Conscious Processing and Cortico-cortical Functional Connectivity in Golf Putting

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Introduction

The *Theory of Reinvestment:*[1]
Automated motor processes are disrupted when task-relevant declarative knowledge is used to consciously control movements.

left temporal (verbal/analytic) ⟷ frontal (pre-motor)
EEG: High alpha (10-12 Hz)

Functional connectivity:
- Lower in expert (vs. novice) marksmen.[2]
- Higher in novice golfers with high (vs. low) propensity for conscious processing of movement.[3]

Hypotheses:
- Conscious processing: experts < novices
- Left temporal to frontal connectivity: experts < novices; holed < missed

Methods

Participants:

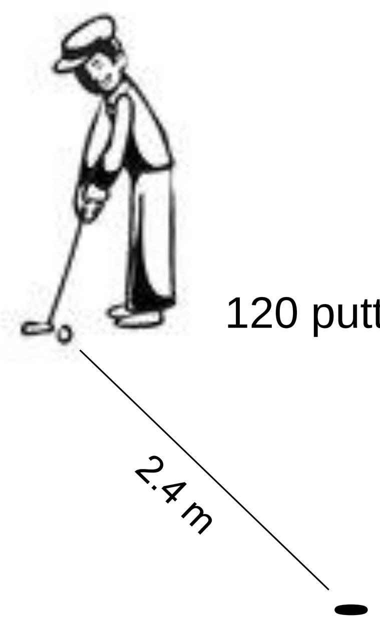
	Handicap *M*	Experience yrs. *M*
- *Experts* (N = 10)	1.50	11.25
- *Novices* (N = 10)	no formal handicap	1.85

Design:

- *Between subjects*
Group (expert, novice)

- *Within subjects*
Outcome (holed, missed)
Epoch (-4 to -3s, -3 to -2s, -2 to -1s, -1 to 0s, 0 to +1s)

Task: Golf putting



120 putts

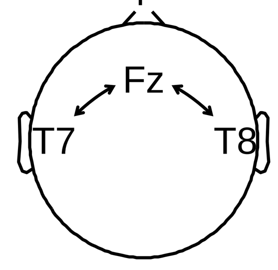
Measures:

- *Conscious Processing*
Putting Reinvestment scale
1 = low reinvestment
5 = high reinvestment

- *Functional Connectivity*
Inter Site Phase Clustering

$ISPC(f) = \left| n^{-1} \sum_{t=1}^{n} e^{i\Delta\theta(t,f)} \right|$

0 = no functional connectivity
1 = perfect functional connectivity



Results

Group:	Expert *M (SD)*	Novice *M (SD)*	*F*(1, 18)	*p*	η_p^2
T7-Fz ISPC	0.39 (0.04)	0.48 (0.04)	3.89	.06	.178
T8-Fz ISPC	0.48 (0.05)	0.51 (0.05)	0.15	.70	.01
Consc. Proc.	2.80 (0.93)	3.50 (0.77)	3.55	.07	.165

Table 1. Mean (standard deviation) of the left temporal (T7) / right temporal (T8) to frontal (Fz) high alpha (10-12 Hz) Inter Site Phase Clustering (ISPC) and Conscious Processing in experts and novices. Results of repeated-measure ANOVAs are reported.

Outcome:	Holed *M (SD)*	Missed *M (SD)*	*F*(1, 18)	*p*	η_p^2
T7-Fz ISPC	0.40 (0.04)	0.46 (0.05)	5.71	.03	.241
T8-Fz ISPC	0.48 (0.05)	0.51 (0.06)	2.07	.17	.103

Table 2. Mean (standard deviation) of the left temporal (T7) / right temporal (T8) to frontal (Fz) high alpha (10-12 Hz) Inter Site Phase Clustering (ISPC) in holed and missed putts. Results of repeated-measure ANOVAs are reported.

