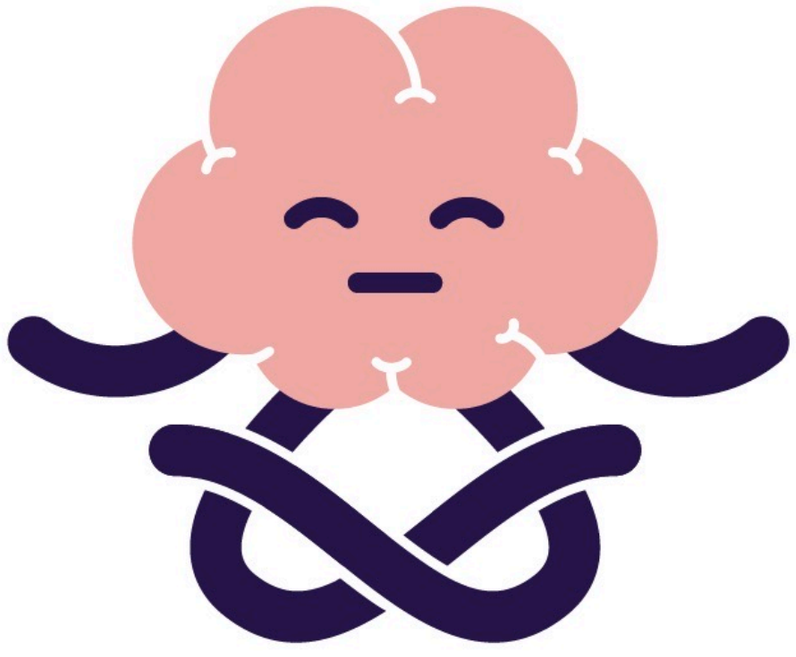
Neuroscience and Yoga Online Conference

The Experiment Results



Introduction

Disclaimer

- These studies were not conducted under controlled conditions

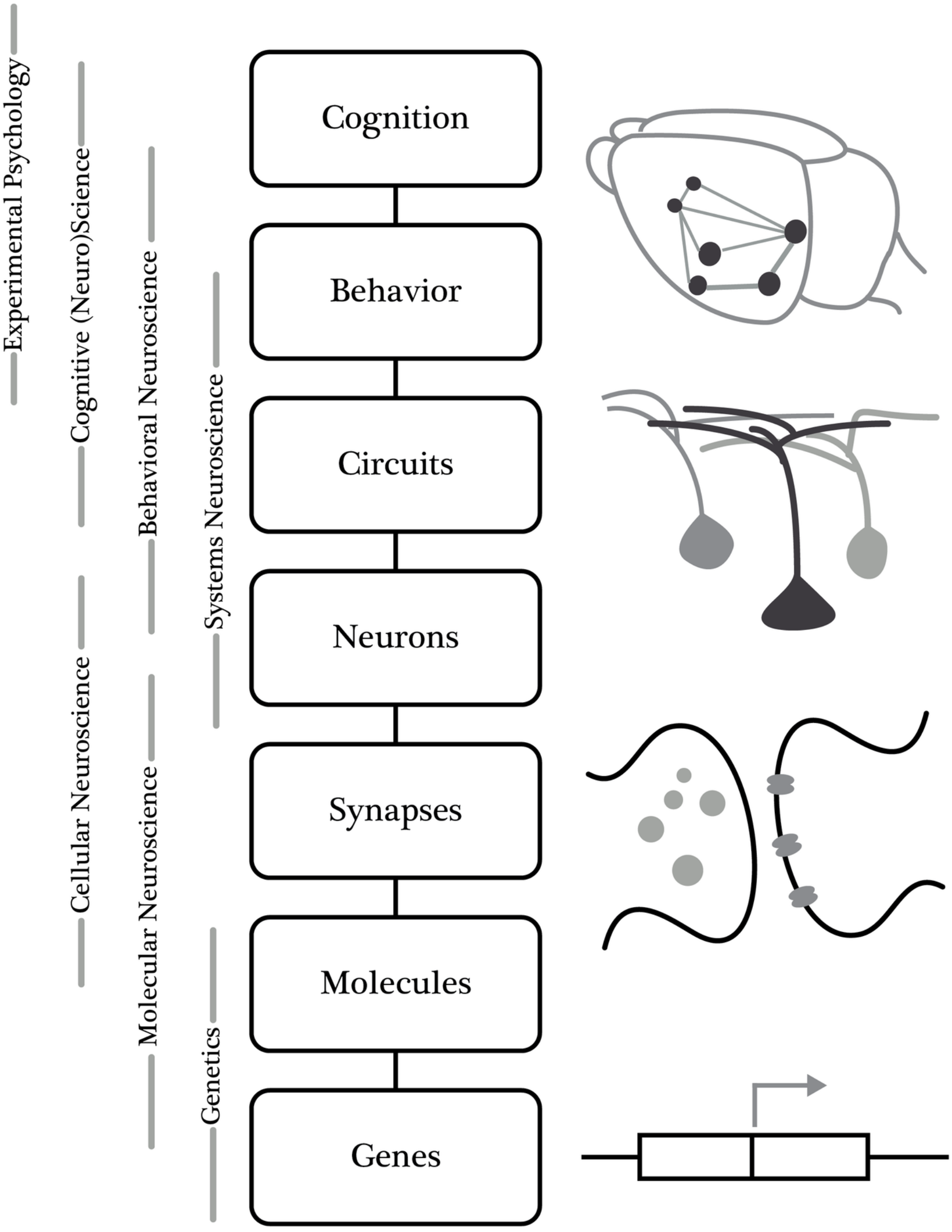
- Sample numbers were quite small. Proceed with caution.

- There are many confounds that may contribute to these results. One major confound is that participants were more familiar with all tests when they took them the second time. Further, participants are enthusiastic about yoga.

Outline

- **Yoga and Child Development**
  - Stress regulation (Perceived Stress Scale)
  - Executive function (Go/No-Go Task)
- **Yoga and Brain Aging**
  - Visual Attention (Concentration Grid Task)
  - Positive and negative affect (PANAS)
- **Yoga and Addiction**
  - Temporal discounting and addiction (ED50)
  - Risk tolerance/seeking (Iowa Gambling Task)

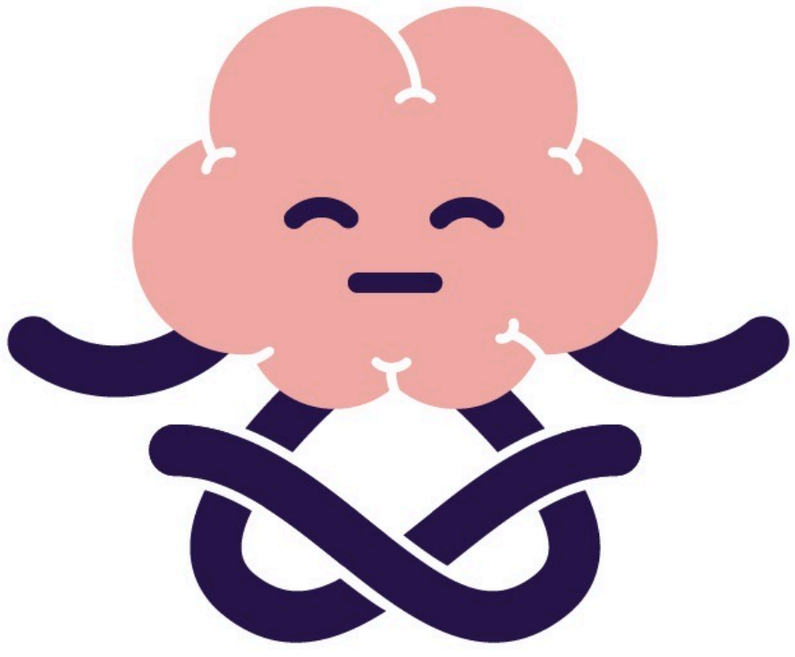
“Levels of Explanation” and their related subfields



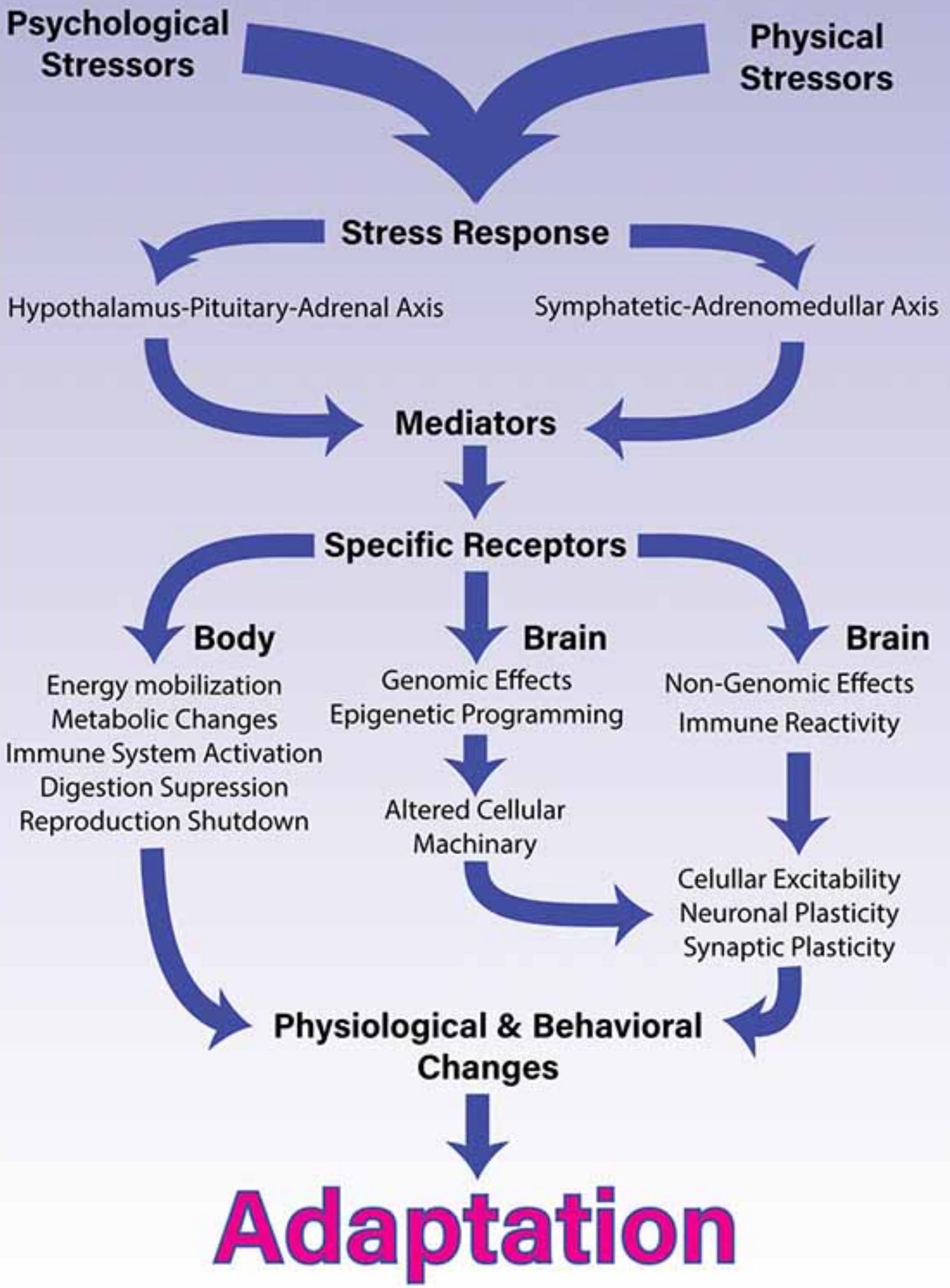
Graphic: Ashley Juavinett. Largely adapted from Churchland, Koch, and Sejnowski (1988), “What is computational neuroscience?”

