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(973")

(2015CB351800)

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“ ” (nature-versus-nurture)

[1]

[2]

[15]

[16-19]

[20]

(1)

[21]

V4^[22]

V3A^[23-24]
FFA^[27]

MT^[25-26]

[3-4]

[28]

“

”

“

” [29-30]

[5]

()

[6]

[7]

[8]

[9]

[10]

[11]

[12]

[13]

[14]

[31-33]

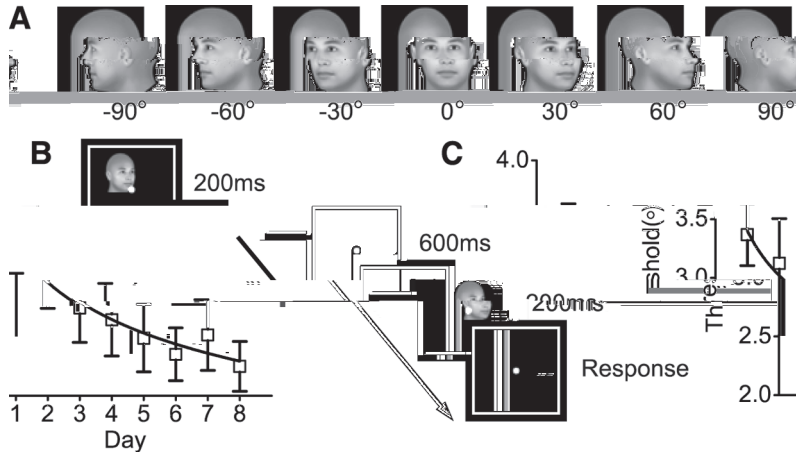
1

(LIP)

(IPS)
(ACC)

()^[34]

[32]



A

B

C

1

[21]

[35]

[36]

[17-19,42-43]

4~5 d

[44]

[38]

[19,40-41]

[39]

[45]

[46]

[37]

[31,47-49]

2

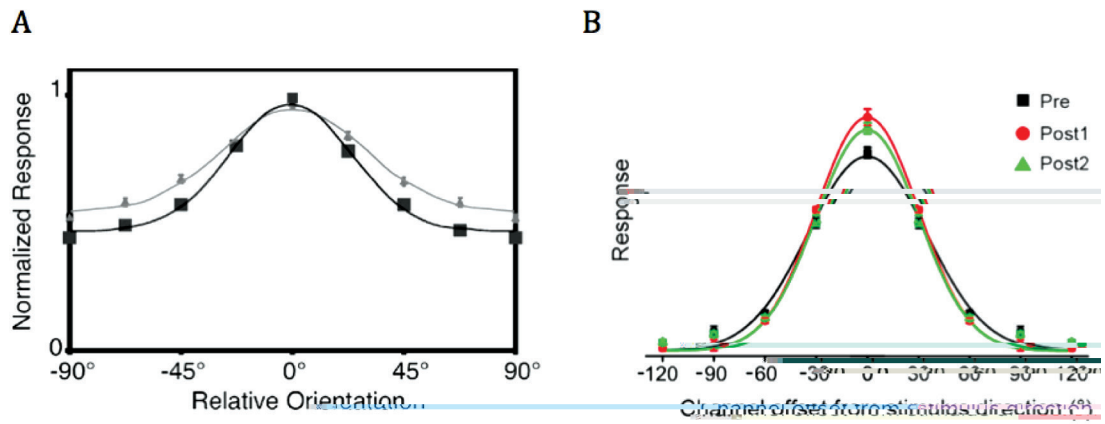
2A

V4

[22]

[40-41]

(tuning curve)