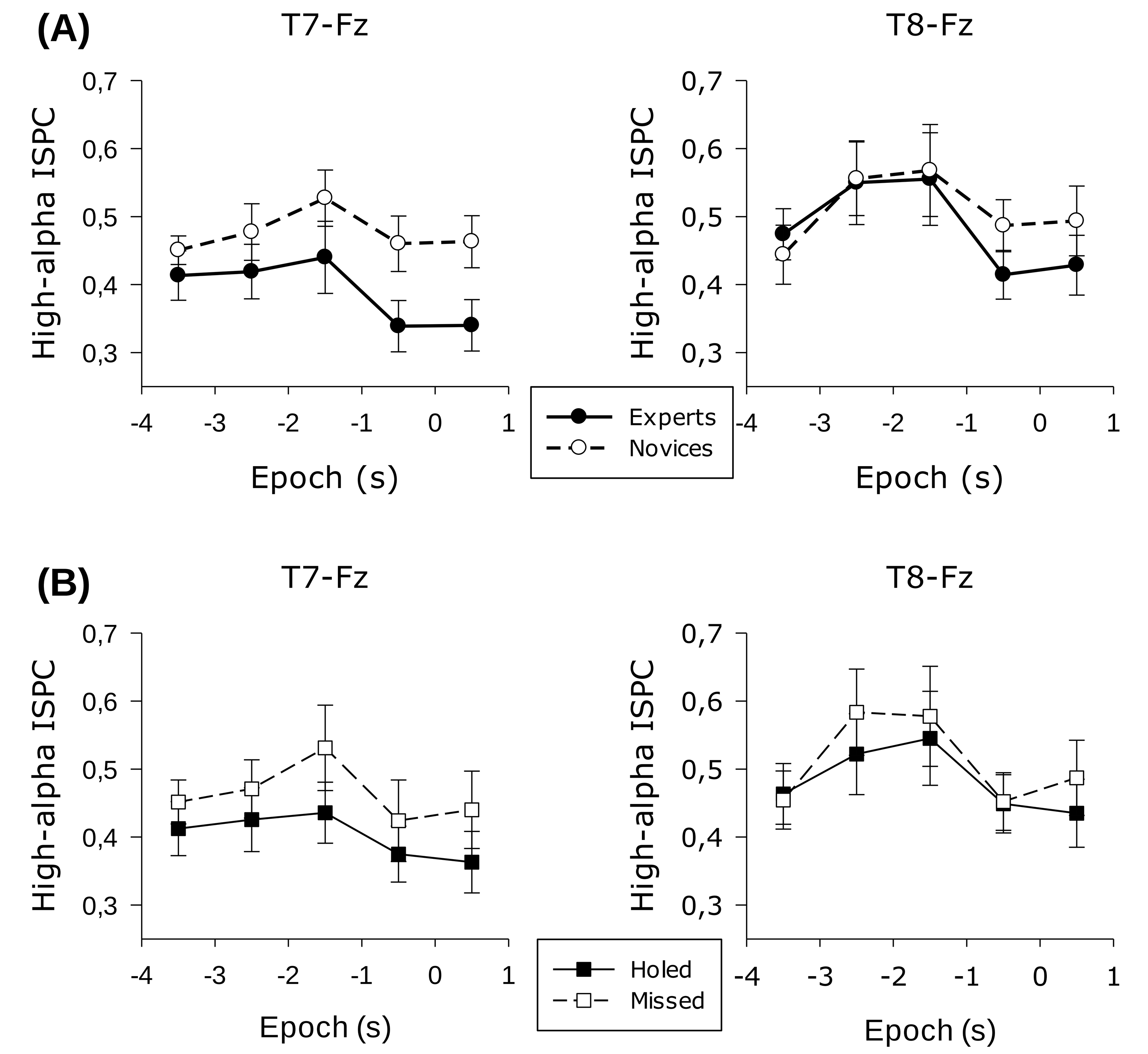


Figure 1. Left temporal (T7) / right temporal (T8) to frontal (Fz) high-alpha (10-12 Hz) Inter Site Phase Clustering (ISPC) as a function of Epoch and Group (panel A) and Outcome (panel B). Vertical bars represent SE of the means.