Yoga + Child Development

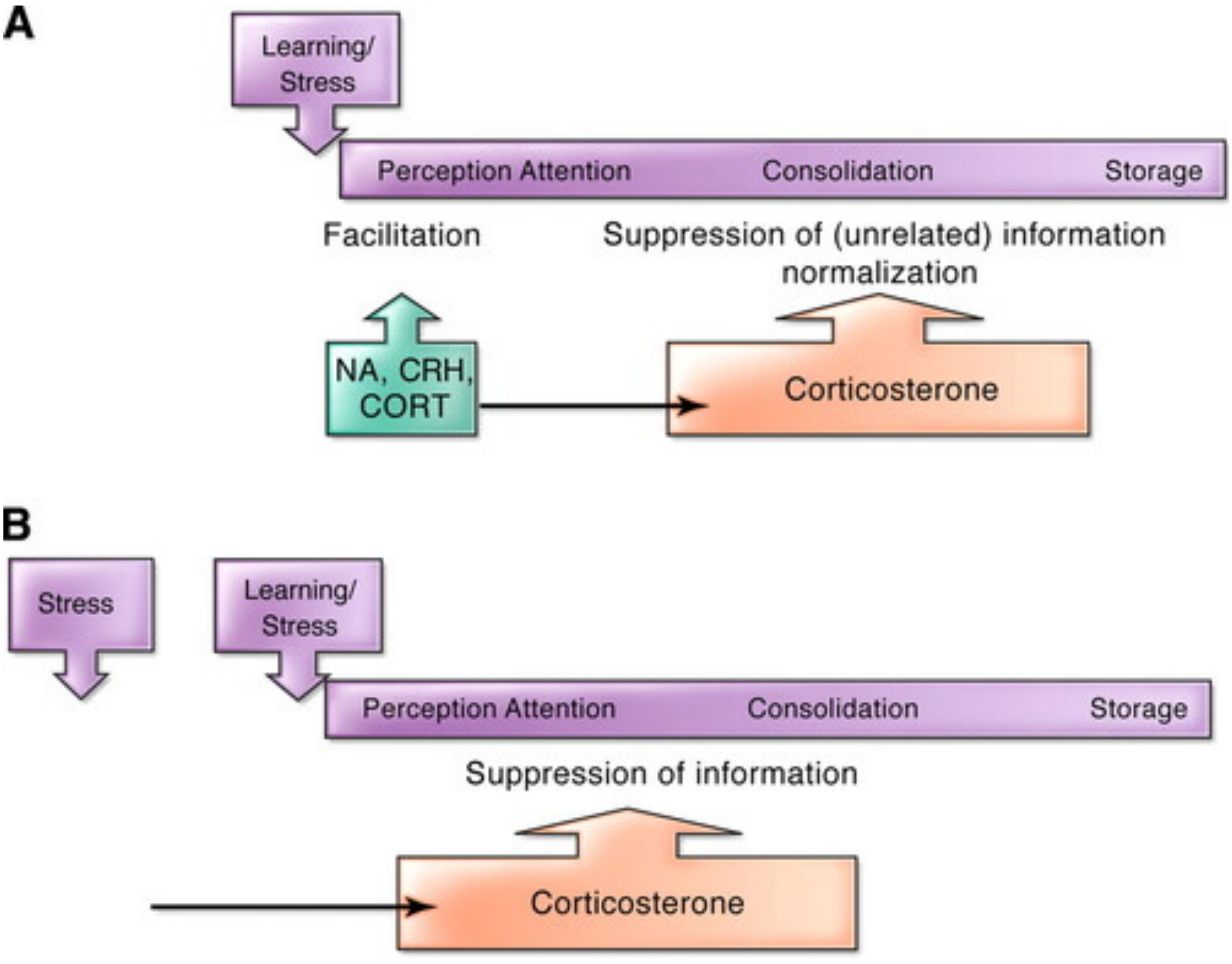
Experiment Results



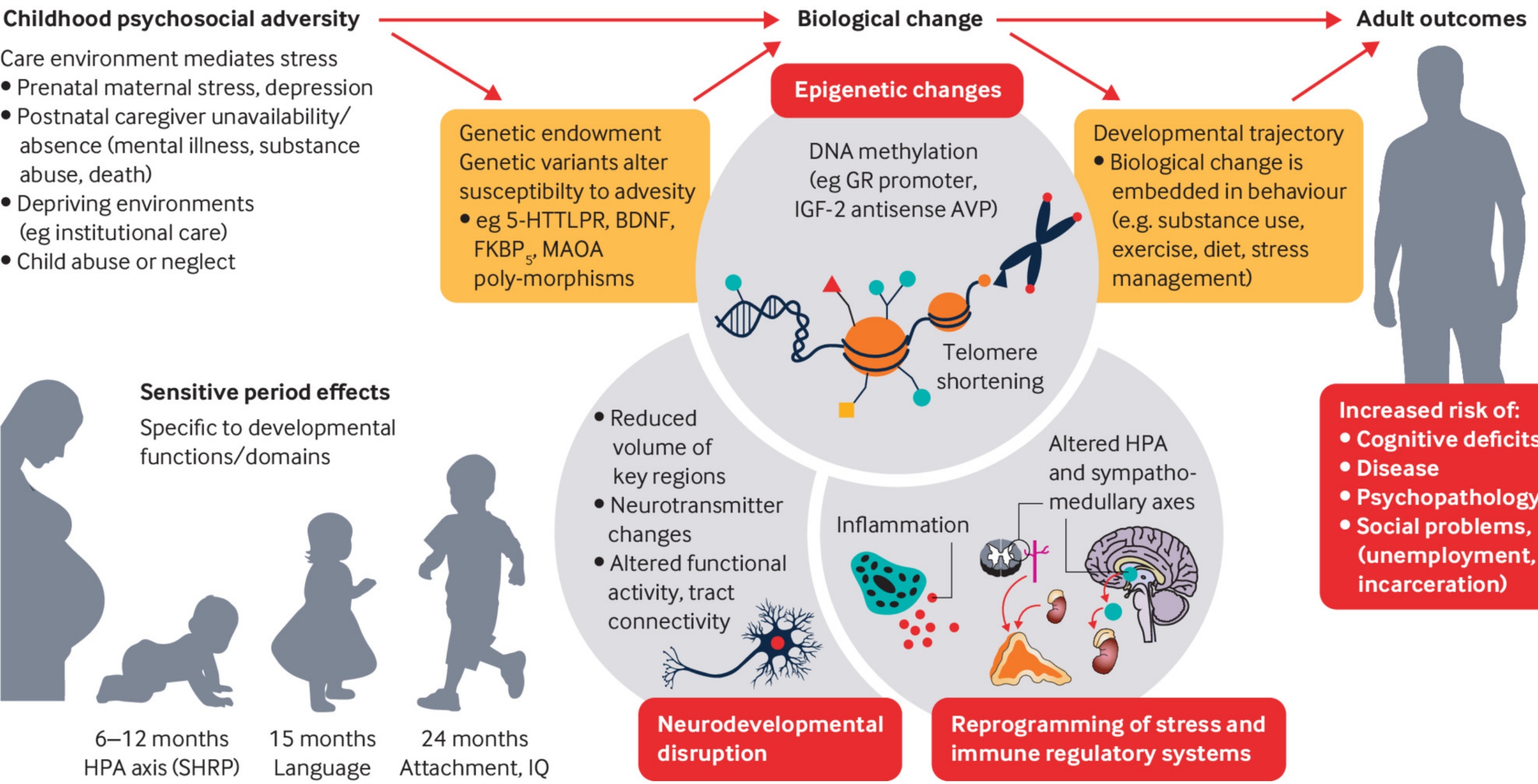
The Stress System



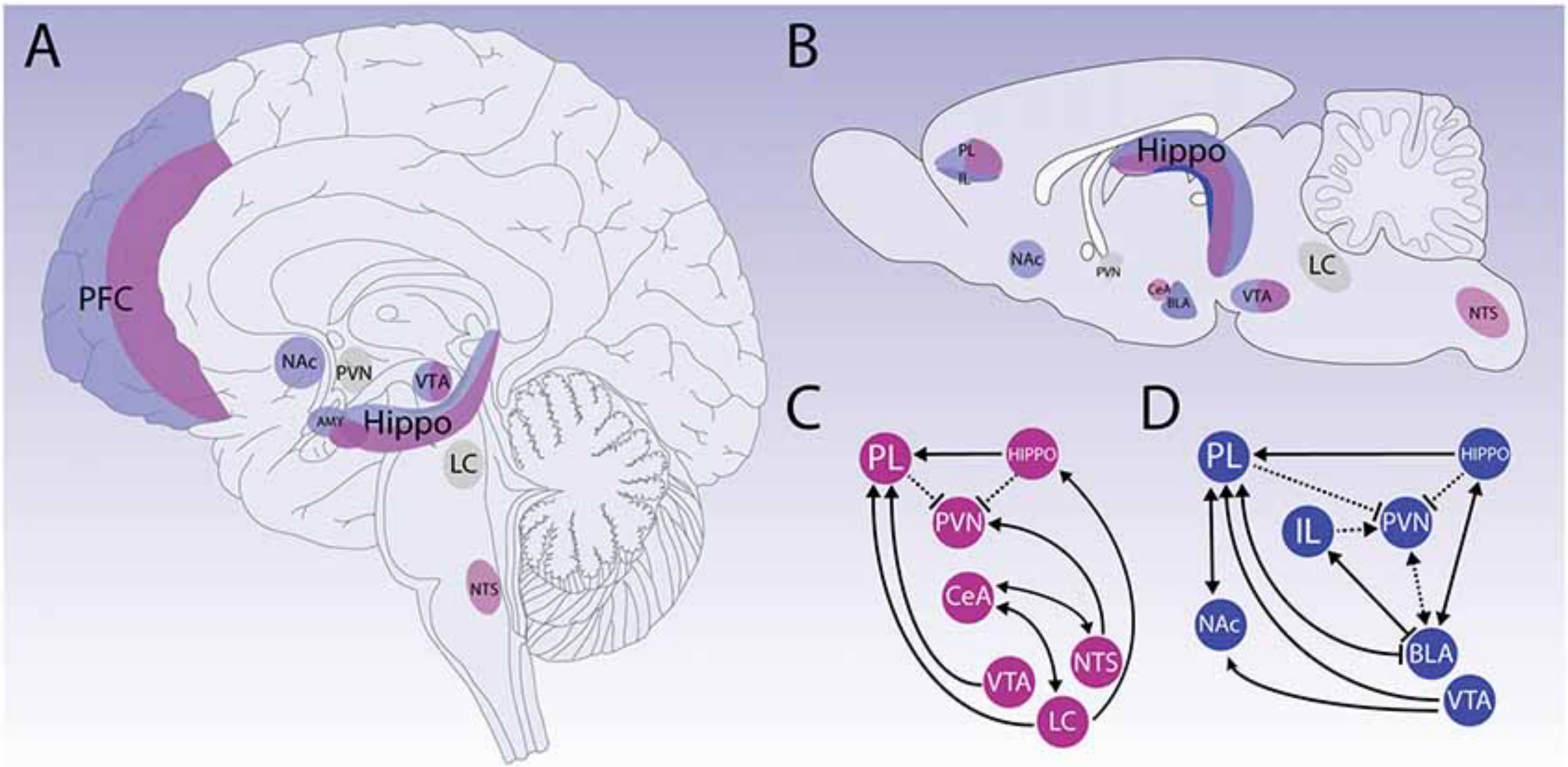
Timing of stress matters



Timing of stress matters



Brain networks that identify stress



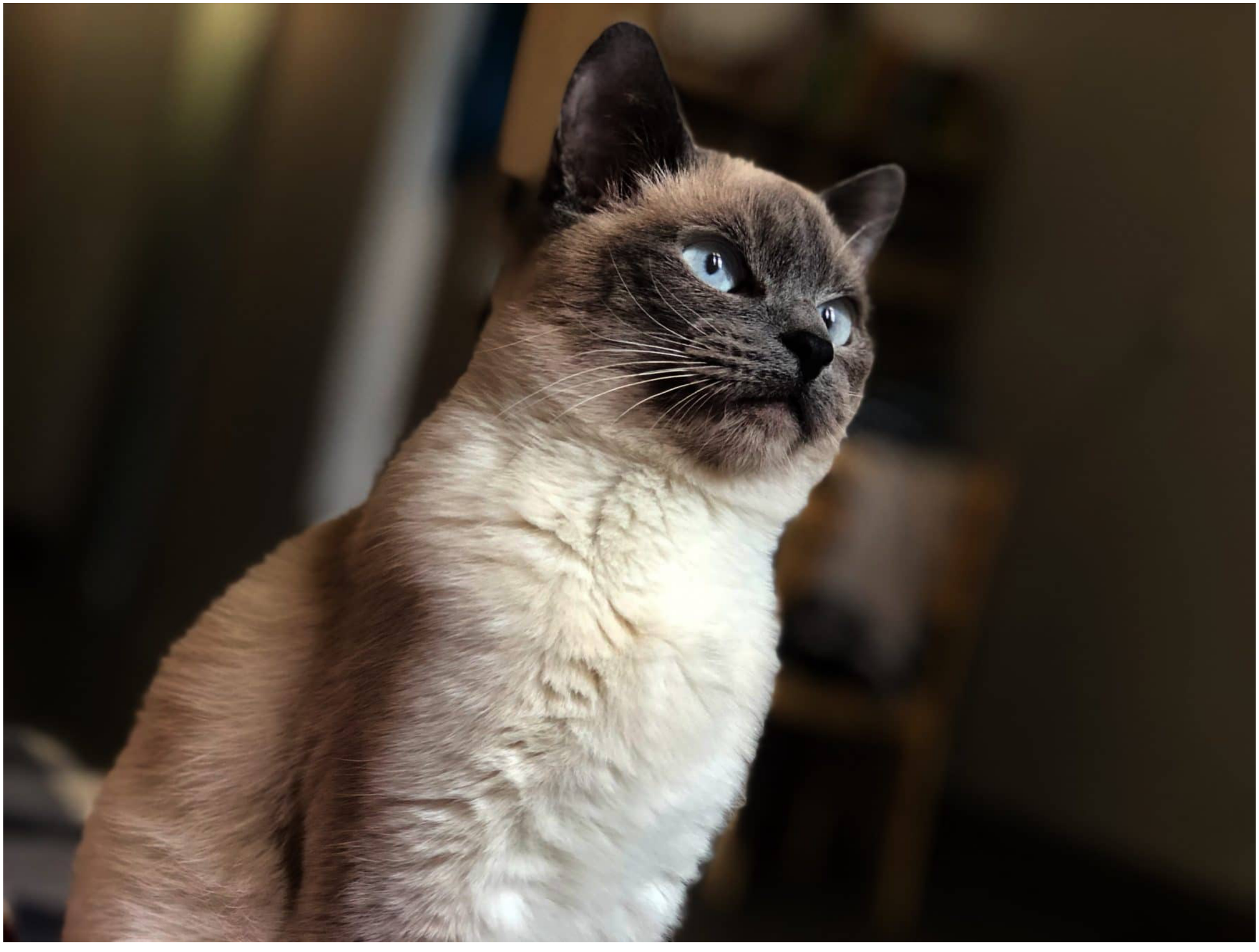
Definitions

- **Perceived Stress Scale**: a validated measure of someone's subjective experience of stress over the past month, with scores ranging from 0 (low stress) to 40 (high stress)

- **Go/No-Go Task**: a validated measure of executive function, specifically response inhibition, which is the ability to have a motor response only with a certain stimulus

