Transcranial magnetic stimulation as a candidate cognitive enhancer

Eric Wassermann, MD
NIH/NINDS

General issues for cognitive enhancement

- Cognition is studied in laboratories as a set of artificially isolated processes without concern for ethological validity
- Interventions that bias brain activity in favor of one process are, *ipso facto*, likely to disadvantage another, particularly when they have networks in common
- Distinction between enhancement of learning and other cognitive functions is important

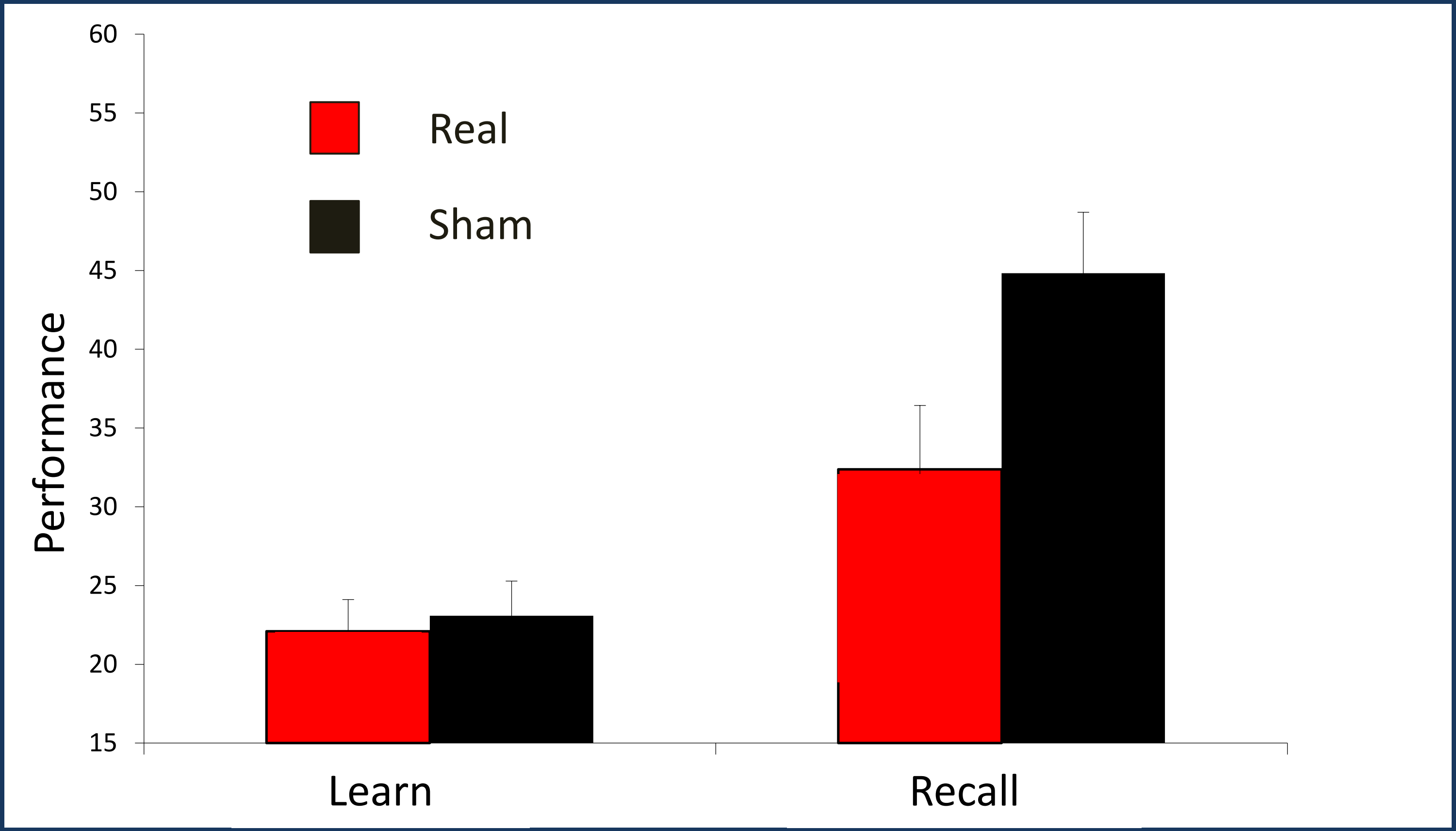
Issues specific to noninvasive brain stimulation studies

