Slow oscillation spindle coupling during slow wave sleep impairs emotional memory consolidation following stress

Dan Denis[1*], Sara Y. Kim[1], Sarah M. Kark[2], Ryan T. Daley[3], Sara E. Alger[4], Elizabeth A. Kensinger[2], Jessica D. Payne[1]
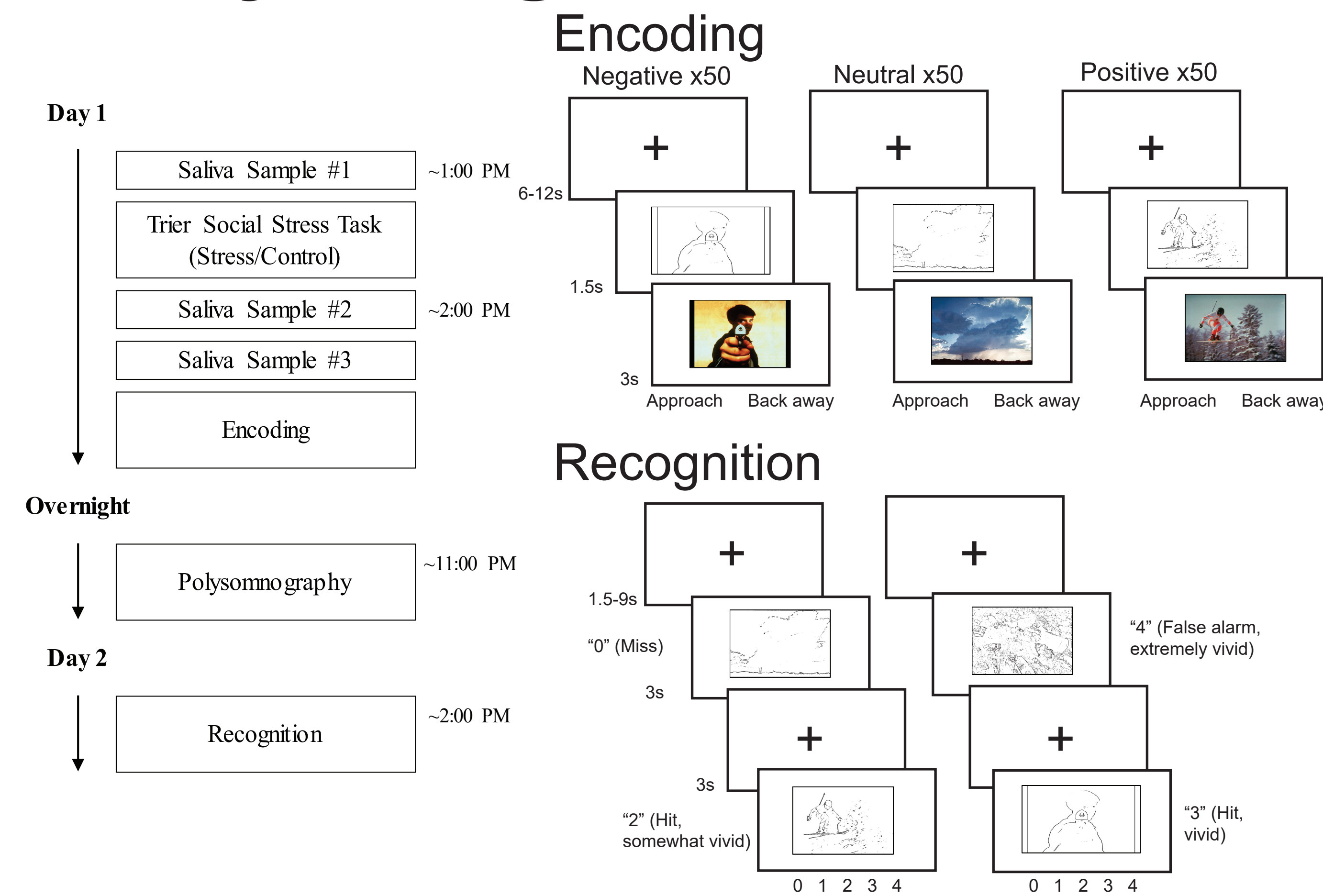
1 Department of Psychology, University of Notre Dame
2 Center for Neurobiology of Learning and Memory, University of California Irvine
3 Department of Psychology, Boston College
4 Walter Reed Army Institute of Research