Measuring Cognitive Control with the Go/No-Go Test

Measuring Cognitive Control with the Go/No-Go Test

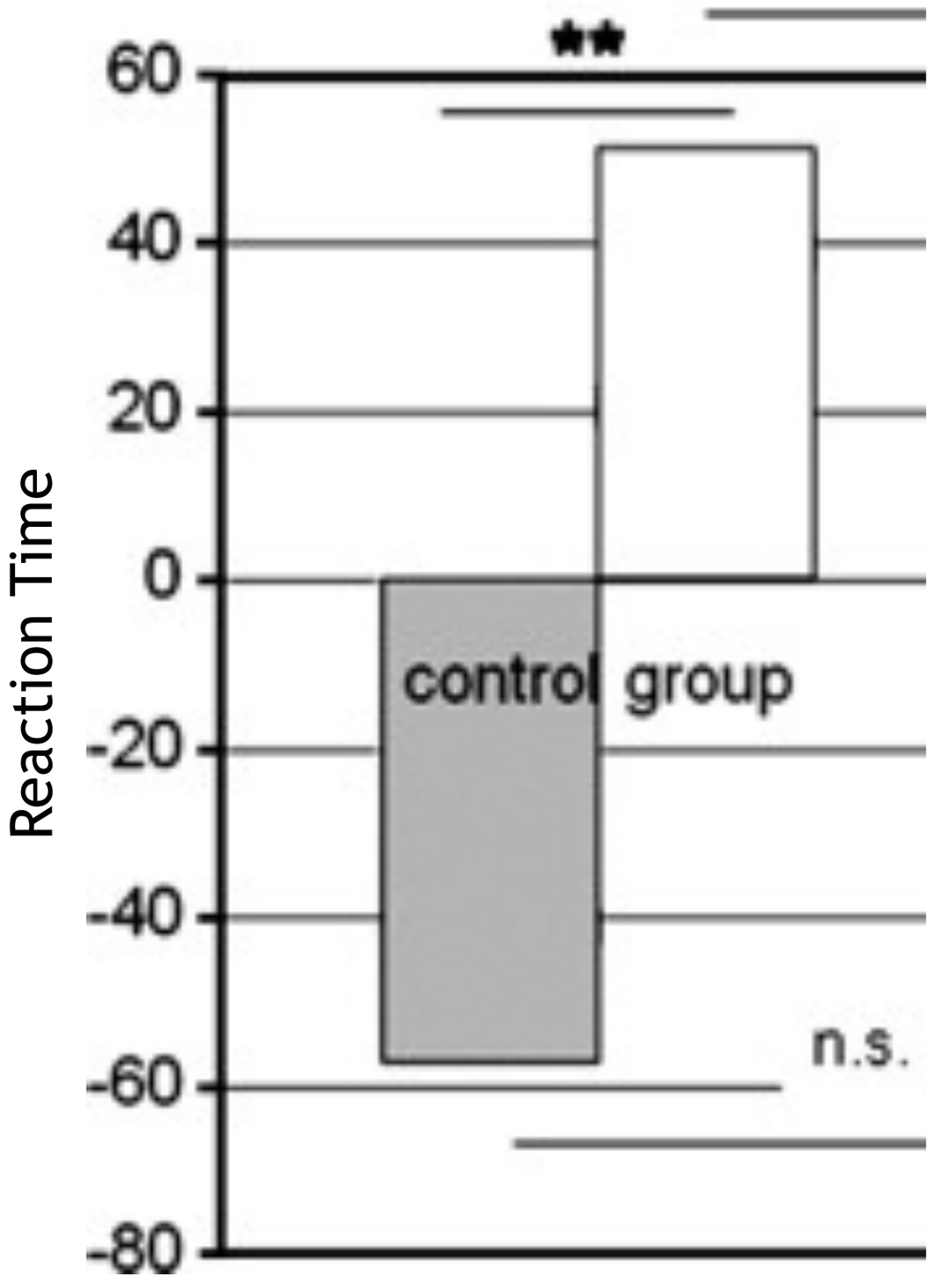


Measuring Cognitive Control with the Go/No-Go Test

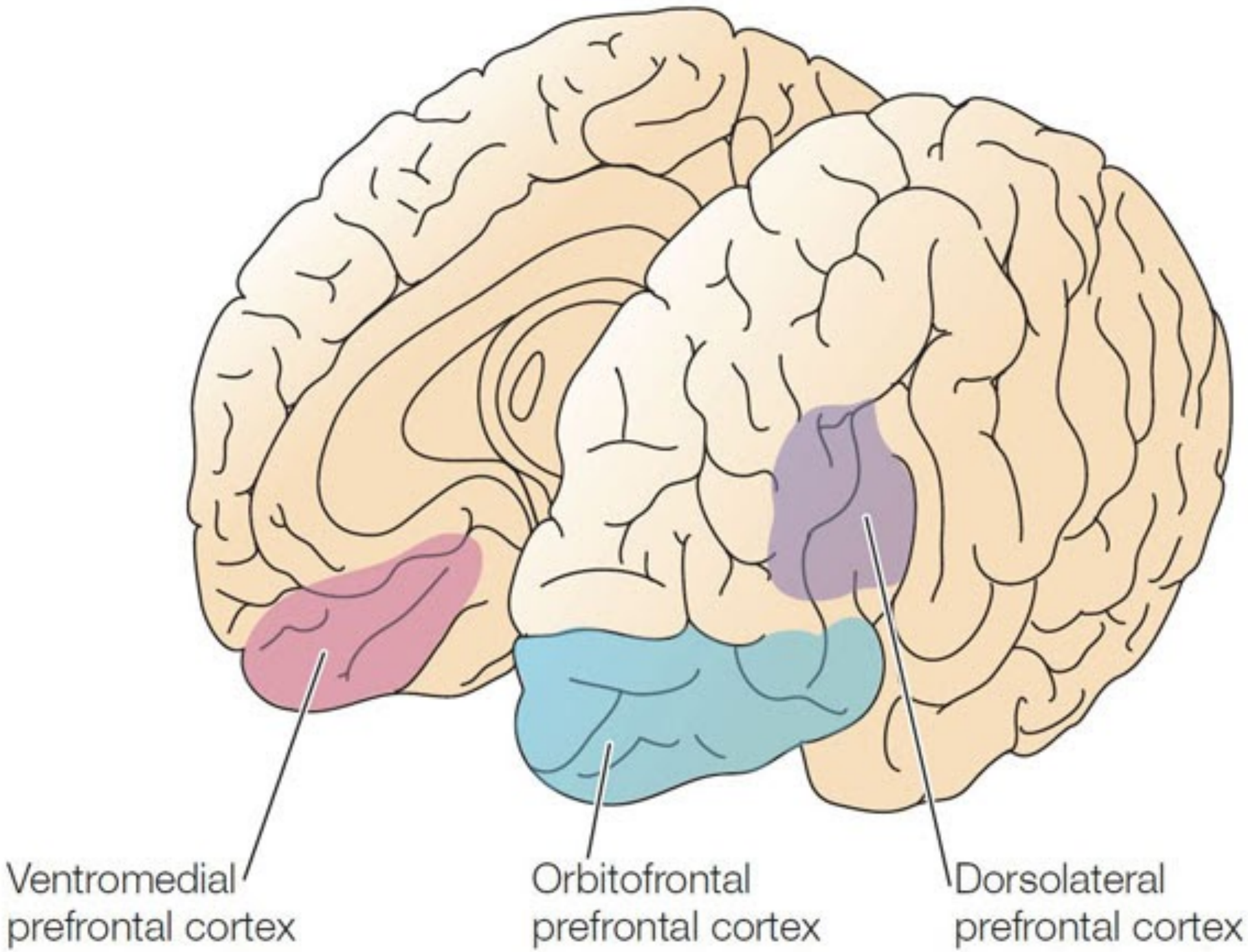
Measuring Cognitive Control with the Go/No-Go Test

Measuring Cognitive Control with the Go/No-Go Test

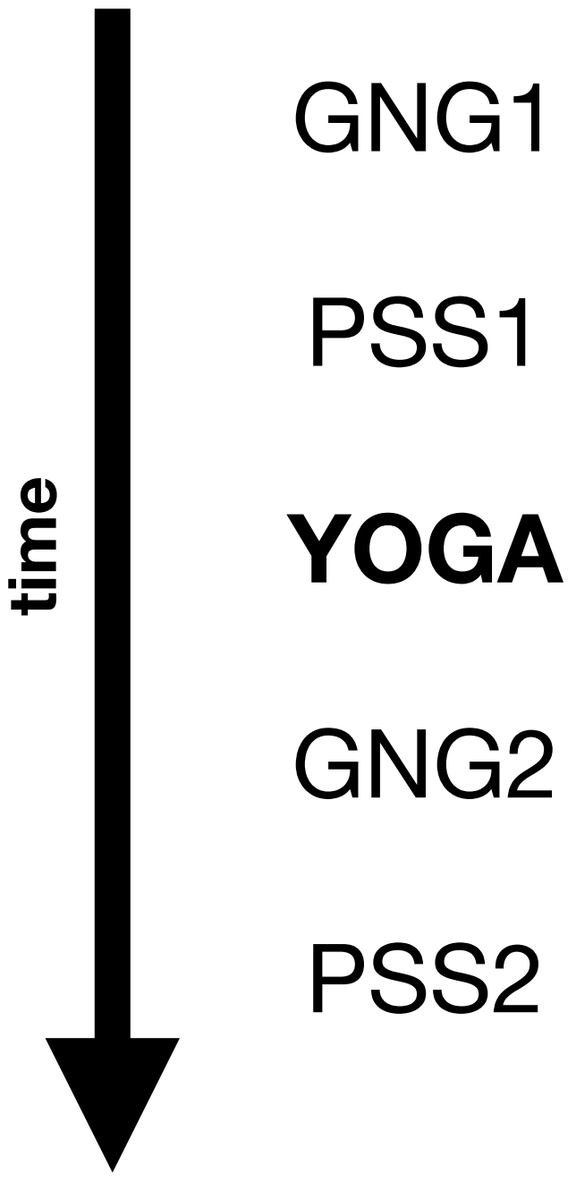
Wasn’t that hard?


Reaction Time
60
40
20
0
-20
-40
-60
-80
**
control group
n.s.

Dorsolateral Prefrontal Cortex Flexibly Switches How Motor Response Link to Perceptual Inputs



Experimental Design

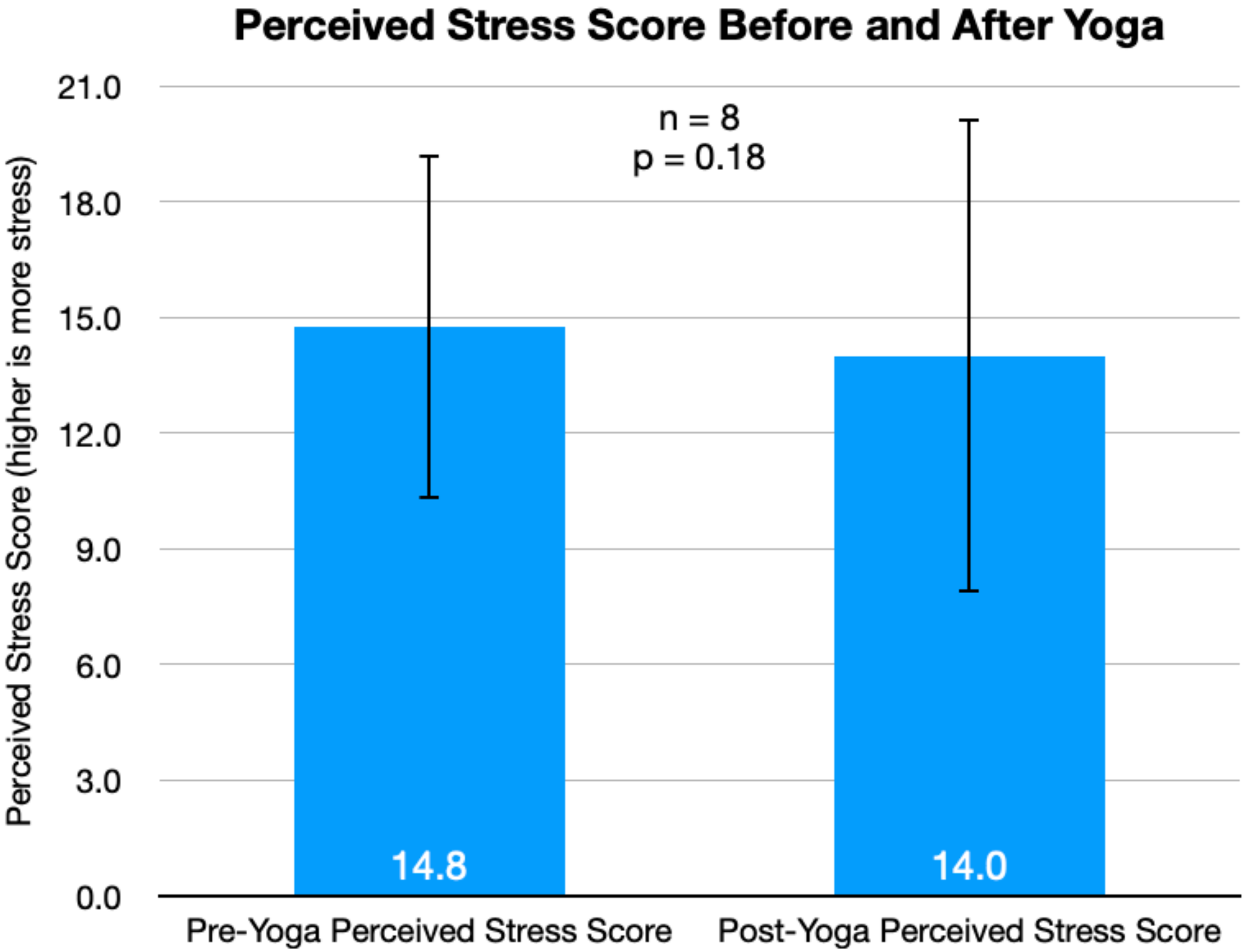


Our Hypotheses

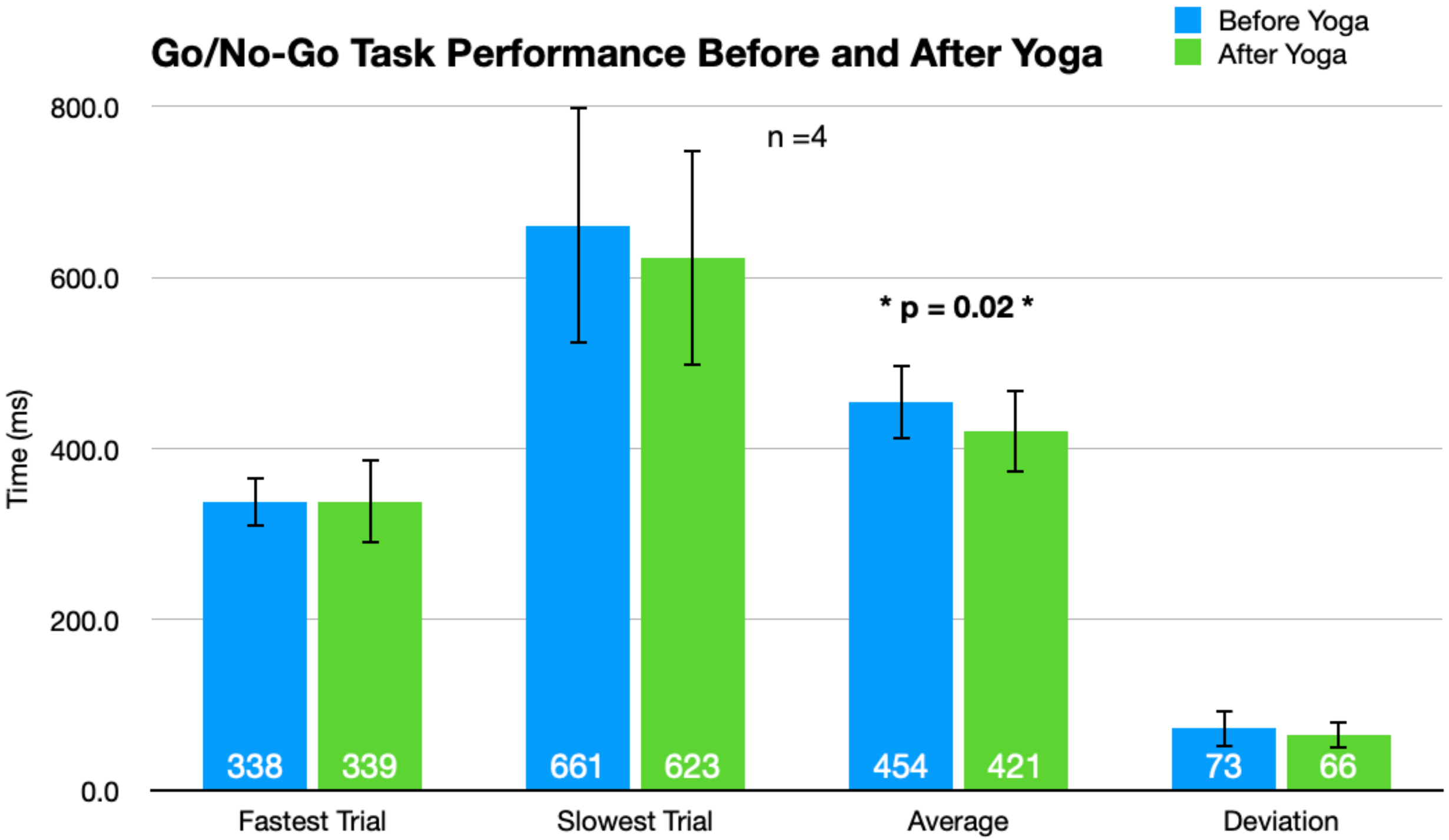
1. PSS2 will be lower than PSS1, because yoga will reduce the identification and experience of stimuli as stressors