- Cognitive functions reside in networks, not spots on the cortex
- No independent confirmation of targeting in most studies
- No surrogate indicators of target “engagement”—little thought given to mechanism
- No biological evidence that deep areas can be targeted selectively, despite claims
- Little replication
- Most of these issues *far* more serious for transcranial electrical neuromodulatory techniques

Reproducible results

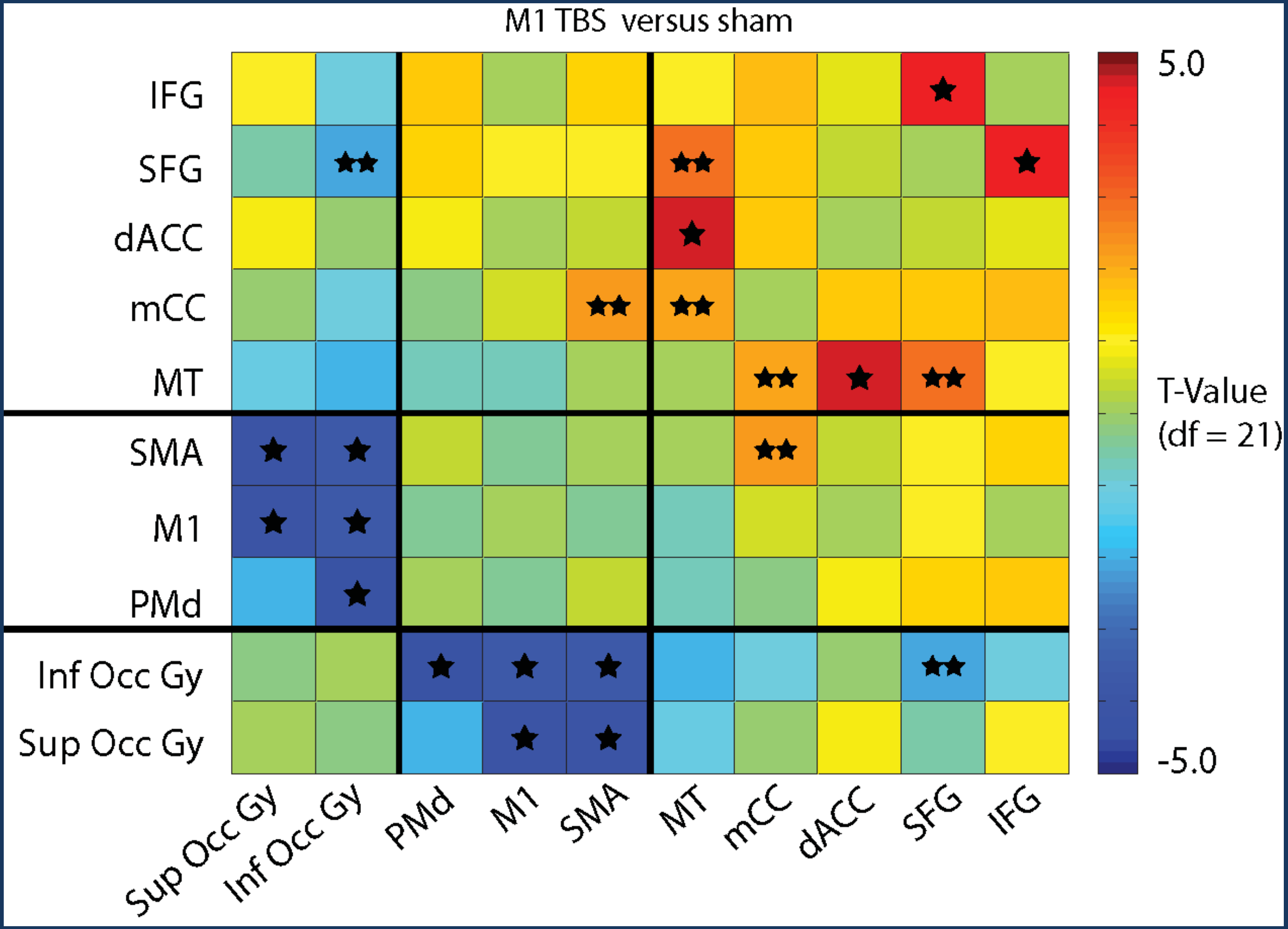
- Depression
- Chronic pain
- Tinnitus
- Auditory hallucinosis
- Motor learning (M1)
- Episodic memory (Voss)