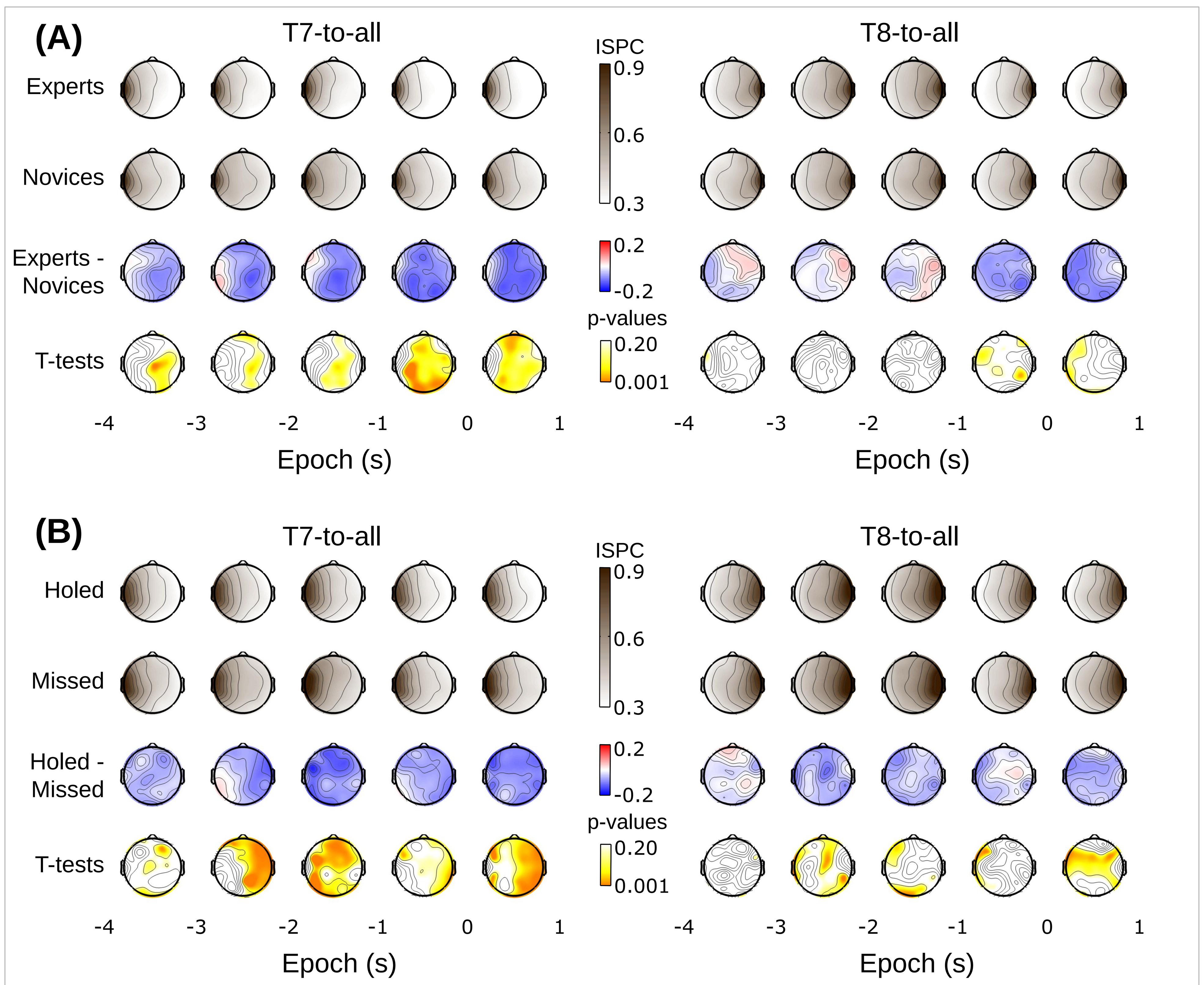


Figure 2. Left temporal (T7) / right temporal (T8) to all channels high-alpha (10-12 Hz) Inter Site Phase Clustering (ISPC) as a function of Epoch and Group (panel A) and Outcome (panel B).

Discussion

Skilled motor performance ⟵ Lower conscious processing of task-relevant declarative knowledge to control movement execution

Skilled motor performance ⟵ Diminished communication: left temporal (verbal/analytic) ⟷ frontal (pre-motor)

Indirect support to the *Theory of Reinvestment*:[1]

Errors in movement performance (i.e., missed putts) ⟵ Verbal/analytic interference with movement preparation and execution (i.e., higher left temporal to frontal functional connectivity)

Future directions:

- *Implicit motor learning*
A motor skill can be learned implicitly (i.e., with reduced movement-relevant declarative knowledge being generated).[1]
Implicit learners display lower communication between left temporal and frontal areas and perform better compared to explicit learners.[3]

- *Neurofeedback*
Individuals can be trained to alter selective features of their cortical activity during the acquisition of a motor skill.[4]
Training individuals to reduce the communication between their left temporal and frontal cortical areas during motor learning could prevent the formation of movement-related declarative knowledge, promote implicit motor learning, and expedite the novice-expert transition.

References

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