2. The reaction time on GNG2 will be lower than on GNG1, because yoga reduces the effects of stress

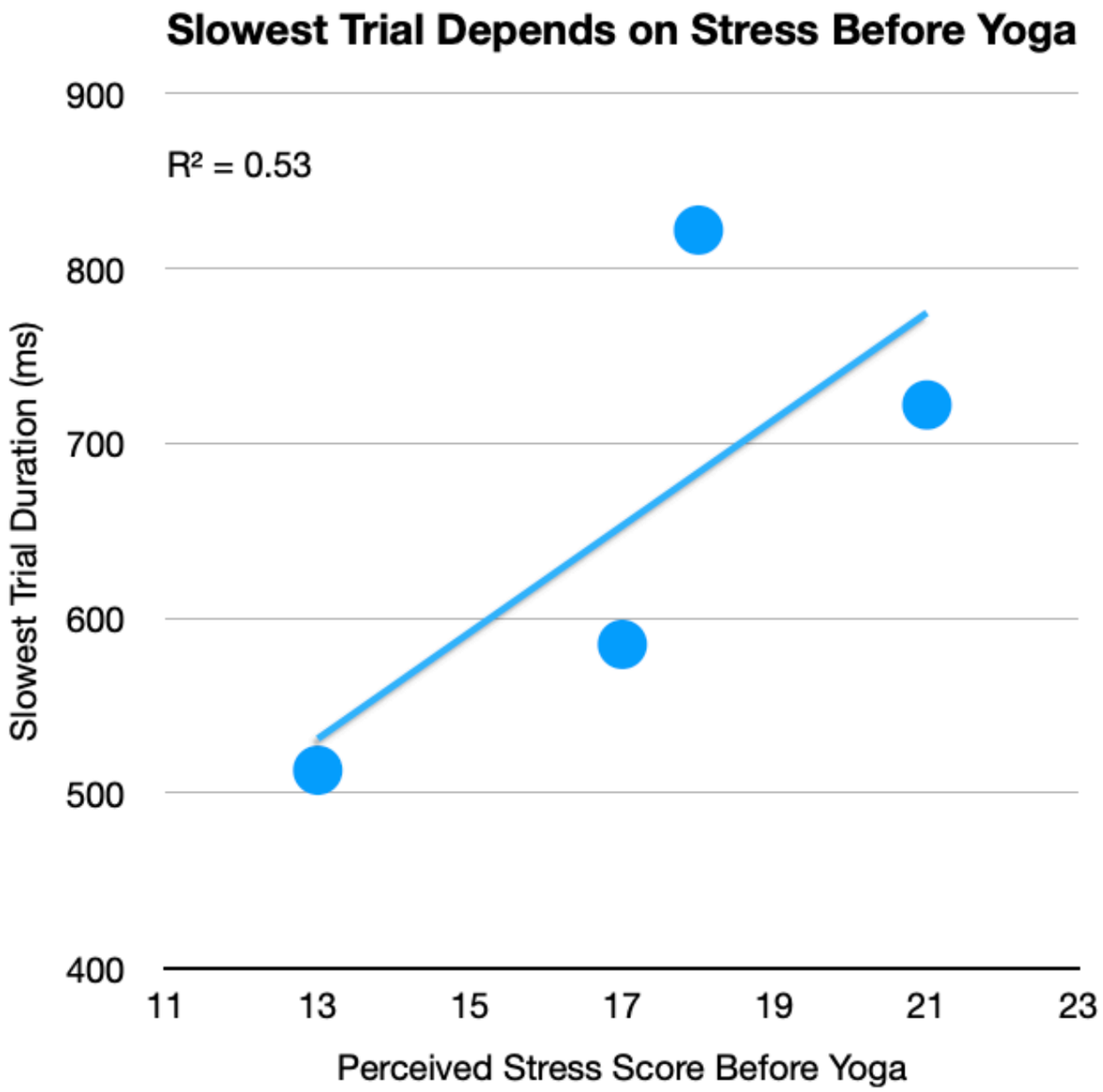
3. Changes in GNG will correlate with changes in PSS, because stress affects performance on the GNG task

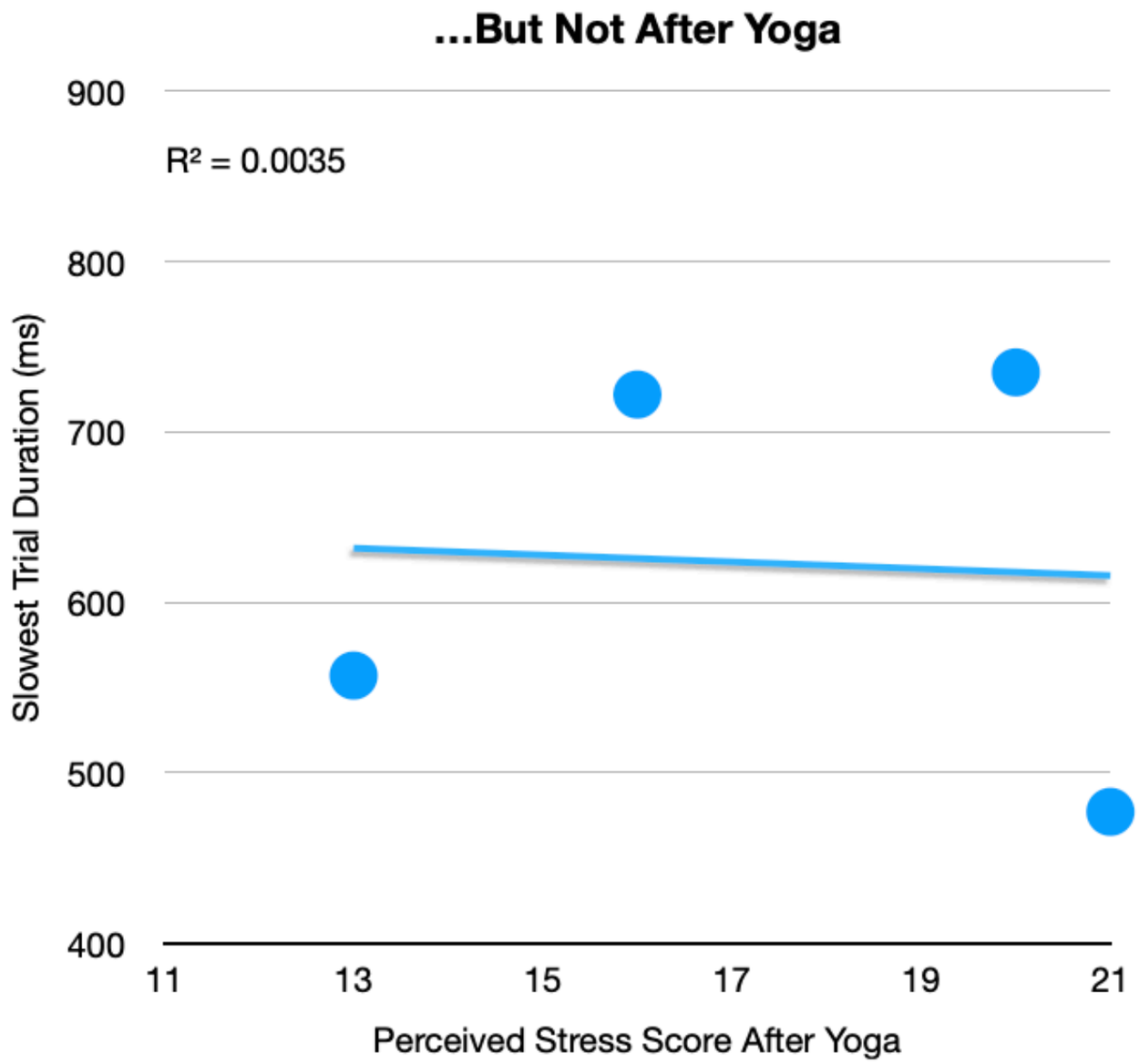


Interpretation: after yoga, participants trended to have less perceived stress



Interpretation: after yoga, individuals had significantly faster average reaction time in the GNG task, and trended to have faster slower trial times





Interpretation: slowest reaction time correlated strongly with perceived stress before yoga, but not after yoga, suggesting yoga prevented stress from affecting performance

Conclusions

1. PSS2 will be lower than PSS1, because yoga will reduce the identification and experience of stimuli as stressors
    - **Verdict**: ✅ yup! There was a trend towards decreased stress response, supporting the model that yoga impacts higher order stress networks in the brain.

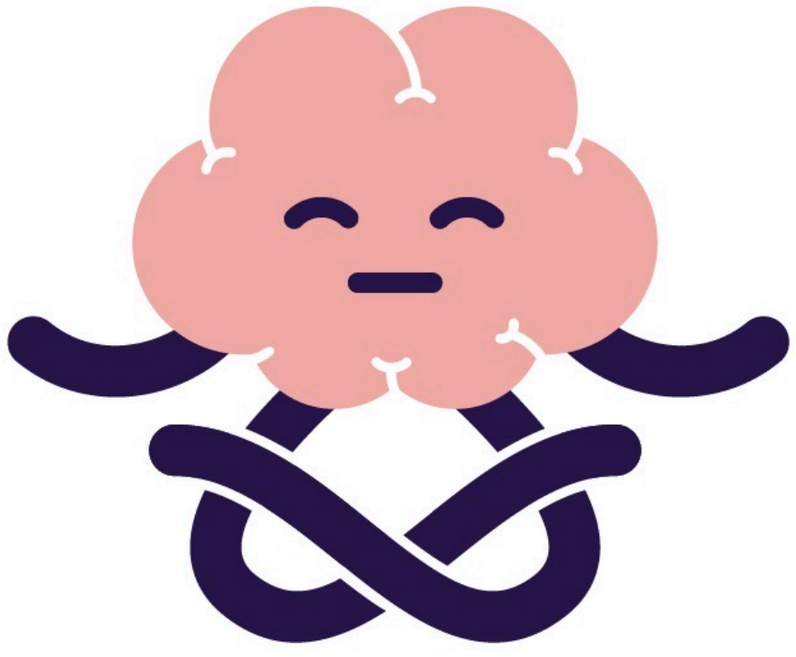
2. The reaction time on GNG2 will be lower than on GNG1, because yoga reduces the effects of stress
    - **Verdict**: ✅ yup! Average reaction time significantly improved after yoga, though of course practice effects contributed to this. A better version of this study would have a control group.

3. Changes in GNG will correlate with changes in PSS, because stress affects performance on the GNG task
    - **Verdict**: ✅ yup! Correlations with small sample sizes are very tricky; we cautiously report that slower reaction times on the GNG task were associated with higher PSS before yoga, but not after yoga, suggesting yoga weakened the effects of stress on performance in the GNG task

Questions?

Yoga + Brain Aging

Experiment Results



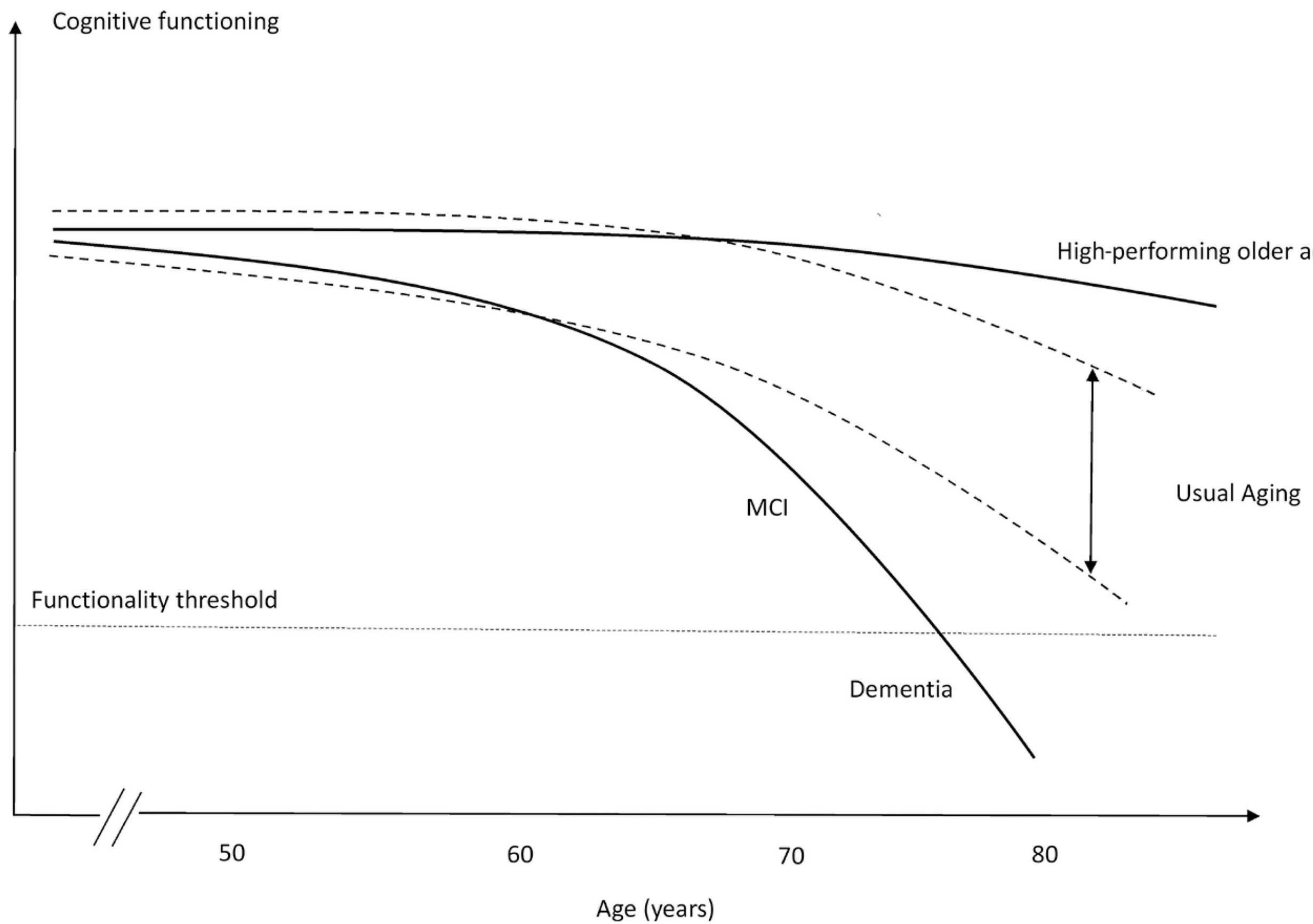
Definitions

- **Positive and Negative Affect Schedule (PANAS):** a validated subjective measure of the tendency to experience stimuli positively and negatively

- **Concentration Grid task**: a measure of sustained attention in a visual search task, where you find ordered numbers in a gigantic grid