Motor cortex rTMS effect on motor learning



Wilkinson, et al. Cortex, 2015

rTMS effect on learning investigated with functional connectivity



Steel et al., Cortex, In press

The Cognitive and Neural Architecture of Sequence Representation

Steven W. Keele
University of Oregon

Richard Ivry
University of California, Berkeley

Ulrich Mayr
University of Oregon

Eliot Hazeltine
University of California, Berkeley

Herbert Heuer
Institut für Arbeitsphysiologie, Dortmund

The authors theorize that 2 neurocognitive sequence-learning systems can be distinguished in serial reaction time experiments, one dorsal (parietal and supplementary motor cortex) and the other ventral

Central mechanisms of motor skill learning

Okihide Hikosaka*, Kae Nakamura†, Katsuyuki Sakai‡, Hiroyuki Nakahara§

Recent studies have shown that frontoparietal cortices and interconnecting regions in the basal ganglia and the cerebellum are related to motor skill learning. We propose that motor skill learning occurs independently and in different coordinates in two sets of loop circuits: cortex–basal ganglia and cortex–cerebellum. This architecture accounts for the

associations, sensorimotor adaptations, cellular mechanisms of neural plasticity, and motor learning in birds.

Multiple neural mechanisms for motor skill learning

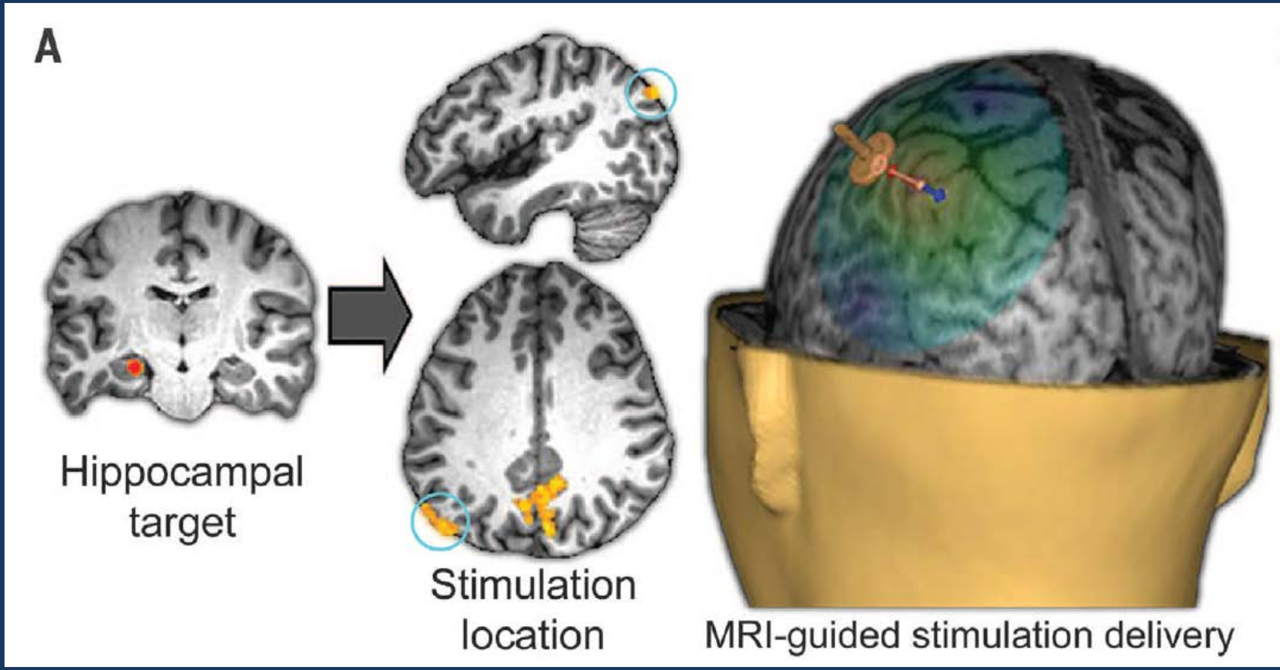
A complex motor skill is often composed of a fixed