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* ddenis@nd.edu

- Sleep and stress interact to promote consolidation of emotional memories[1]
- During slow wave sleep, coupling between slow oscillations and spindles are believed to facilitate memory consolidation[2]
- The role of slow wave sleep processes in emotional memory consolidation is unclear
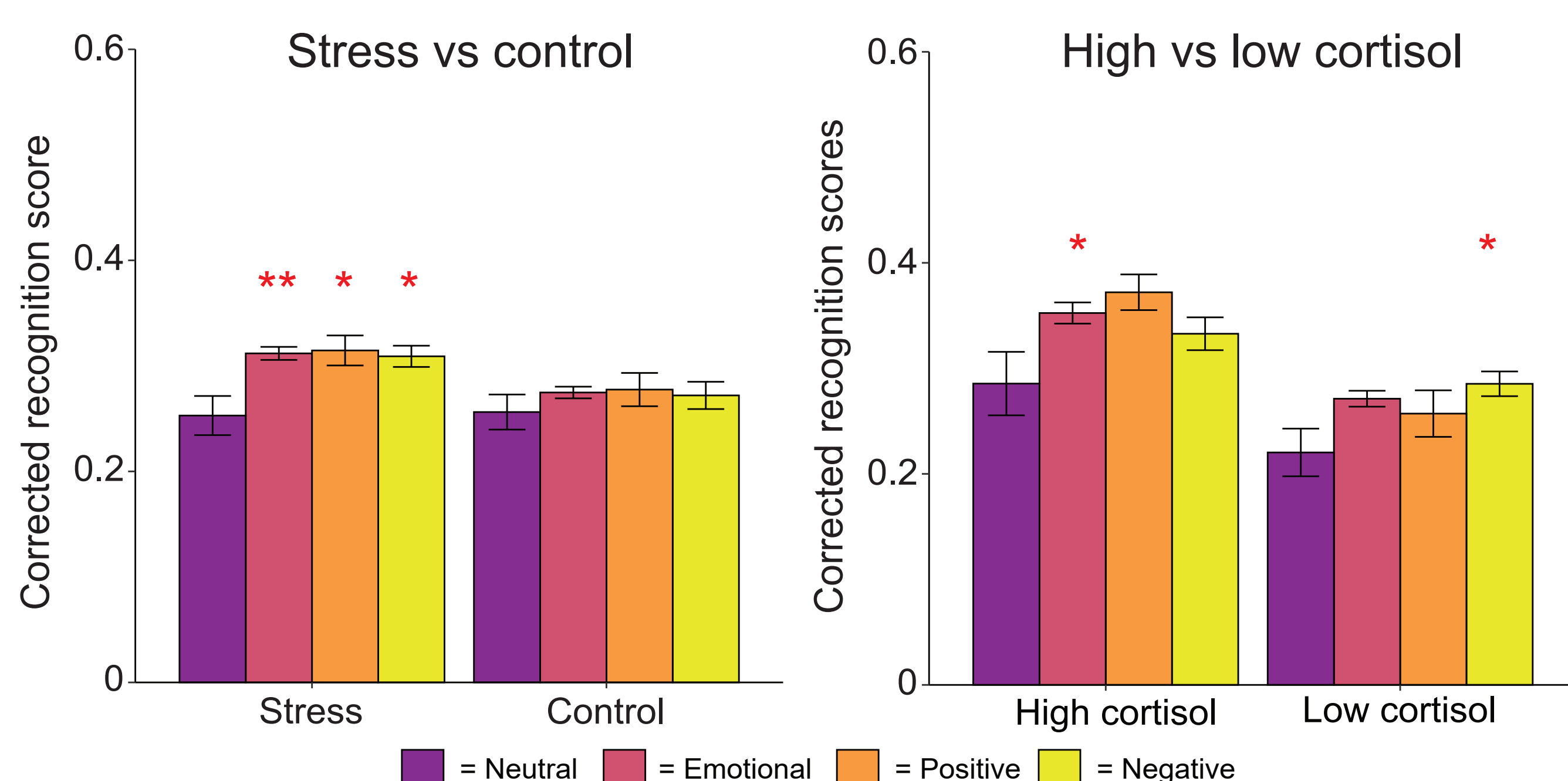- How stress may impact these relationships has not been explored