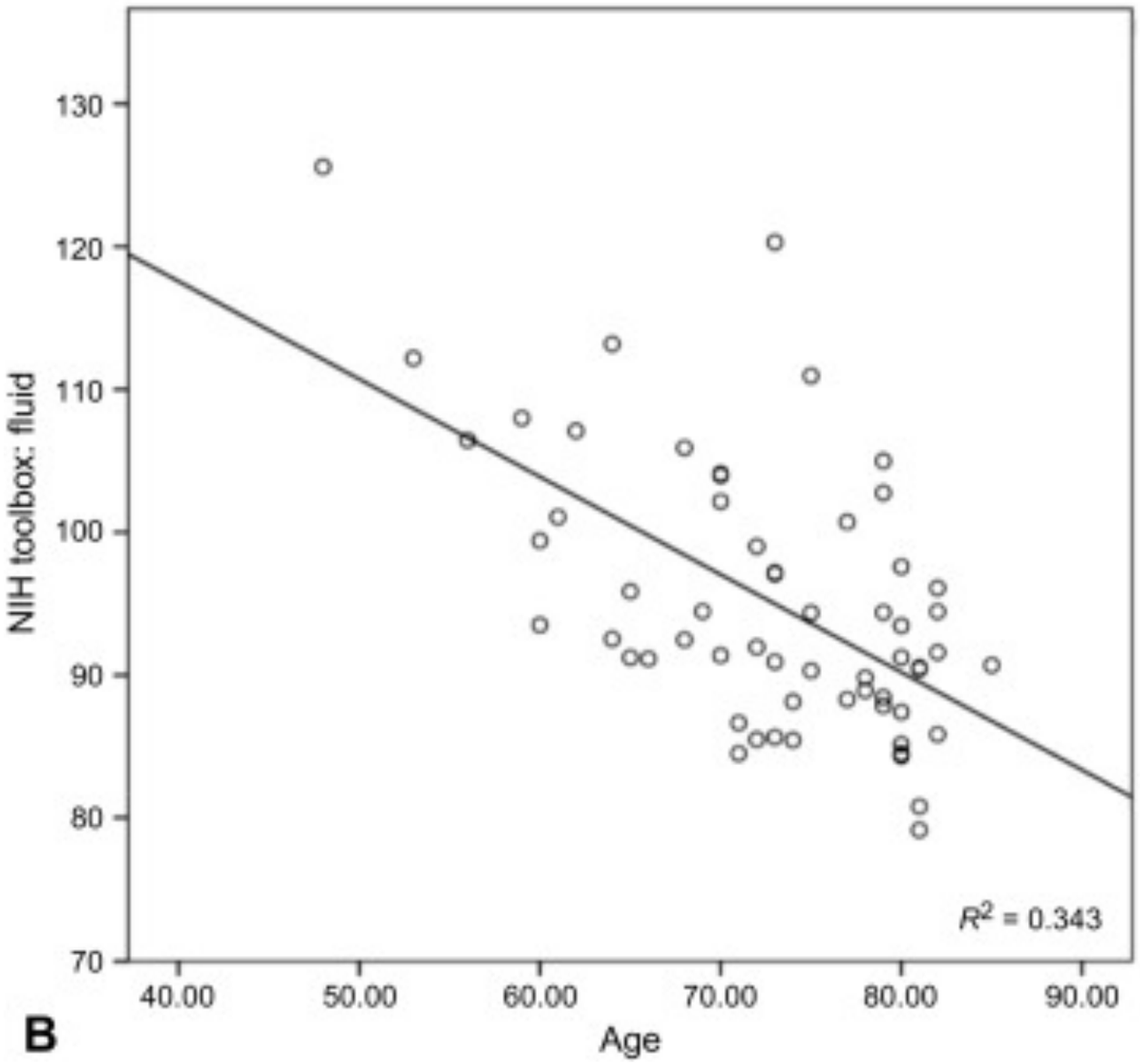
66	42	45	52	22	49	20	85	10	61
13	57	43	72	07	28	21	51	88	56
55	78	74	25	23	17	68	05	69	91
06	12	37	53	36	58	04	67	29	63
01	92	03	15	71	50	83	19	81	46
82	73	80	62	09	59	89	95	76	34
32	38	65	11	64	77	08	79	47	35
87	16	99	44	98	96	75	02	39	27
24	33	41	30	60	14	54	94	86	18
00	48	26	84	90	93	31	70	40	97

Cognition over time as people age

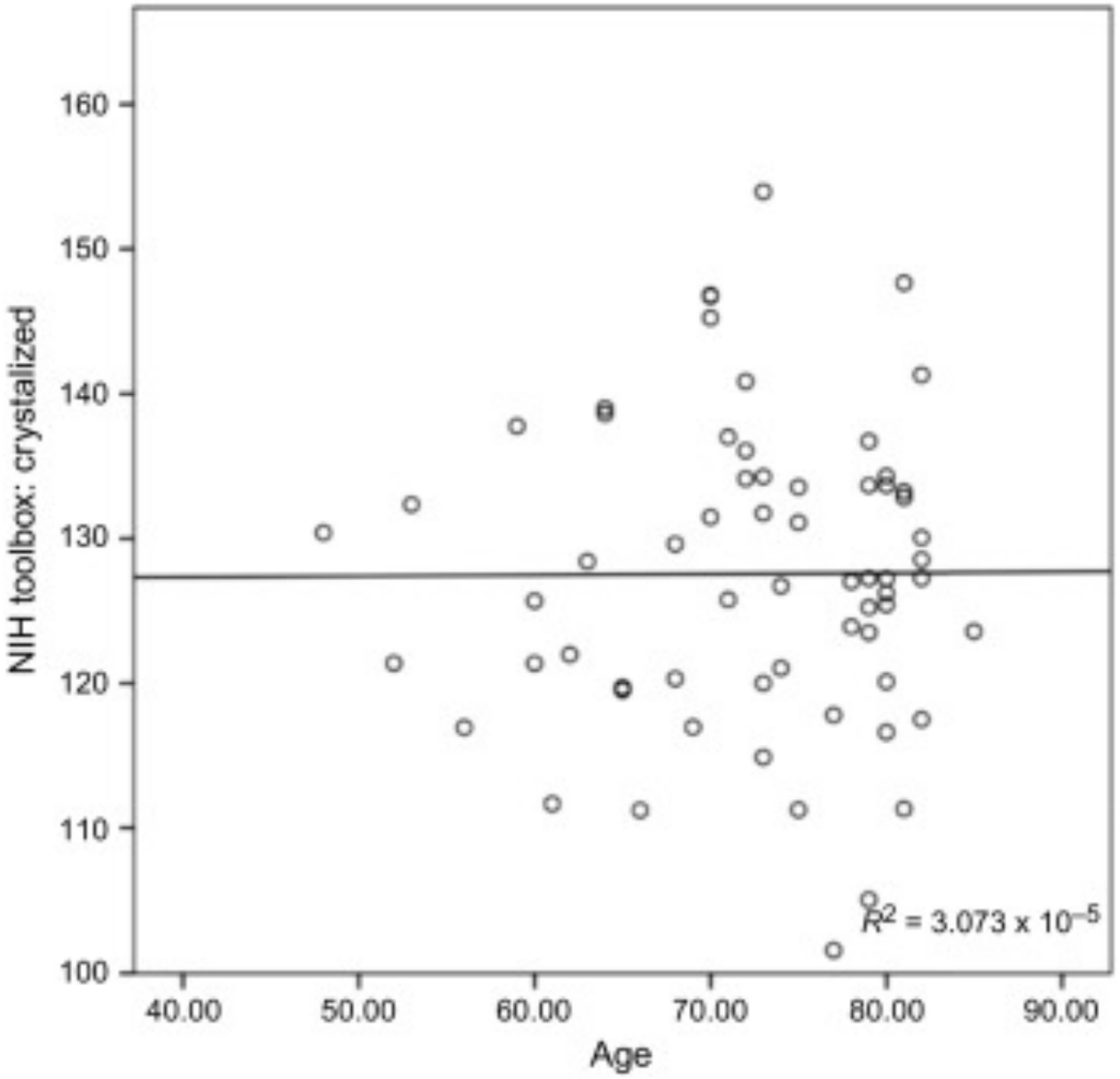


Cognition over time as people age

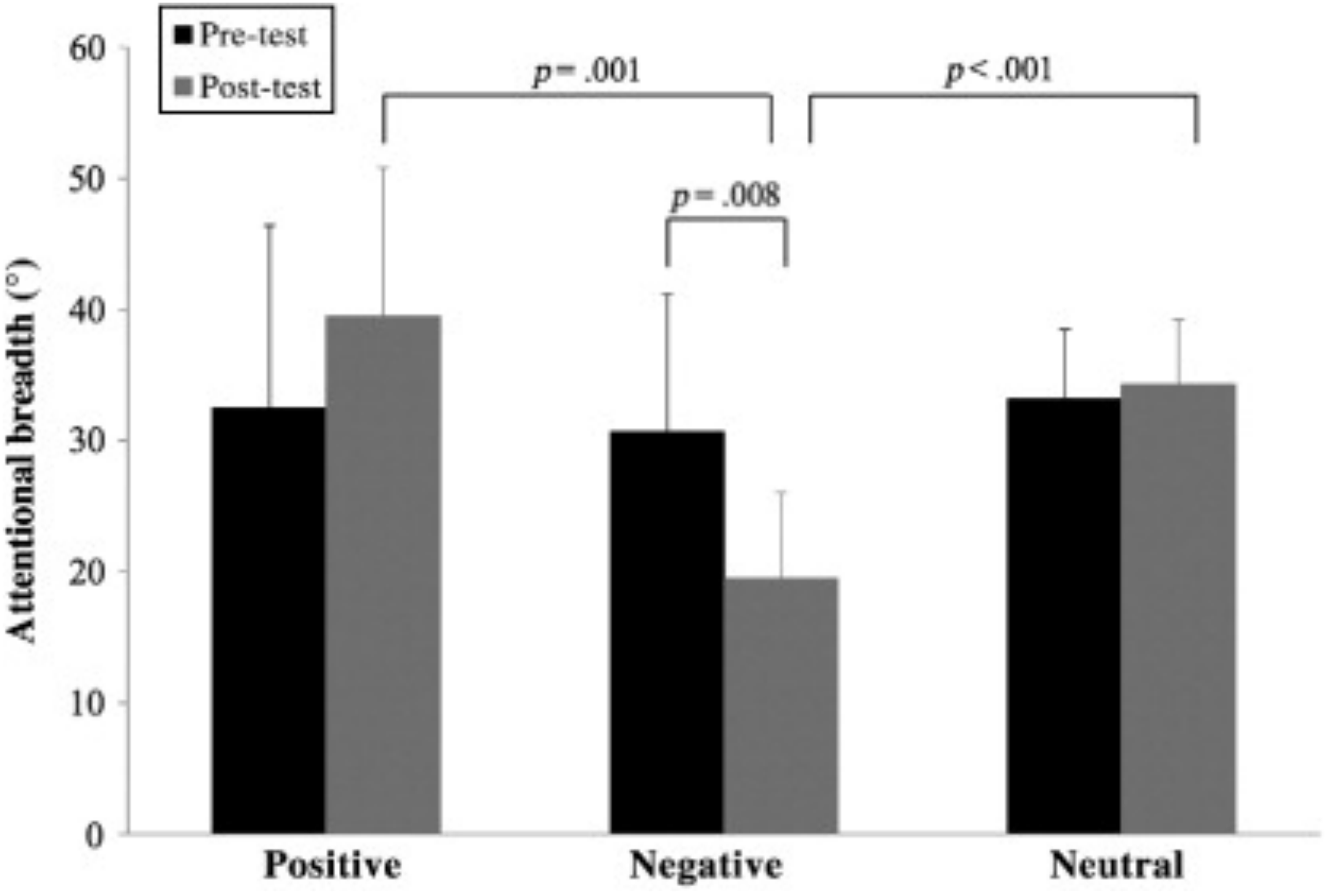
Fluid cognition declines with age but not crystallized cognition