A study that gets almost everything right

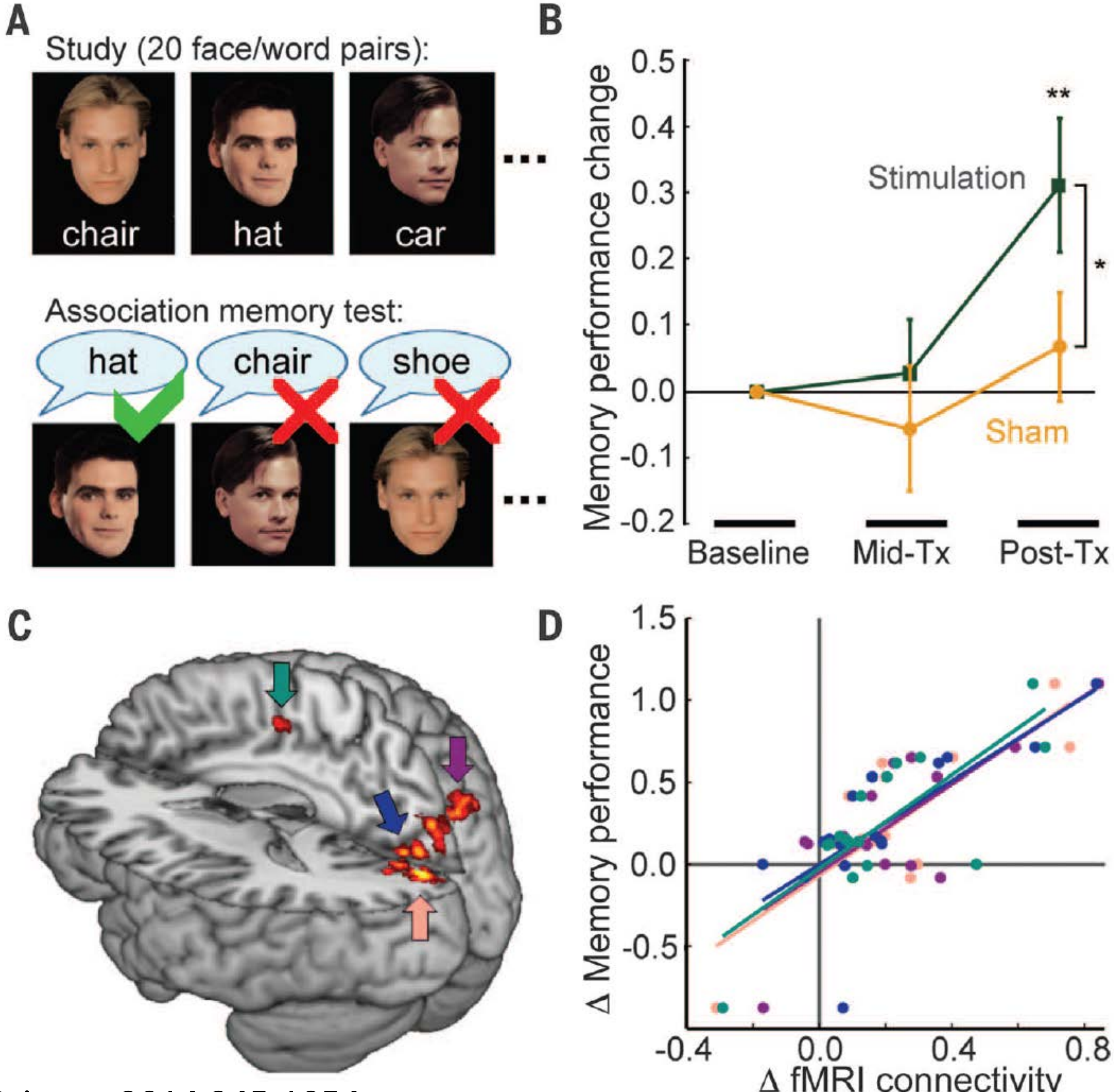
MEMORY ENHANCEMENT

Targeted enhancement of cortical-hippocampal brain networks and associative memory