A

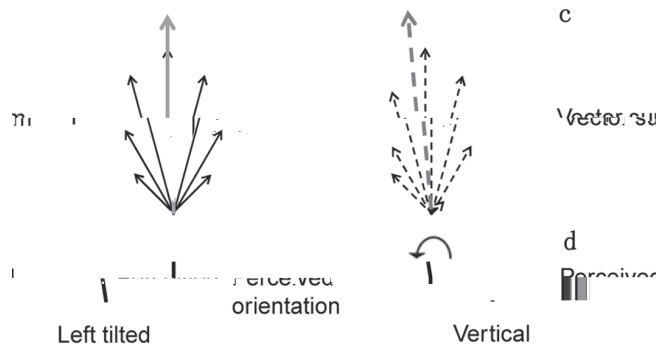
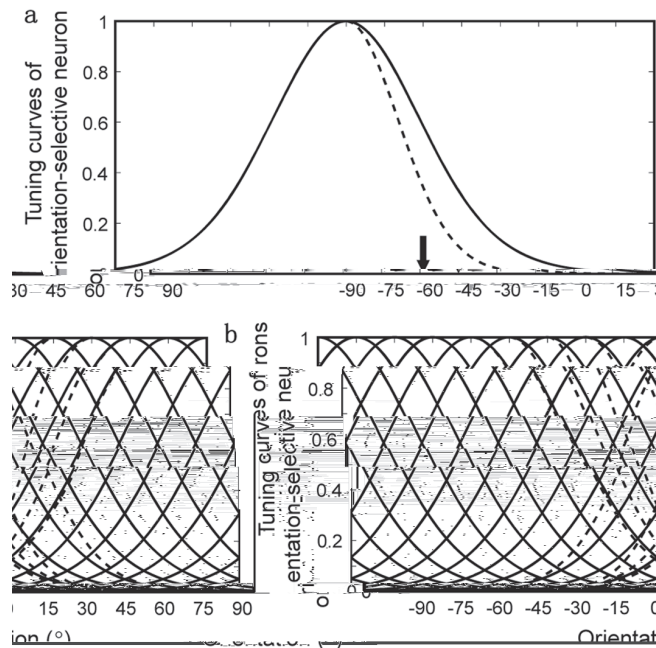
V4

[22] B

V3A

[24]

2



A

-15°

(15°)

[50]

B

A~C

D

3

[51]

(response profile)

[24]

V3A

(noise correlation)

[55-56]

(2B)

(PTM)

()

[37]

3

[50]

[51]

[57]

[58]

N170

[52]

-

[52]

2 h

-

(DTI)

[59]

4

[27]

[52]

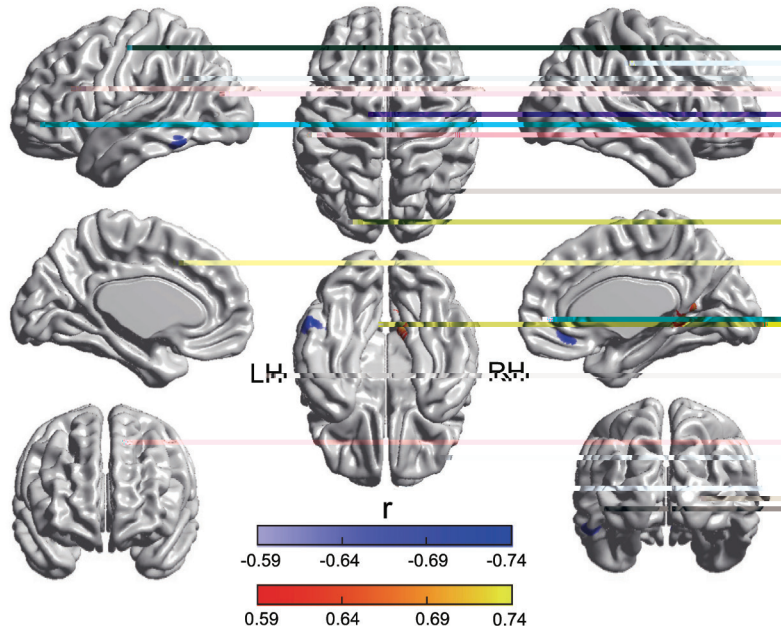
[53]

(FFA)

[27]

Fano

[54]



4

[27]

V3A MT
[61]

[67]

()

[62-63]

) TMS tDCS(

[64-65]

[68-69]

[70-71]

tDCS()
tRNS()
[66]

TMS

[]