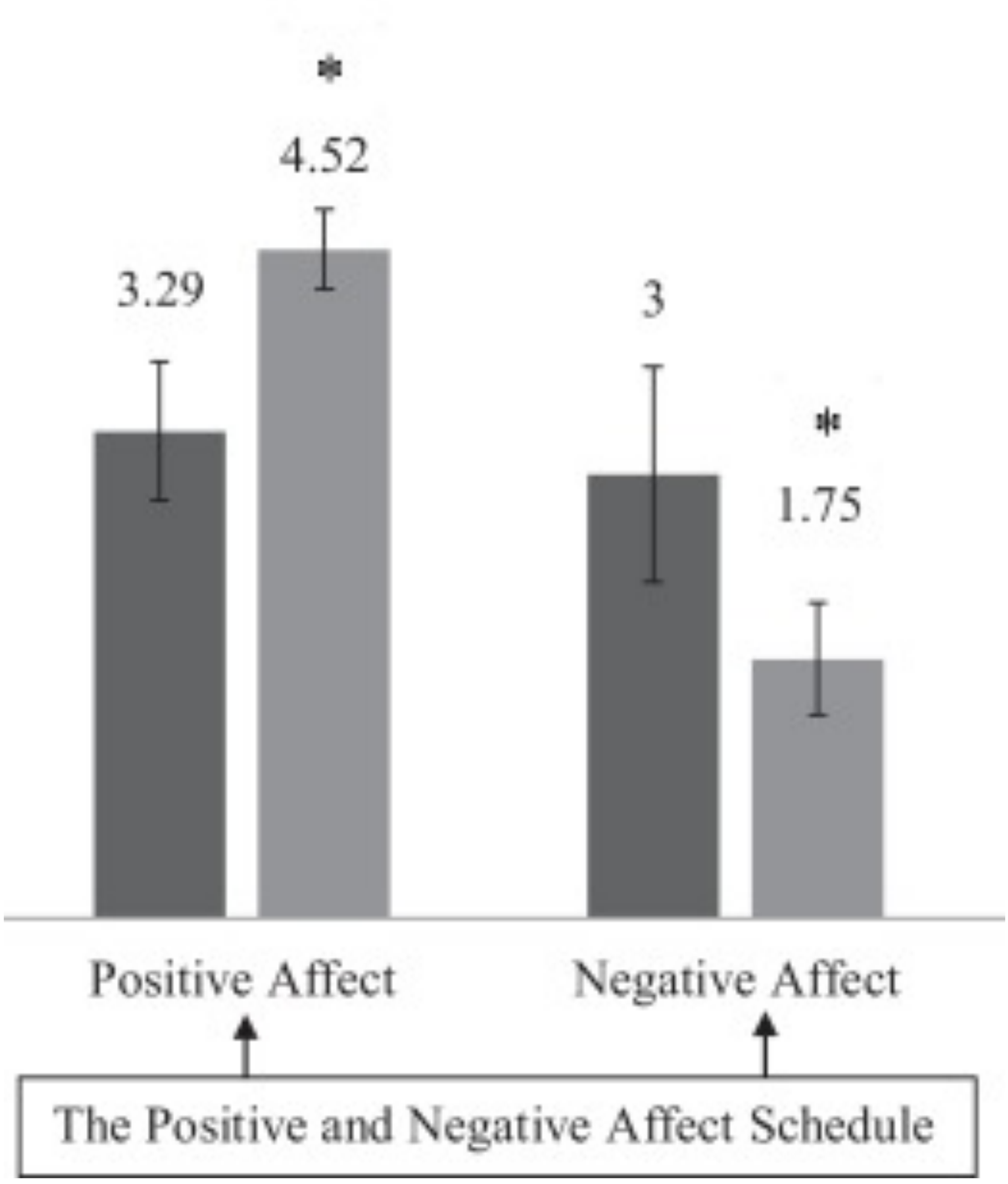
B



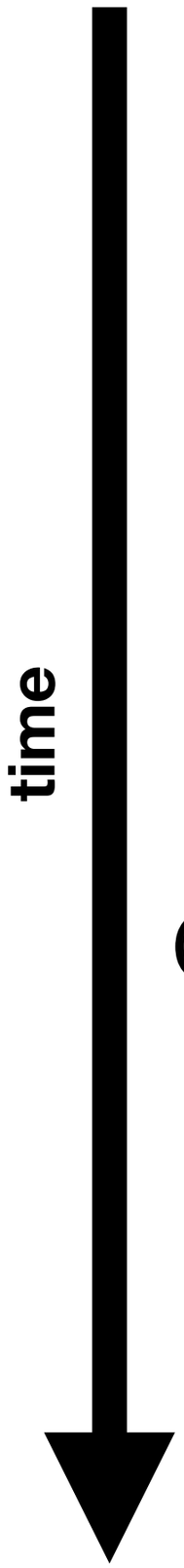
Mood affects visual attention



Yoga affects mood



Experimental Design



Concentration Grid 1

PANAS 1

YOGA

Concentration Grid 2

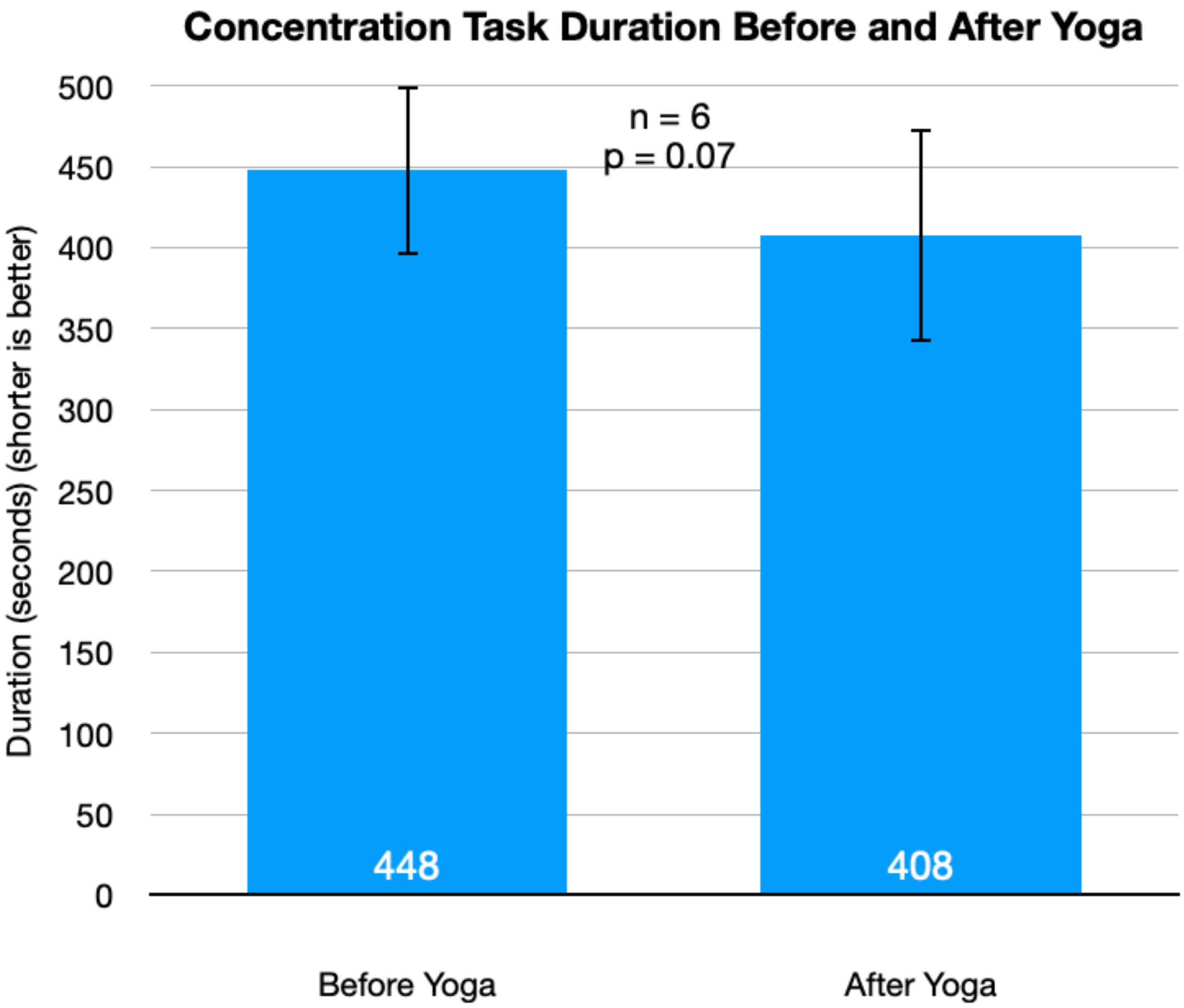
PANAS 2

Our Hypotheses

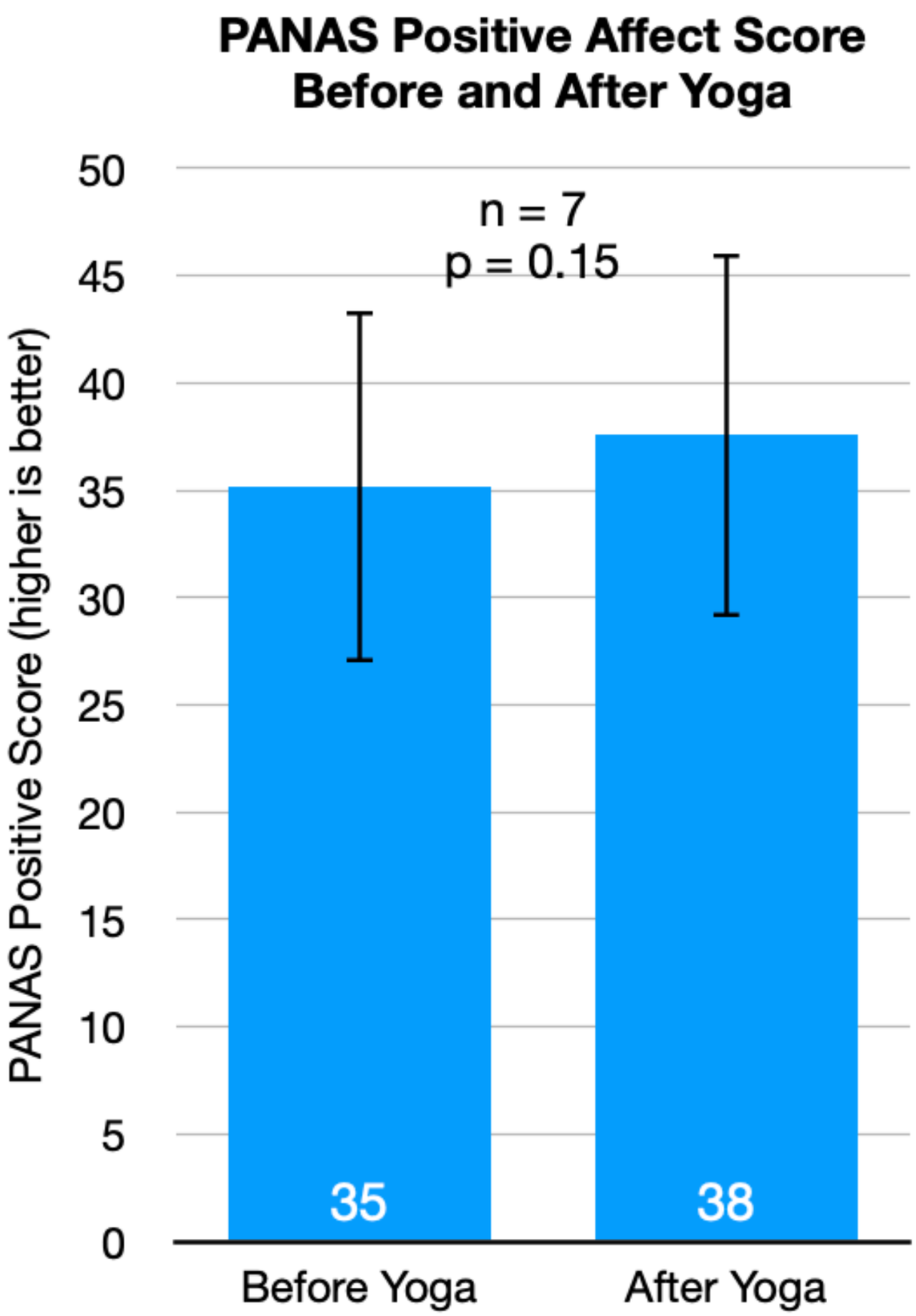
1. PANAS2 will show more positive affect and less negative affect than PANAS1, because yoga will improve mood

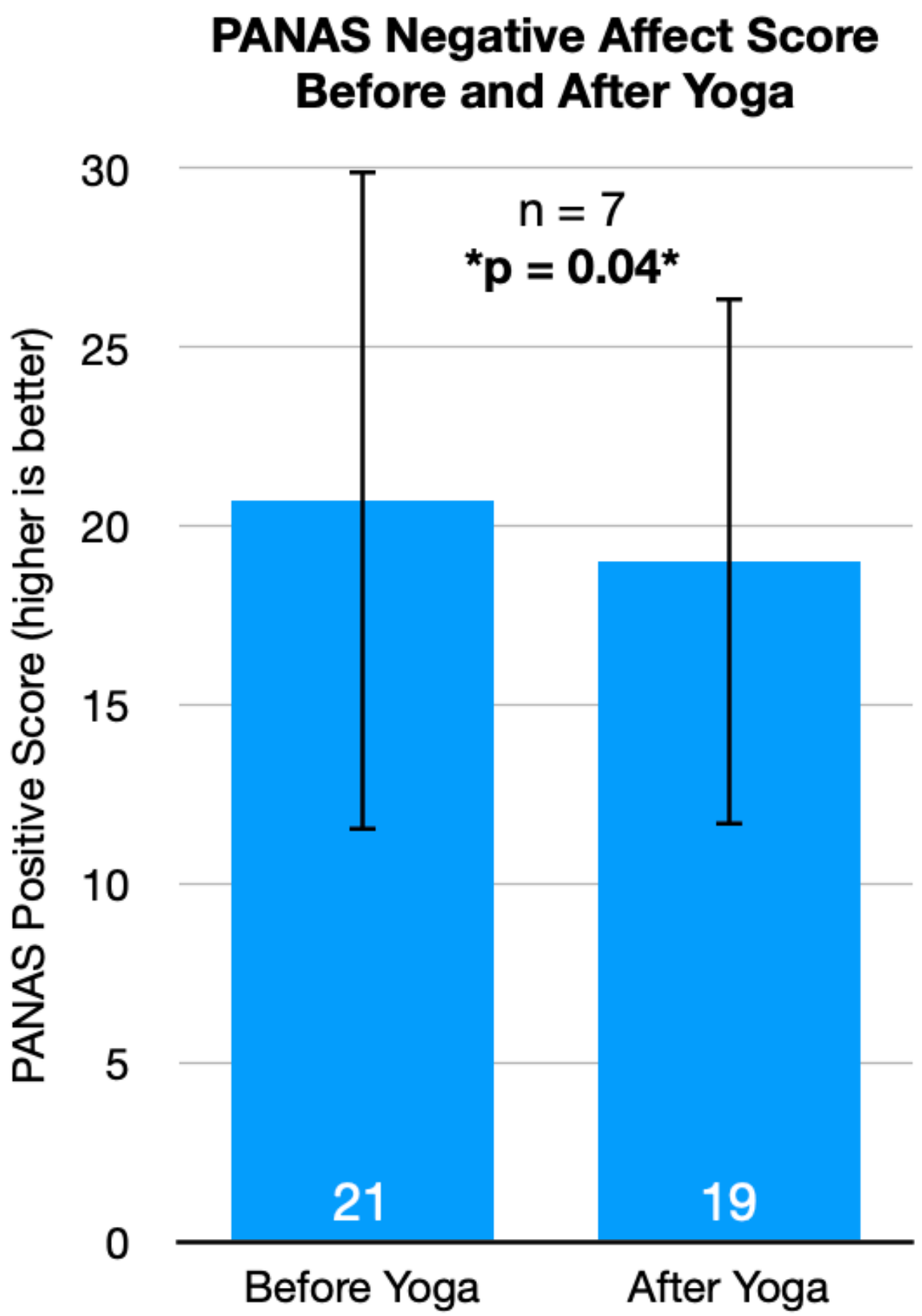
2. CG2 will take less time than CG1, because yoga will improve visual attention

3. Improvements in PANAS will correlate with improvements in CG, because mood may be one of the drivers of visual attention