Study design

Encoding

Negative x50   Neutral x50   Positive x50

Day 1
- Saliva Sample #1   ~1:00 PM
- Trier Social Stress Task (Stress/Control)   ~2:00 PM
- Saliva Sample #2
- Saliva Sample #3
- Encoding

6-12s
1.5s
3s
Approach   Back away   Approach   Back away   Approach   Back away

Overnight
- Polysomnography   ~11:00 PM

Recognition

1.5-9s
"0" (Miss)
3s
"4" (False alarm, extremely vivid)

3s
"2" (Hit, somewhat vivid)   "3" (Hit, vivid)
0 1 2 3 4   0 1 2 3 4

Day 2
- Recognition   ~2:00 PM

Stress: n = 32   Control: n = 32

Behavior

Stress vs control

Corrected recognition score

High vs low cortisol

Corrected recognition scores

= Neutral   = Emotional   = Positive   = Negative

** = Compared to neutral at p < .01
* = Compared to neutral at p < .05
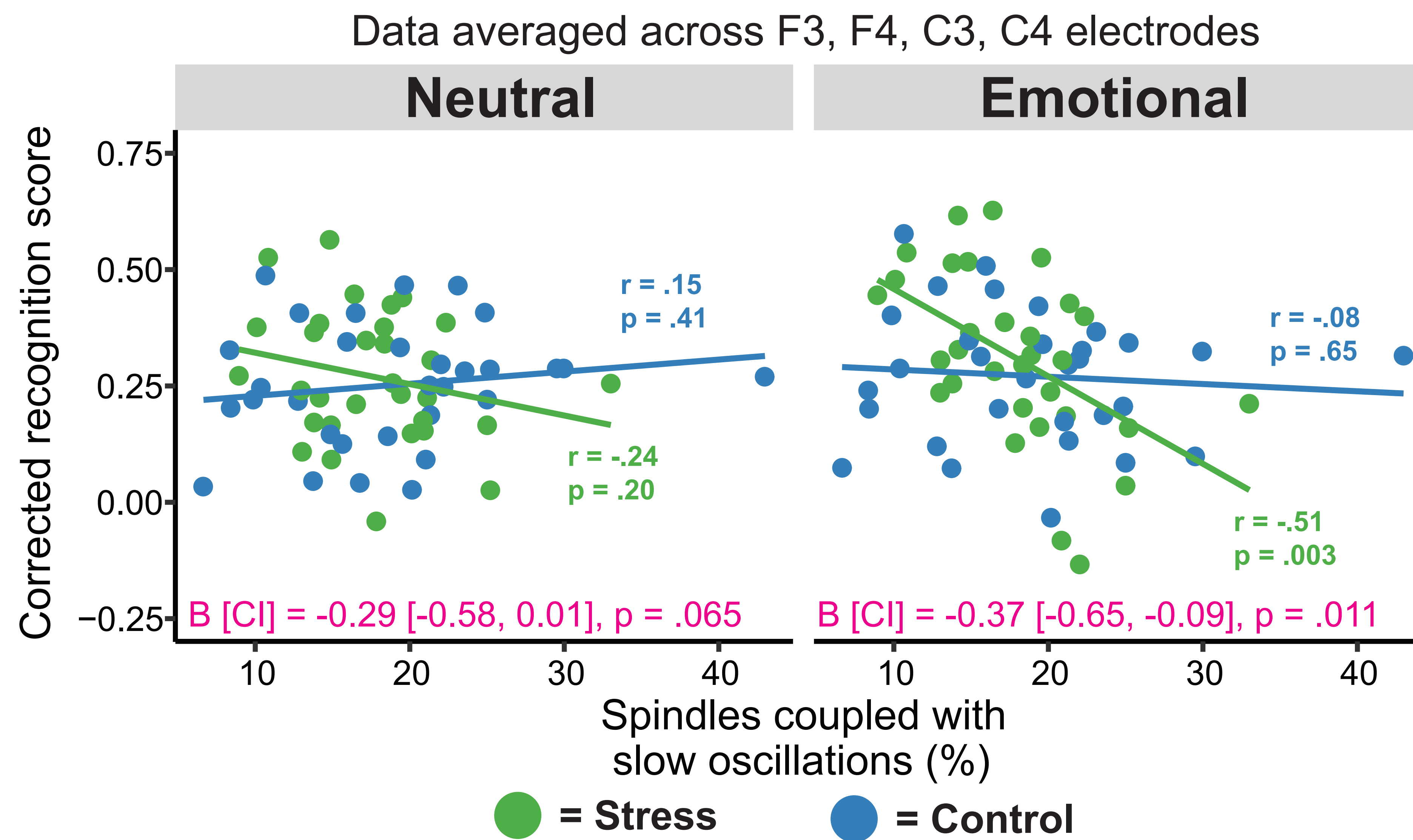
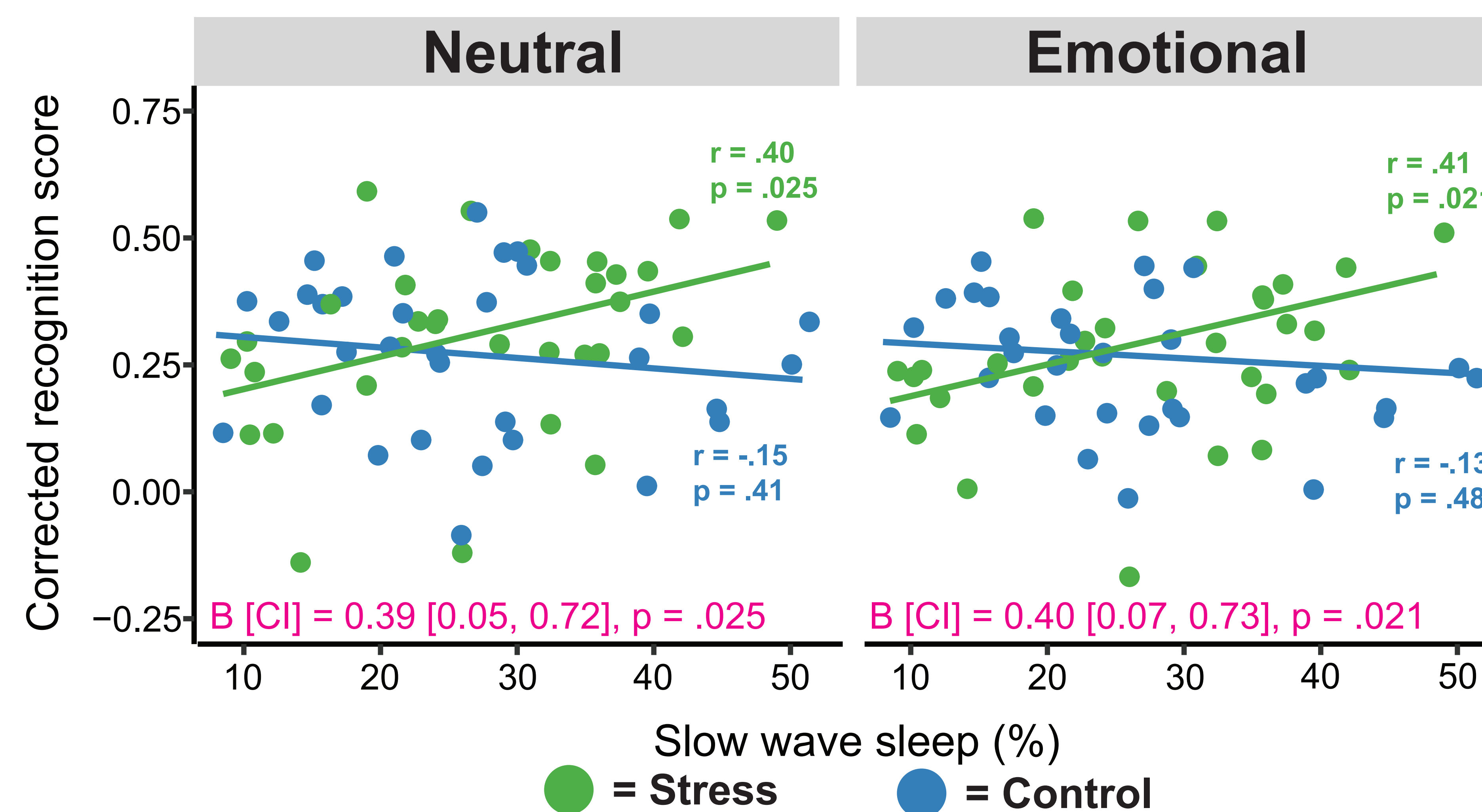- Memory was better for emotional items compared to neutral items in the stress group