- [1] Hubel DH, Wiesel TN. Receptive of cells in striate cortex of very young, visually inexperienced kittens. J Neurophysiol, 1963, 26: 994-1002
- [2] Wiesel TN, Hubel DH. Comparison of the effects of

unilateral and bilateral eye closure on cortical unit responses in kittens. *J Neurophysiol*, 1965, 28: 1029-40

- [3] Xu JP, He ZJ, Ooi TL. Effectively reducing sensory eye dominance with a push-pull perceptual learning protocol. *Curr Biol*, 2010, 20: 1864-8
- [4] Zhou Y, Huang C, Xu P, et al. Perceptual learning improves contrast sensitivity and visual acuity in adults with anisometropic amblyopia. *Vision Res*, 2006, 46: 739-50
- [5] Yu C, Klein SA, Levi DM. Perceptual learning in contrast discrimination and the (minimal) role of context. *J Vis*, 2004, 4: 169-82
- [6] Schoups AA, Vogels R, Orban GA. Human perceptual learning in identifying the oblique orientation: retinotopy, orientation specificity and monocularly. *J Physiol*, 1995, 483: 797-810
- [7] Ball K, Sekuler R. Direction-specific improvement in motion discrimination. *Vision Res*, 1987, 27: 953-65
- [8] Berardi N, Fiorentini A. Interhemispheric transfer of visual information in humans: spatial characteristics. *J Physiol*, 1987, 384: 633-47
- [9] Fendick M, Westheimer G. Effects of practice and the separation of test targets on foveal and peripheral stereoacuity. *Vision Res*, 1983, 23: 145-50
- [10] Fahle M, Edelman S. Long-term learning in vernier acuity: Effects of stimulus orientation, range and of feedback. *Vision Res*, 1993, 33: 397-412
- [11] Karni A, Sagi D. Where practice makes perfect in texture discrimination: evidence for primary visual cortex plasticity. *Proc Natl Acad Sci USA*, 1991, 88: 4966-70
- [12] Sigman M, Gilbert CD. Learning to find a shape. *Nat Neurosci*, 2000, 3: 264-9
- [13] Gold J, Bennett PJ, Sekuler AB. Signal but not noise changes with perceptual learning. *Nature*, 1999, 402: 176-8
- [14] Op de Beek HP, Baker CI, DiCarlo JJ, et al. Discrimination training alters the oblique, 6(V1 n9-40n0 -0Tj-2.52 -1.333 Td([52j-0.021.3-1.(1: 549-53)Tj)0.033 Tc 0.082 Tw 252 0 Td[(62ahle M, Edelman S. Long-term learning in vernier acuity. *Vision Res*, 1993, 33: 397-412
- [5P]LoS Ons -1.121.3 Te44D0[