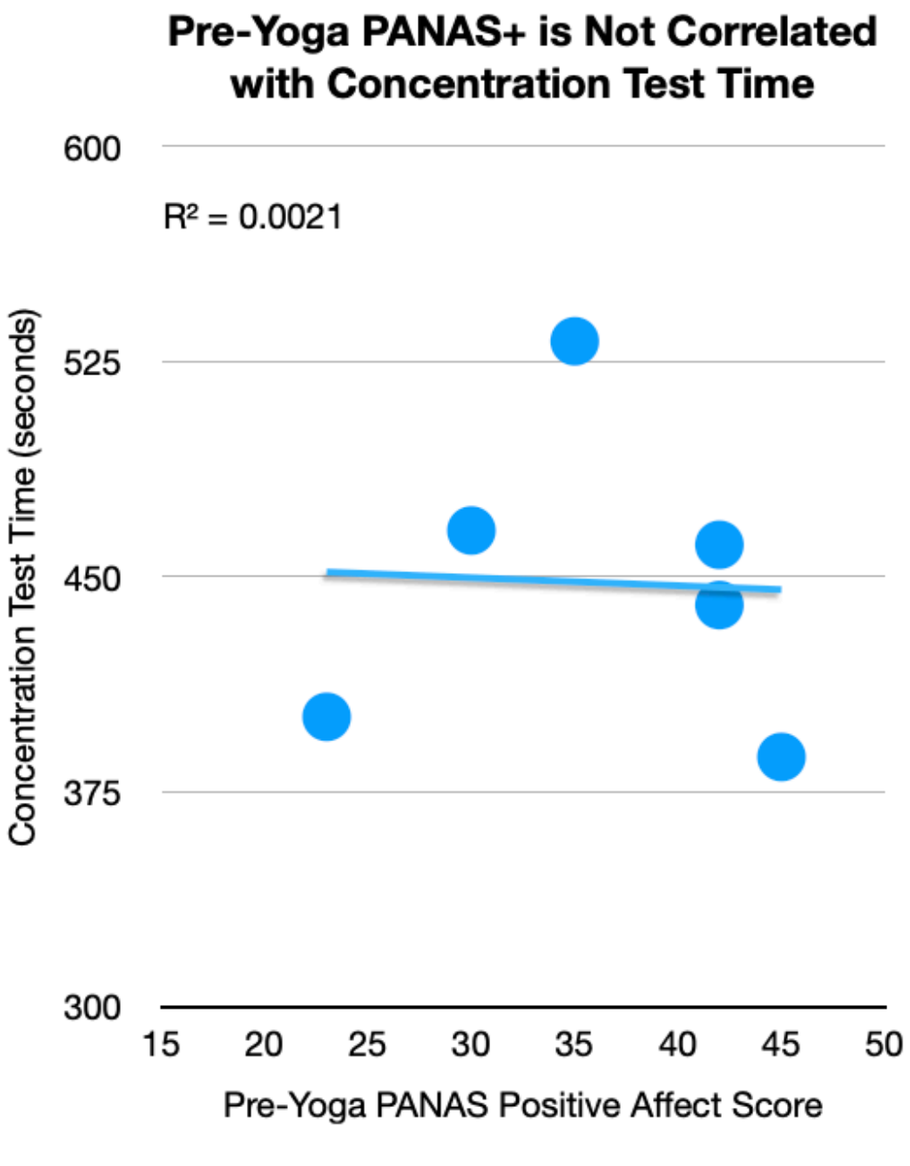


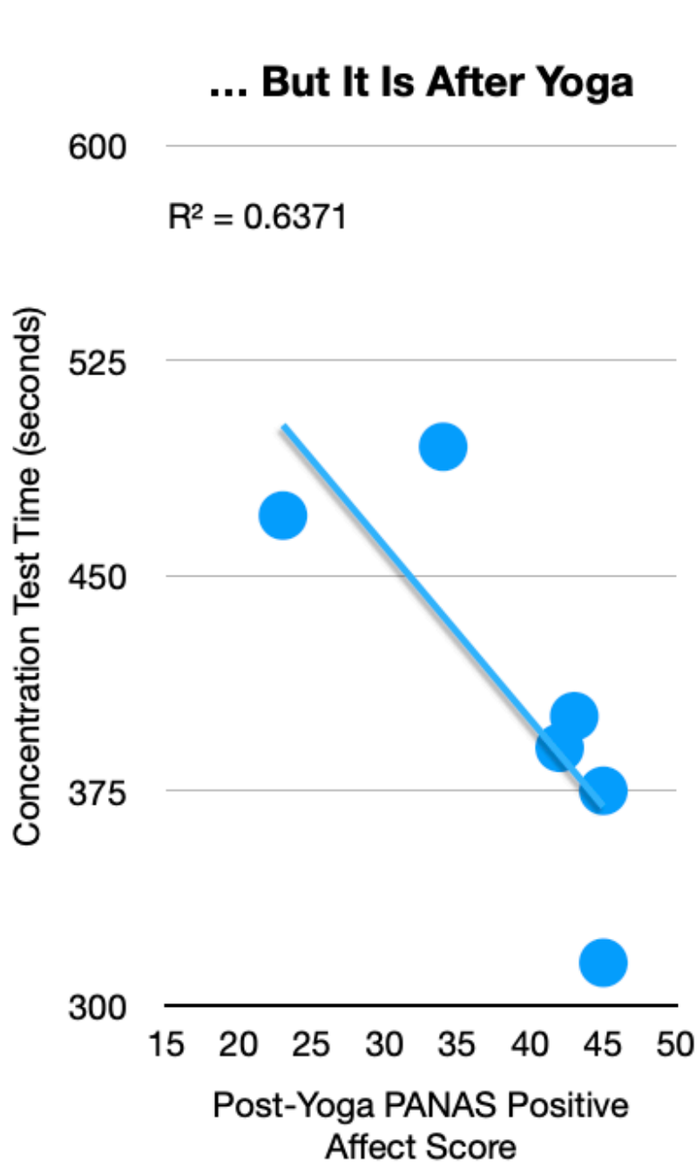
Interpretation: concentration task performance trended towards faster performance (better visual attention)

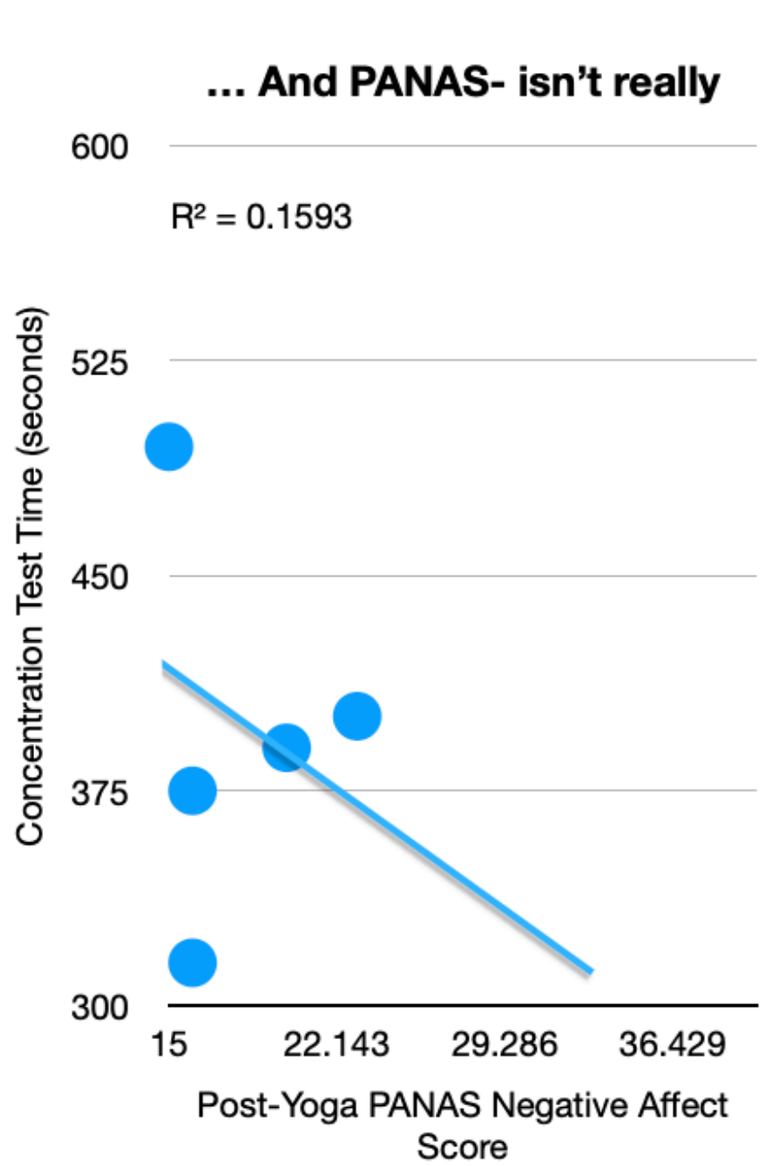




Interpretation: after yoga, participants had significantly lower negative affect, and trended towards higher positive affect







Interpretation: after yoga, but not before, there is a relationship of positive affect to speed on the concentration grid

Conclusions

1. PANAS2 will show more positive affect and less negative affect than PANAS1, because yoga will improve mood
    - **Verdict**: ✅ yes, positive affect trended towards increase, and negative affect significantly decreased. This suggests broad effects of yoga on many mood networks in the brain.

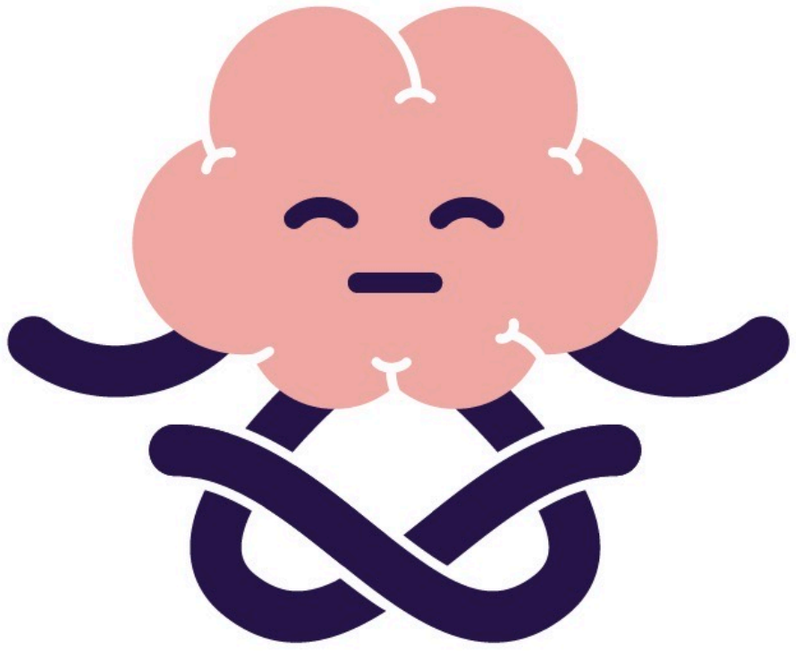
2. CG2 will take less time than CG1, because yoga will improve visual attention.
    - **Verdict**: ✅ yes, there was a trend towards faster performance, but there is of course practice effect contributing to this.

3. Improvements in PANAS will correlate with improvements in CG, because mood may be one of the drivers of visual attention
    - **Verdict**: ✅ yes! there was a correlation of positive affect with performance on the CG after yoga, but not before yoga. This strengthens the argument that some of the improvement in reaction time in CG2 was related to yoga's effects on mood.

Questions?

Yoga + Addiction

Experiment Results

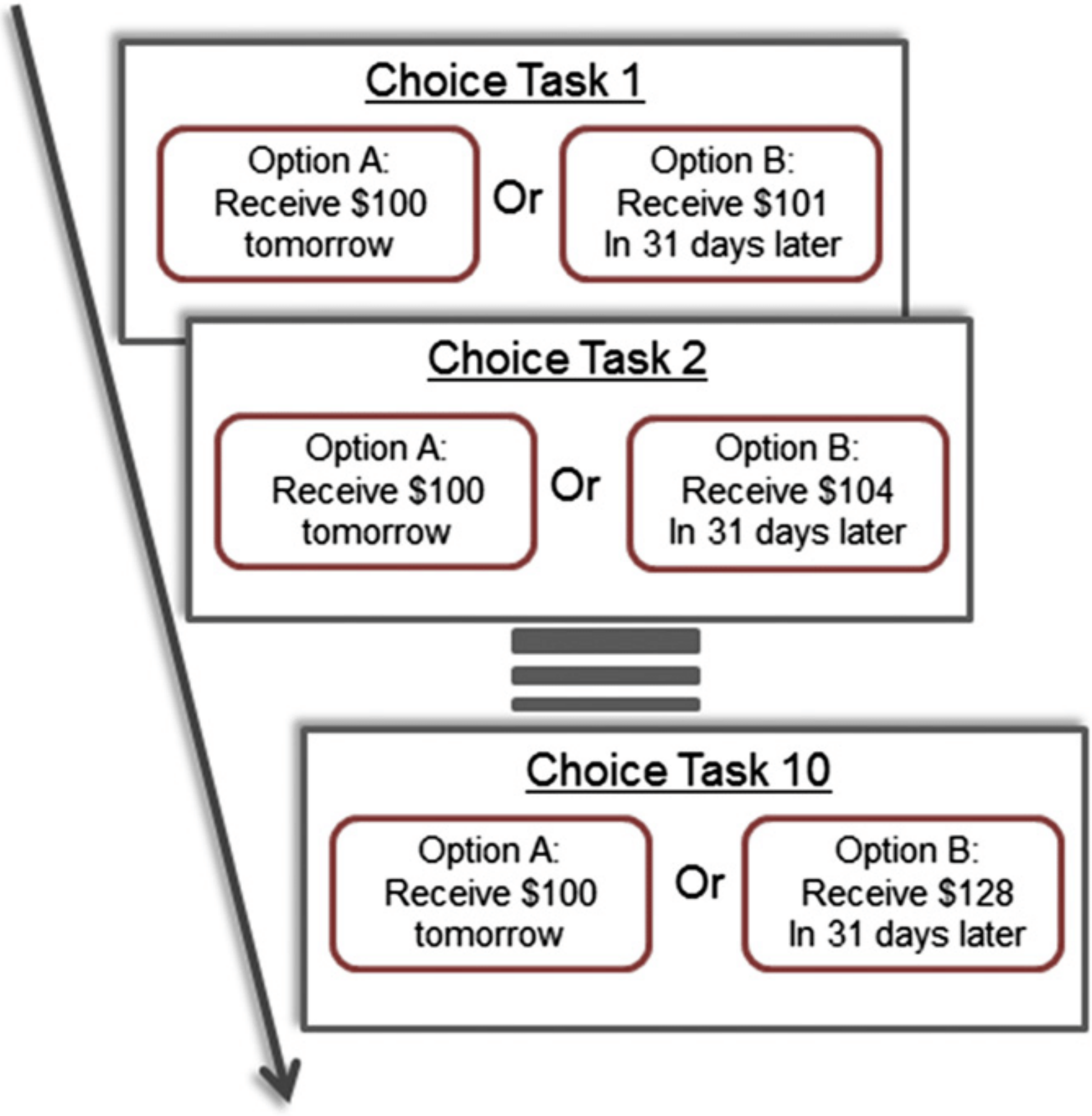


Definitions

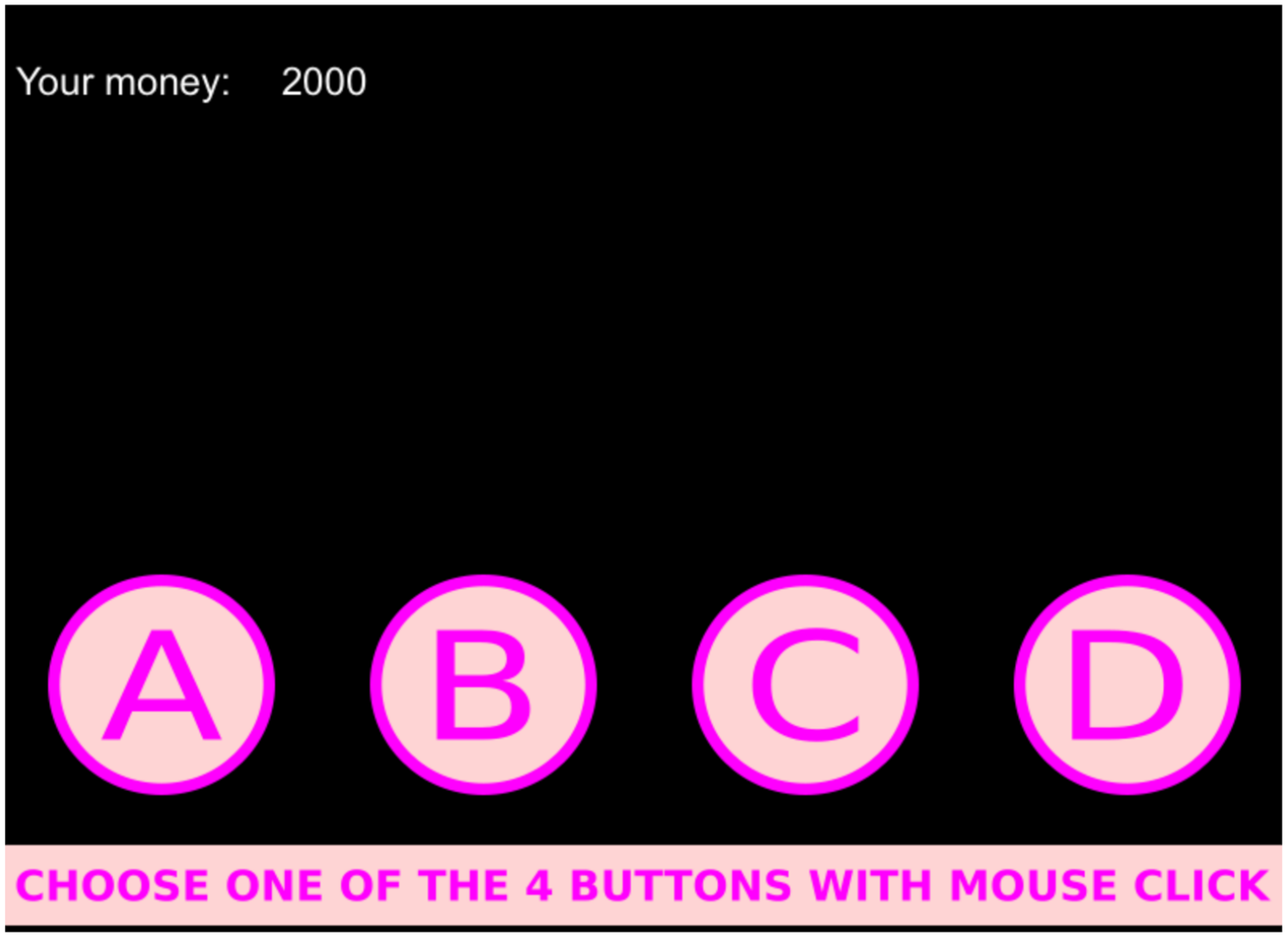
- **Temporal Discounting**: an individual's tendency to perceive the same objective value in the future as less valuable than one in the present. For example, $50 today is more valuable than $50 in 10 years (even without inflation). We will report the ED50, which is how many days it takes for money to lose 50% of its value.

