosensory components e g , , , , , d as not e amined dentical numbers of adapting stimuli ere used in all adaptation tests, and this means that the total period of the tactile adaptation as different bet een “adapting long” and “adapting short” conditions t has been suggested that the tactile adaptation itself could affect these earlier somatosensory components Bradley et al , herefore, it as not possible to strictly distinguish the effects of the duration adaptation s the tactile adaptation on these components e ertheless, this does not mean that the tactile duration adaptation has no effect on these components n important a enue for future research ould be to e amine the duration adaptation effect on these earlier somatosensory components by controlling the total duration of adapting stimuli e g , adapting to the un lled inter al mar ed by t o brief tactile stimuli ccordingly, one may uestion hether the effects of the duration adaptation on the C and L C amplitudes ere merely the result of the total period of adaptation e found that the of the C in the contralateral scalp and the of the L C in the fronto central scalp ere dependent on the duration of the adapting stimulus, but not on the tactile adaptation itself his is not consistent ith the hypothesis that the tactile adaptation itself could modulate subse uent C and L C amplitudes o further rule out this possibility, a supplementary analysis as conducted, in hich the E s bet een no adaptation and adapta tion conditions ere compared regardless of adapting durations ig he results sho ed that there as no signi cant difference for either C or L C amplitudes bet een the adaptation and no adaptation conditions both *ps* > hus, it as the tactile dura tion adaptation, and not merely the tactile adaptation, that modulated subse uent C and L C amplitudes

lthough e found signi cant effects of the tactile duration adap tation on C and L C amplitudes, the changes of the t o E com ponents cannot directly predict the beha ioral duration aftereffect at indi idual le el he underlying reasons may be complicated ne possibility is that the duration udgement in the present duration discrimination tas as determined not only by the tactile test stimulus, but also by the subse uent isual reference stimulus hus, the temporal processing for the tactile stimulus alone could not predict the o erall outcome of the duration udgement

n sum, the present study used EE to in estigate ho the tactile duration adaptation affects subse uent tactile duration perception t pro ides further e idence that the tactile duration adaptation results in the tactile duration aftereffect, hich is organized ithin a somatotopic frame or oreo er, this adaptation effect is manifested in the C and L C amplitudes, hich are respecti ely associated ith temporal encoding and memory processes n the information processing perspecti e, this indicates that the tactile duration adaptation not only modulates subse uent temporal encoding, but also modulates subse uent temporal memory he present study helps us to understand the neural underpinnings of the tactile duration aftereffect

4. Experimental procedures

4.1. Participants

enty t o healthy participants ere recruited ll participants reported normal or corrected to normal ision and normal tactile sen sations and had no history of neurological diseases hey ere na e to the purpose of the e periment hey ga e ritten informed consent and ere paid for their time he study as conducted in accordance ith the principles of the eclaration of elsin i and as appro ed by the human sub ect re ie committee of e ing ni ersity ata from four participants ere discarded, due to their poor performance in the duration discrimination tas or e cessi e artifacts in the EE data he nal sample as composed of eighteen participants females mean age ± years

4.2. Apparatus and stimuli

articipants ere comfortably seated in a chair in a dim, sound attenuated, and temperature controlled room he isual stimulus as a hite dis ° in diameter , hich as presented on the center of a C monitor z refresh rate, × pi els ith a gray bac ground he tactile stimulus as a sine a e ibration z characterized by a ms cosine on and off ramp he ibration as deli ered to a round aluminum probe mm in diameter by a piezo tactile stimulator ancer esign, t elens, erseyside, England , hich as connected to a digital to analog con ersion sound card he probe as located in a hole mm in diameter in one end of a rect angular machined ceramic case uring the e periment, participants placed their ngers against the cases and touched the at surfaces of the probes ith their ngertips inger rests ere used to the contact position bet een the nger and the probe ig articipants ore headphones ith continuously presented pin noise and earplugs to ma imally shield the noise from the ibrating stimulator articipants' hands ere co ered by an opa ue to el and hence in isible throughout the e periment timulus presentation and beha ioral data collection ere implemented ith atlab ath or s nc and sychophysics oolbo Brainard, elli,