1. Kim & Payne (2020). Curr. Opin. Behav. Sci.
2. Klinzing et al (2019). Nat. Neurosci.

Slow oscillation spindle coupling

Data averaged across F3, F4, C3, C4 electrodes

Neutral
r = .15, p = .41
r = -.24, p = .20
B [CI] = -0.29 [-0.58, 0.01], p = .065

Emotional
r = -.08, p = .65
r = -.51, p = .003
B [CI] = -0.37 [-0.65, -0.09], p = .011

Corrected recognition score

Spindles coupled with slow oscillations (%)

● = Stress   ● = Control

- After stress, a higher percentage of spindles coupled with slow oscillations was associated with worse memory, especially for emotional items.
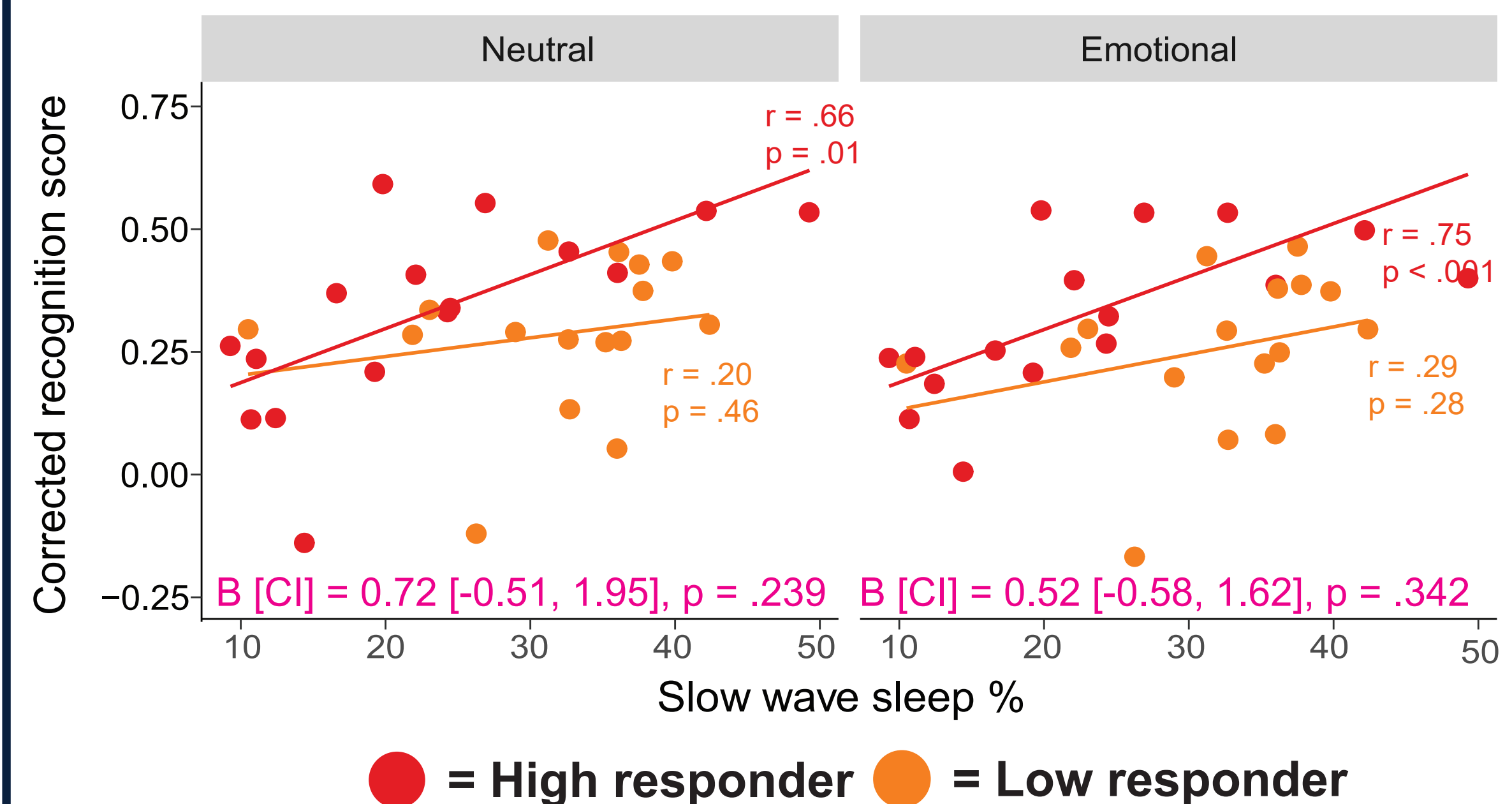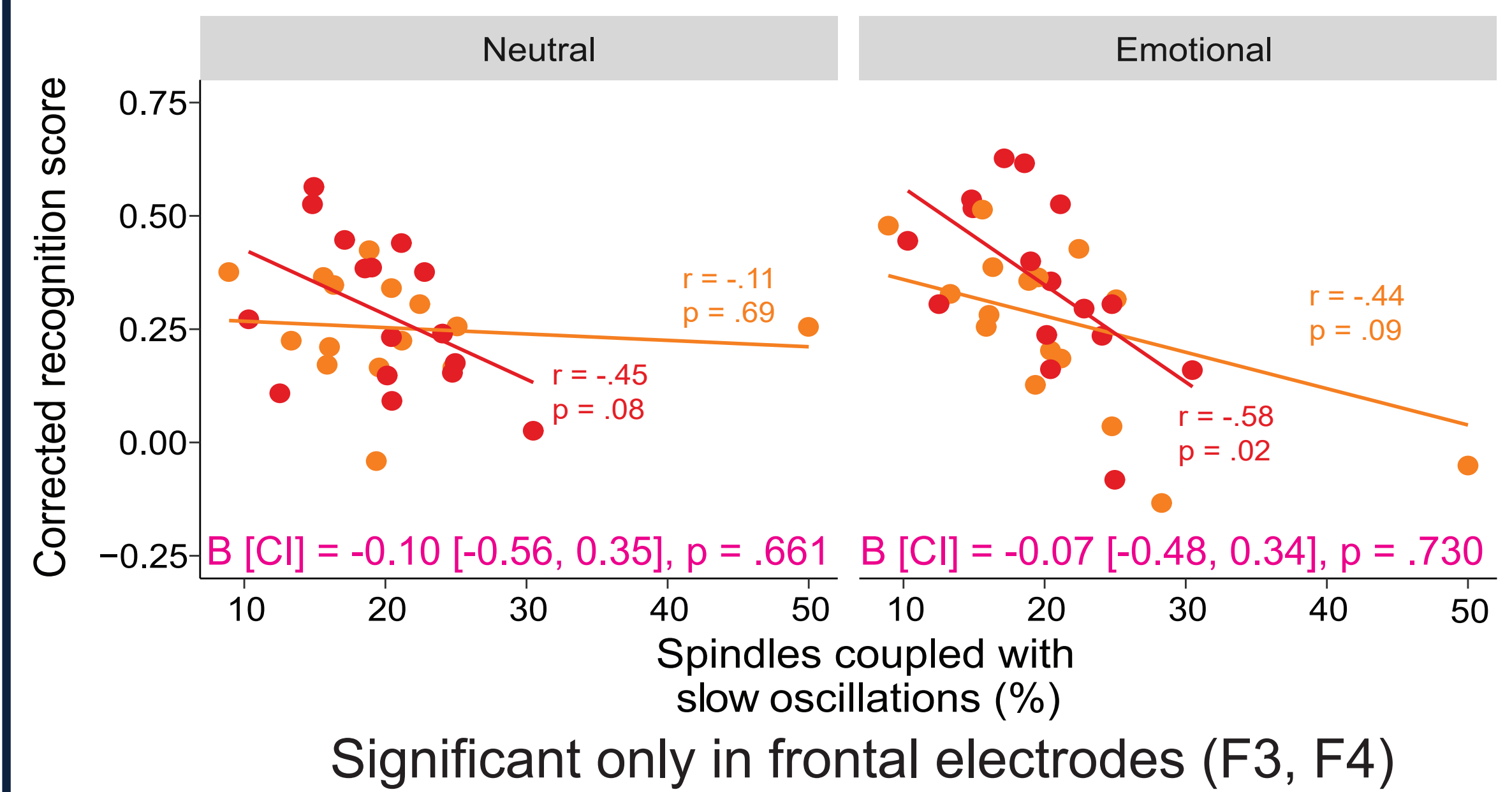
Slow wave sleep percentage