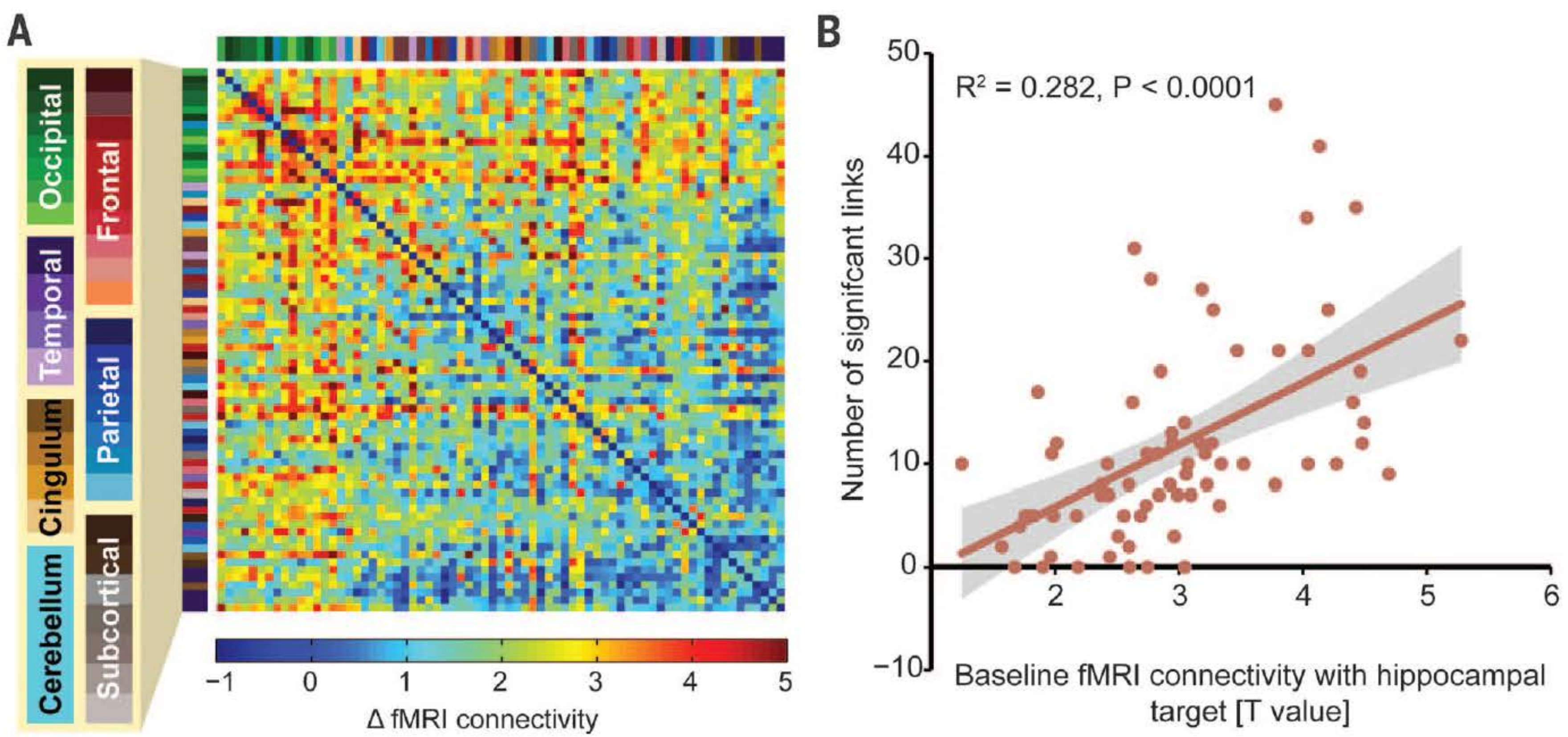
Jane X. Wang,[1] Lynn M. Rogers,[2] Evan Z. Gross,[1] Anthony J. Ryals,[1] Mehmet E. Dokucu,[3] Kelly L. Brandstatt,[1] Molly S. Hermiller,[1] Joel L. Voss[1*]