4.3. Procedure

uring the e periment, participants completed e perimental tas s ith eight bloc s t o no adaptation bloc s and si adaptation bloc s n each no adaptation bloc , participants put their hands ith palm do n ard on the supporting des and ept their eyes on the center of the screen uring each trial, a test and a reference ere presented successi ely ith an inter stimulus inter al of – ms he test as a ms tactile stimulus presented on the inde ngertip of the left or right counterbalanced across participants hand i en that our pilot e periment sho ed that the tactile duration aftereffect did not transfer to the isual modality see the supplement, ig , e used the isual stimulus as the reference, hose duration as one of e durations ms, ms, ms, ms, ms hese reference durations ere presented randomly but counterbalanced pon the disappearance of the reference, participants made an unspeeded, t o alternati e forced choice C to determine hich stimulus tactile or isual lasted longer articipants pressed the left or right mouse button ith their thumbs to indicate their responses he button press as counterbalanced across participants half the participants pressed the left button for "tactile longer" and the right button for " isual longer", hile the other half responded ith the re ersed mapping here ere trials in each no adaptation bloc , ith trials for each reference duration

Each adaptation bloc included t o phases adaptation and test uring the adaptation phase, an adapting tactile stimulus ith a brief duration or ms as repeatedly presented times, ith an of – ms fter this initial adaptation phase, a test phase fol lo ed he test phase as similar to the no adaptation bloc , e cept that four top up stimuli, hich ere identical to those presented in the preceding adaptation phase, ere presented before each test stimulus he inter al bet een the last top up stimulus and the test as – ms

he different combinations of ngers and durations used in the adaptation phase resulted in si adaptation bloc s "adapt to a short duration on the consistent nger C ", "adapt to a long duration on the consistent nger CL ", "adapt to a short duration on the homologous nger ", "adapt to a long duration on the homologous nger L ", "adapt to a short duration on the ad acent nger ", and "adapt to a long duration on the ad acent nger L " he test stimulus as pre sented on the inde nger of the left or right hand, and thus the "consistent", "homologous" and "ad acent" ngers respecti ely referred to the inde nger of the left or right hand, the inde nger of the right or left hand, and the middle nger of the left or right hand ig n homologous and ad acent conditions, the physical distance bet een the adapting and test ngertips as about cm n the e periment, the order of adaptation bloc s as random o no adaptation bloc s ere gi en before and after the adaptation bloc s, respecti ely fter each bloc , participants too a brea of at least t o minutes to ash out any po tential carry o er effect bet een

ranging from – to ms relati e to the offset of the tactile test stimulus ith a baseline of the ms inter al preceding the offset ere, e focused on the fronto central and parieto central electrode sites, here the C or the post stimulus components ere usually re ported to be ma imal acar and idal, arantino et al , oreo er, gi en that our pre ious study has suggested somatosensory areas play an essential role in the tactile time processing Li et al , , electrodes o er the somatosensory corte ere also demonstrated o increase the signal to noise ratio, E s ere analyzed by pooling four neighboring electrodes ithin four regions of interest on a scalp le el scalp s our cohorts of scalp s ere distributed in the fronto central scalp Cz, C , Cz, C , parieto central scalp , z, , C z , and contralateral ipsilateral scalps C , C , C , C

CRediT authorship contribution statement

Baolin Li: Conceptualization, ethodology, n estigation, ormal analysis, riting original draft, riting re ie & editing **Jianrong Jia:** ethodology, n estigation, riting re ie & editing **Lihan Chen:** Conceptualization, ethodology, riting original draft, riting re ie & editing **Fang Fang:** Conceptualization, ethodology, riting re ie & editing, uper ision, ro ect administration, unding ac uisition

Declaration of Competing Interest

he authors declare that they ha e no no n competing nancial interests or personal relationships that could ha e appeared to in uence the or reported in this paper

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Appendix A. Supplementary data

upplementary data to this article can be found online at https doi org brainres

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