- learning transiently changes cortical somatotopy. *Neuroimage*, 2008, 40: 1748-54
- [41] Reed A, Riley J, Carraway R, et al. Cortical map plasticity improves learning but is not necessary for improved performance. *Neuron*, 2011, 70: 121-31
- [42] Schwartz S, Maquet P, Frith C. Neural correlates of perceptual learning: a functional MRI study of visual texture discrimination. *Proc Natl Acad Sci USA*, 2002, 99: 17137-42
- [43] Bao M, Yang L, Rios C, et al. Perceptual learning increases the strength of the earliest signals in visual cortex. *J Neurosci*, 2010, 30: 15080-4
- [44] Karni A, Sagi D. The time course of learning a visual skill. *Nature*, 1993, 365: 250-2
- [45] Yamahachi H, Marik SA, McManus JN, et al. Rapid axonal sprouting and pruning accompany functional reorganization in primary visual cortex. *Neuron*, 2009, 64: 719-29
- [46] Barlow HB. Single units and sensation: a neuron doctrine for perceptual psychology. *Perception*, 1972, 1: 371-94
- [47] Jehee JF, Ling S, Swisher JD, et al. Perceptual learning selectively refines orientation representations in early visual cortex. *J Neurosci*, 2012, 32: 16747-53
- [48] Schiltz C, Bodart JM, Dubois S, et al. Neuronal mechanisms of perceptual learning: changes in human brain activity with training in orientation discrimination. *Neuroimage*, 1999, 62: 46-62
- [49] Schoups A, Vogels R, Qian N, et al. Practising orientation identification improves orientation coding in V1 neurons. *Nature*, 2001, 412: 549-53
- [50] Chen N, Fang F. Tilt aftereffect from orientation discrimination learning. *Exp Brain Res*, 2011, 215: 227-34
- [51] Yan Y, Rasch MJ, Chen M, et al. Perceptual training continuously refines neuronal population codes in primary visual cortex. *Nat Neurosci*, 2014, 17: 1380-7
- [52] Gold J, Bennett PJ, Sekuler AB. Signal but not noise changes with perceptual learning. *Nature*, 1999, 402: 176-8
- [53] Adab HZ, Vogels R. Practicing coarse orientation discrimination improves orientation signals in macaque cortical area V4. *Curr Biol*, 2011, 21: 1661-6
- [54] Gu Y, Liu S, Fetsch CR, et al. Perceptual learning reduces interneuronal correlations in macaque visual cortex. *Neuron*, 2011, 71: 750-61
- [55] Bejjanki VR, Beck JM, Lu ZL, et al. Perceptual learning as improved probabilistic inference in early sensory areas. *Nat Neurosci*, 2011, 14: 642-8
- [56] Su J, Chen C, He D, et al. Effects of face view discrimination learning on N170 latency and amplitude. *Vis Res*, 2012, 61: 125-31
- [57] Su J, Tan Q, Fang F. Neural correlates of face gender discrimination learning. *Exp Brain Res*, 2013, 225: 569-78
- [58] Sagi Y, Tavor I, Hofstetter S, et al. Learning in the fast lane: new insights into neuroplasticity. *Neuron*, 2012, 73: 1195-203
- [59] Chowdhury SA, DeAngelis GC. Fine discrimination training alters the causal contribution of macaque area MT to depth perception. *Neuron*, 2008, 60: 367-77
- [60] Cai P, Chen N, Zhou T, et al. Global versus local: double dissociation between MT+ and V3A in motion processing revealed using continuous theta burst transcranial magnetic stimulation. *Exp Brain Res*, 2014, 232: 4035-41
- [61] Walsh V, Ashbridge E, Cowey A. Cortical plasticity in perceptual learning demonstrated by transcranial magnetic stimulation. *Neuropsychologia*, 1998, 36: 363-7
- [62] Chang D, Mevorach C, Kourtzi Z, et al. Training transfers the limits on perception from parietal to ventral cortex. *Curr Biol*, 2014, 24: 1-6
- [63] Peters M, Thompson B, Merabet LB, et al. Anodal tDCS to V1 blocks visual perceptual learning consolidation. *Neuropsychologia*, 2013, 51: 1234-9
- [64] De Weerd P, Reithler J, van de Ven V, et al. Posttraining transcranial magnetic stimulation of striate cortex disrupts consolidation early in visual skill learning. *J Neurosci*, 2012, 32: 19810-8
- [65] Fertonani A, Pirulli C, Miniussi C. Random noise stimulation improves neuroplasticity in perceptual learning. *J Neurosci*, 2011, 31: 15416-23
- [66] Thompson B, Mansouri B, Koski L, et al. Brain plasticity in the adult: modulation of function in amblyopia with rTMS. *Curr Biol*, 2008, 18: 1067-71
- [67] Polat U, Ma-Naim T, Belkin M, et al. Improving vision in adult amblyopia by perceptual learning. *Proc Natl Acad Sci USA*, 2004, 101: 6692-7
- [68] Polat U, Schor C, Tong JL, et al. Training the brain to overcome the effect of aging on the human eye. *Sci Rep*, 2012, 2: 278
- [69] Shawn G, Bavelier D. Action video game modifies visual selective attention. *Nature*, 2003, 423: 534-7
- [70] Bejjanki VR, Zhang R, Li R, et al. Action video game play facilitates the development of better perceptual templates. *Proc Natl Acad Sci USA*, 2014, 111: 16961-6