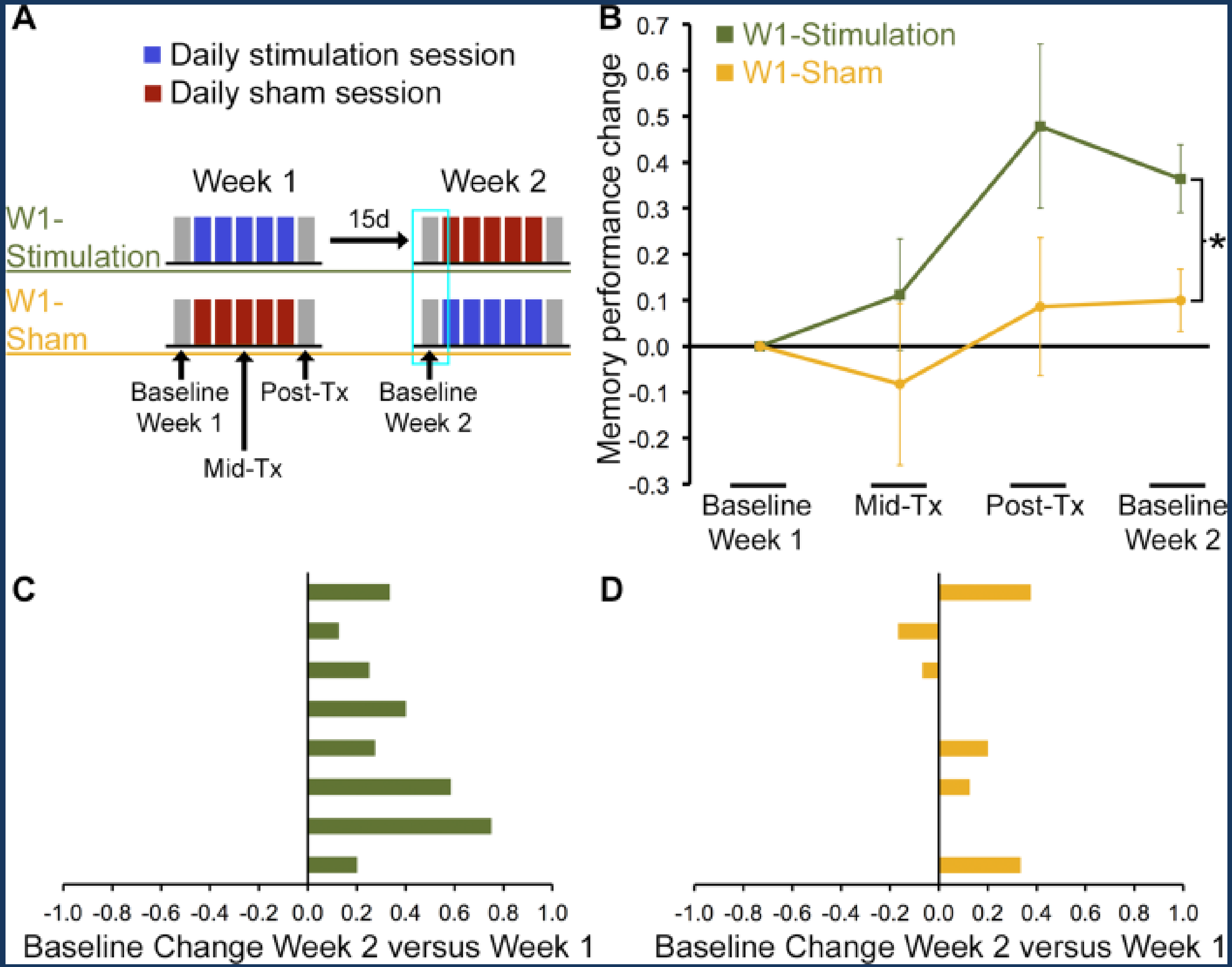


Science 2014 345:1054



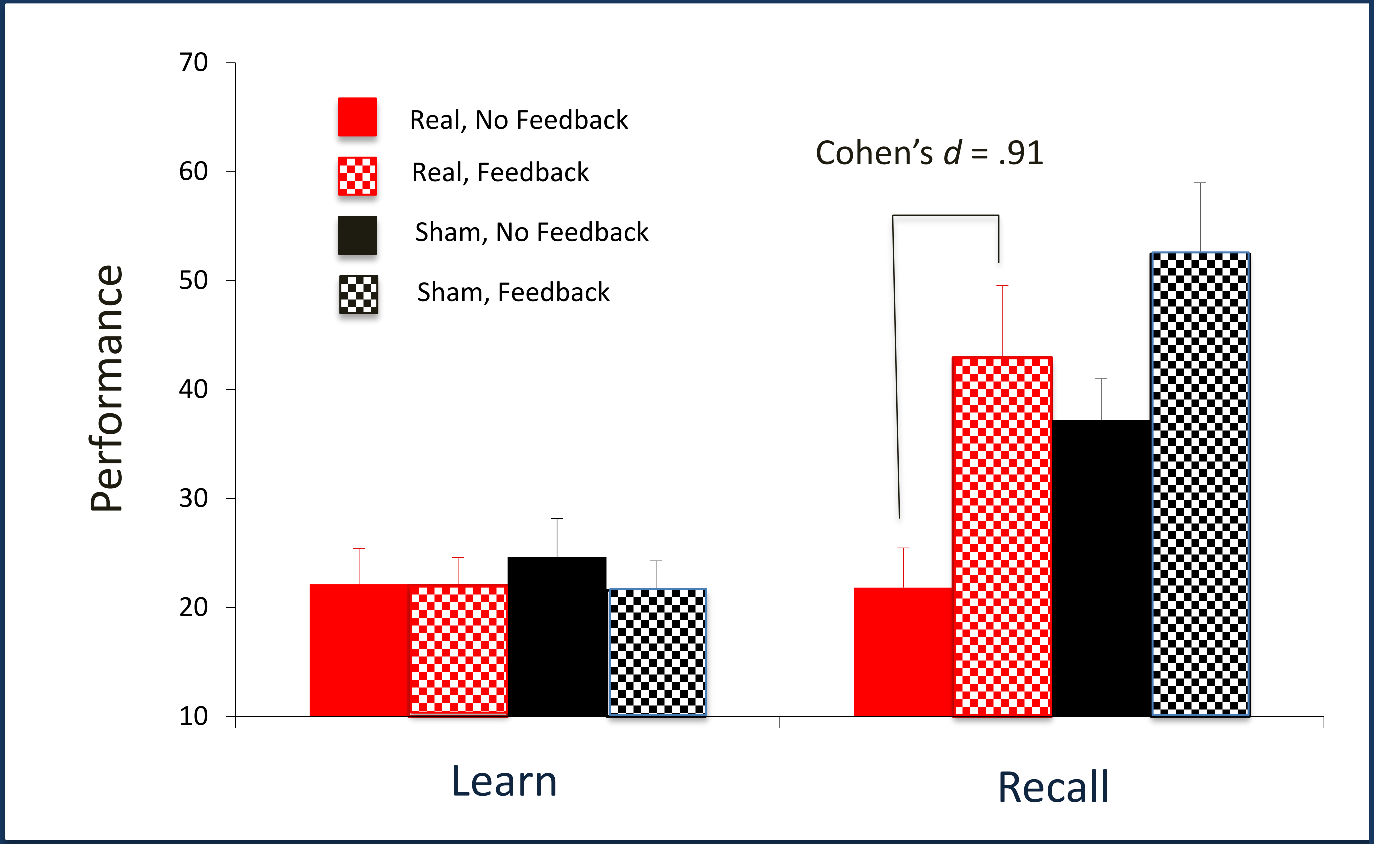
Science 2014 345:1054


A
Occipital
Temporal
Cingulum
Cerebellum
Frontal
Parietal
Subcortical
−1
0
1
2
3
4
5
Δ fMRI connectivity
B
R² = 0.282, P < 0.0001
Number of signifcant links
50
40
30
20
10
0
−10
2
3
4
5
6
Baseline fMRI connectivity with hippocampal target [T value]



Wang et al. Hippocampus 2015; 25: 877

P values don’t make people better; effect sizes do



Wilkinson, et al. Cortex, 2015

Chewing gum selectively improves aspects of memory in healthy volunteers

Lucy Wilkinson[a], Andrew Scholey[a] and Keith Wesnes[a,b]

Table I. Cognitive effects of chewing

Measure	*Chew*	*Sham*	*Quiet*
Simple RT	0·27	**0·30**[a]	0·27
Dig Vig Acc	96	94	97
Dig Vig RT	0·41	0·43	0·41
CRT Acc	94	92	93
CRT	0·43	0·43	0·43
SPM SI	**0·89**[a]	0·80	0·81
SPM RT	0·71	0·71	0·75
NWM SI	0·84	0·85	0·84
NWM RT	**0·68**[a]	**0·66**[a]	0·79
Imm Recall	**8·6**[b]	5·2	6·9
Del Recall	**7·1**[b]	4·3	5·2
Word Rec SI	0·64	0·52	0·65
Word Rec RT	0·73	0·77	0·77
Pic Rec SI	0·69	0·59	0·66
Pic Rec RT	0·85	0·90	0·87