Neutral
r = .40, p = .025
r = -.15, p = .41
B [CI] = 0.39 [0.05, 0.72], p = .025

Emotional
r = .41, p = .021
r = -.13, p = .48
B [CI] = 0.40 [0.07, 0.73], p = .021

Corrected recognition score

Slow wave sleep (%)

● = Stress   ● = Control

- After stress, a higher percentage of time spent in slow wave sleep was associated with better memory.

No group differences in spectral measures

	Stress M (SD)	Control M (SD)	sig
Spindle density (spindles/min)	3.08 (1.45)	2.57 (1.06)	.09
Slow oscillation density (so/min)	3.46 (0.39)	3.62 (0.46)	.12
Slow oscillation amplitude (uV)	181.74 (33.00)	191.26 (43.40)	.33
% spindles coupled	17.80 (4.93)	18.80 (7.63)	.53
Coupling strength (vector length)	.57 (.13)	.54 (.13)	.17
Coupling phase angle (deg)	25.72 (12.72)	30.53 (10.43)	.10

	High cortisol responders M (SD)	Low cortisol responders M (SD)	sig
Spindle density (spindles/min)	2.78 (1.30)	3.37 (1.54)	.11
Slow oscillation density (so/min)	3.54 (0.47)	3.37 (0.27)	.23
Slow oscillation amplitude (uV)	178.65 (39.00)	185.03 (26.20)	.60
% spindles coupled	17.05 (4.49)	18.56 (5.38)	.40
Coupling strength (vector length)	.58 (.11)	.56 (.15)	.41
Coupling phase angle (deg)	27.33 (13.35)	24.06 (12.26)	.46

Note. M = mean, SD = standard deviation, sig = p value (uncorrected) from unpaired samples t-test, so = slow oscillation, deg = degrees.

High vs low cortisol responders

Neutral
r = -.11, p = .69
r = -.45, p = .08
B [CI] = -0.10 [-0.56, 0.35], p = .661

Emotional
r = -.44, p = .09
r = -.58, p = .02
B [CI] = -0.07 [-0.48, 0.34], p = .730

Corrected recognition score

Spindles coupled with slow oscillations (%)

Significant only in frontal electrodes (F3, F4)

Neutral
r = .66, p = .01
r = .20, p = .46
B [CI] = 0.72 [-0.51, 1.95], p = .239

Emotional
r = .75, p < .001
r = .29, p = .28
B [CI] = 0.52 [-0.58, 1.62], p = .342

Corrected recognition score

Slow wave sleep %

● = High responder   ● = Low responder

- Stress impacts the relationship between slow wave sleep and memory
- Sleep stage percentage and the specific events occurring within that stage can have opposing effects on memory