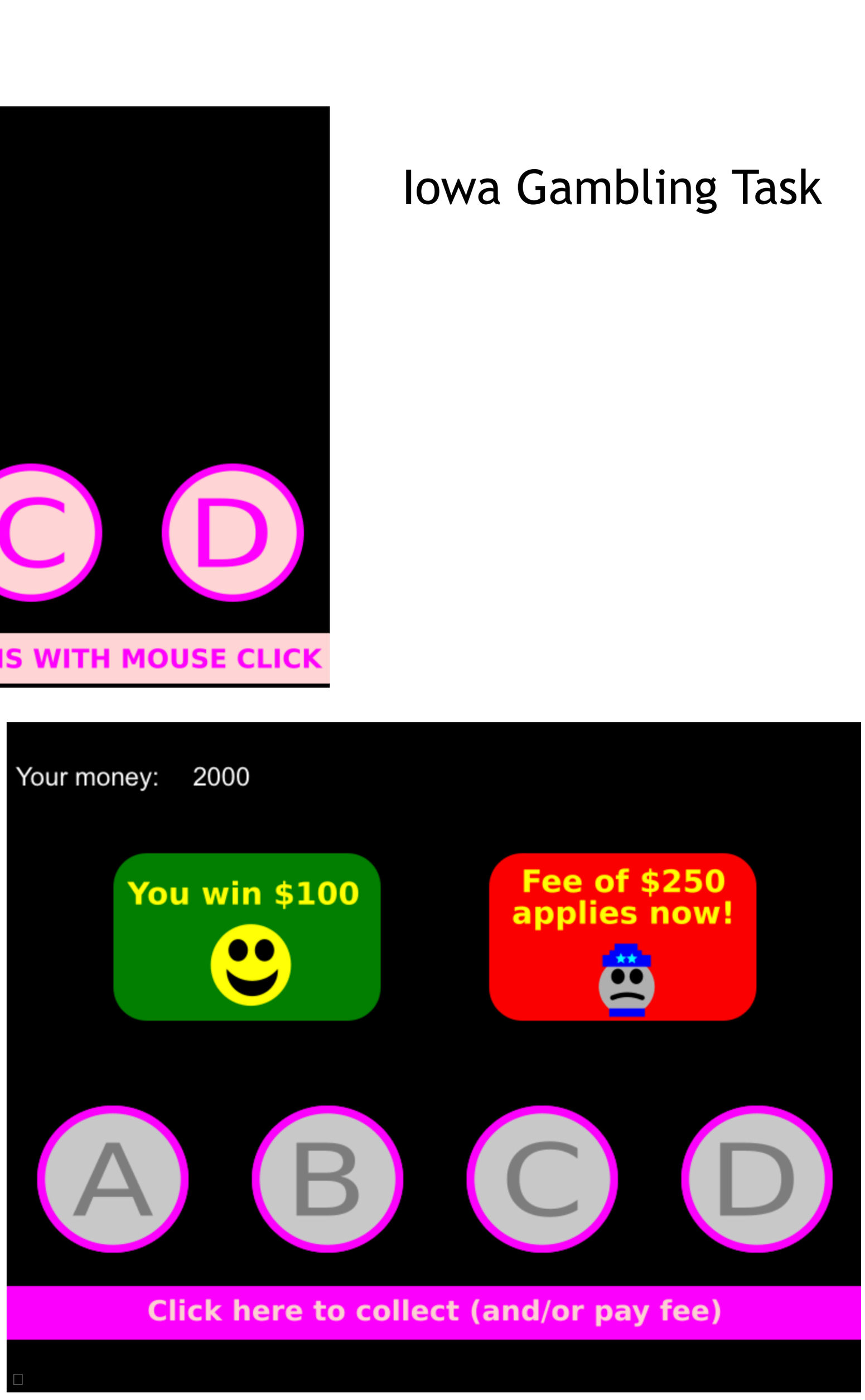
- **Iowa Gambling Task**: a measure of risk calculation in decision-making. Participants choose between high-risk high-reward options and low-risk low-reward options, demonstrating their risk tolerance.

Temporal Discounting



Iowa Gambling Task





Iowa Gambling Task

	A	B	C	D
Gain per card	$100	$100	$50	$50
Loss per card	$250	$250	$50	$50
Loss frequency	50%	50%	50%	50%
Net (10 trials)	-$250	-$250	$250	$250

Addiction and Temporal Discounting

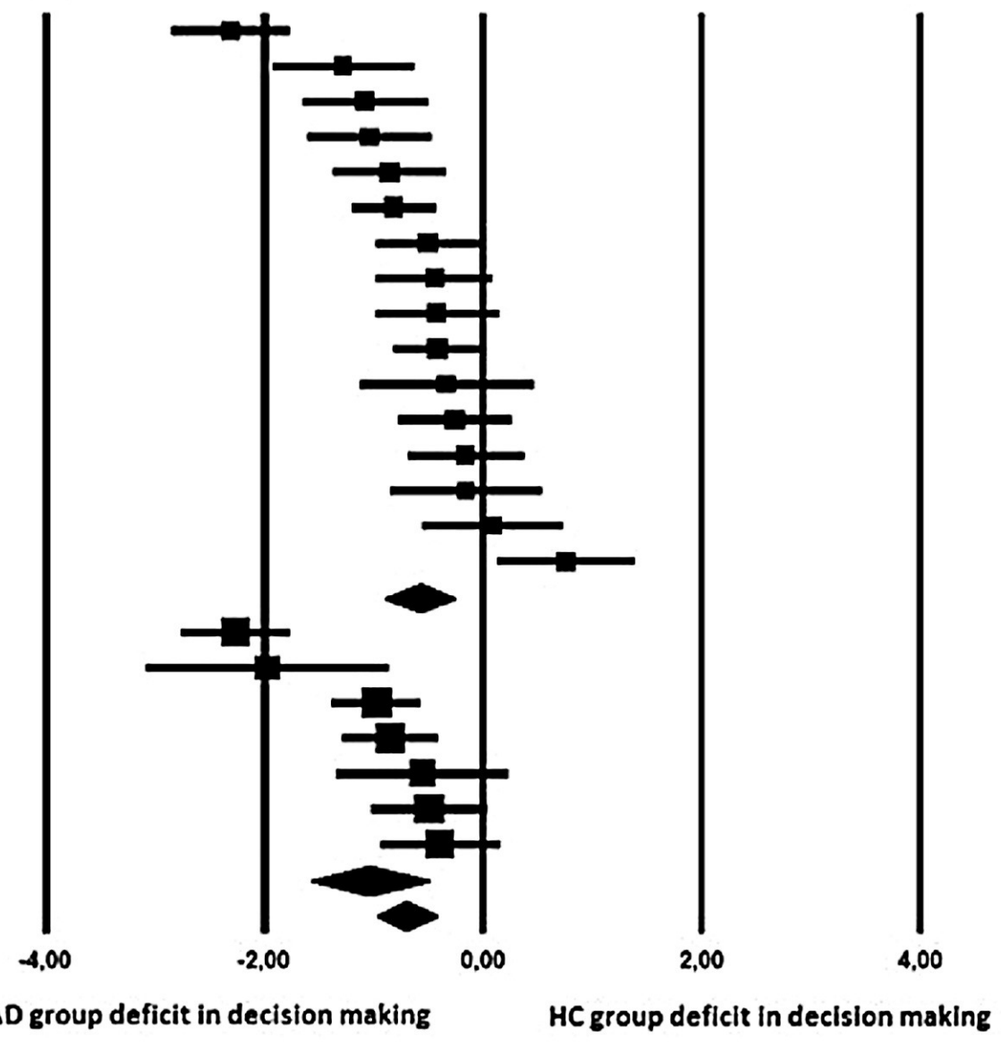
- Temporal discounting is a potentially useful behavioral marker of addiction.

- Temporal discounting correlates with addiction severity and predicts treatment outcome.

- Temporal discounting and addiction may share some genetic and neurological components.

Addiction and Iowa Gambling Task

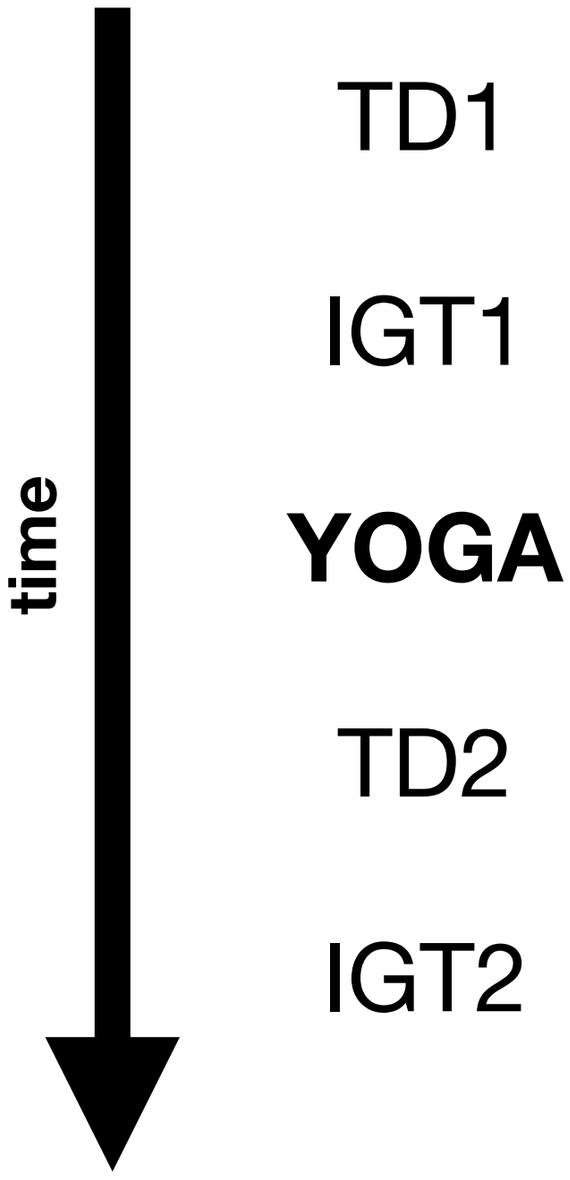
Subgroup within study	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
1	Dom et al., 2006 C	-2,301	0,273	0,074	-2,836	-1,767	-8,444	0,000
1	Kim et al., 2011	-1,274	0,331	0,110	-1,923	-0,625	-3,849	0,000
1	Cordovil et al., 2006 B	-1,074	0,290	0,084	-1,643	-0,506	-3,703	0,000
1	Cordovil et al., 2006 A	-1,034	0,289	0,083	-1,601	-0,468	-3,582	0,000
1	Dom et al., 2006 B	-0,851	0,259	0,067	-1,358	-0,343	-3,284	0,001
1	Bottesi et al., 2015	-0,813	0,193	0,037	-1,191	-0,434	-4,208	0,000
1	Berre et al., 2014	-0,500	0,239	0,057	-0,969	-0,031	-2,090	0,037
1	Murray et al., 2015	-0,438	0,269	0,072	-0,965	0,089	-1,628	0,103
1	Tomassini et al., 2012	-0,417	0,284	0,080	-0,973	0,139	-1,470	0,142
1	Kräplin et al., 2014	-0,407	0,205	0,042	-0,809	-0,006	-1,989	0,047
1	Zorlu et al., 2014	-0,331	0,403	0,162	-1,121	0,459	-0,822	0,411
1	Kim et al., 2006 B	-0,253	0,264	0,070	-0,770	0,264	-0,959	0,338
1	Dom et al., 2006 A	-0,155	0,268	0,072	-0,680	0,370	-0,578	0,563
1	Zorlu et al., 2013	-0,153	0,349	0,122	-0,837	0,530	-0,439	0,660
1	Miranda et al., 2009 B	0,093	0,326	0,107	-0,547	0,733	0,285	0,776
1	Miranda et al., 2009 A	0,763	0,316	0,100	0,144	1,382	2,415	0,016
Means for AD		-0,581	0,160	0,026	-0,895	-0,266	-3,621	0,000
2	Kräplin et al., 2014	-2,261	0,251	0,063	-2,753	-1,769	-9,005	0,000
2	Rossi et al., 2009	-1,967	0,563	0,317	-3,070	-0,865	-3,497	0,000
2	Kertzman et al., 2011	-0,973	0,204	0,042	-1,373	-0,574	-4,775	0,000
2	Bottesi et al., 2015	-0,840	0,219	0,048	-1,268	-0,411	-3,837	0,000
2	Power et al., 2012	-0,550	0,400	0,160	-1,333	0,233	-1,376	0,169
2	Forbush et al., 2008	-0,486	0,267	0,071	-1,010	0,038	-1,819	0,069
2	Cavedini et al., 2002	-0,387	0,276	0,076	-0,928	0,154	-1,403	0,161
Means for GD		-1,034	0,269	0,072	-1,561	-0,507	-3,848	0,000
Means for AD & GD		-0,700	0,138	0,019	-0,970	-0,430	-5,081	0,000



Subgroups:
1: Alcohol Dependent Patients
2: Gambling Disorder Patients

Std diff in means = standardized mean difference
CI = confidence interval

Experimental Design

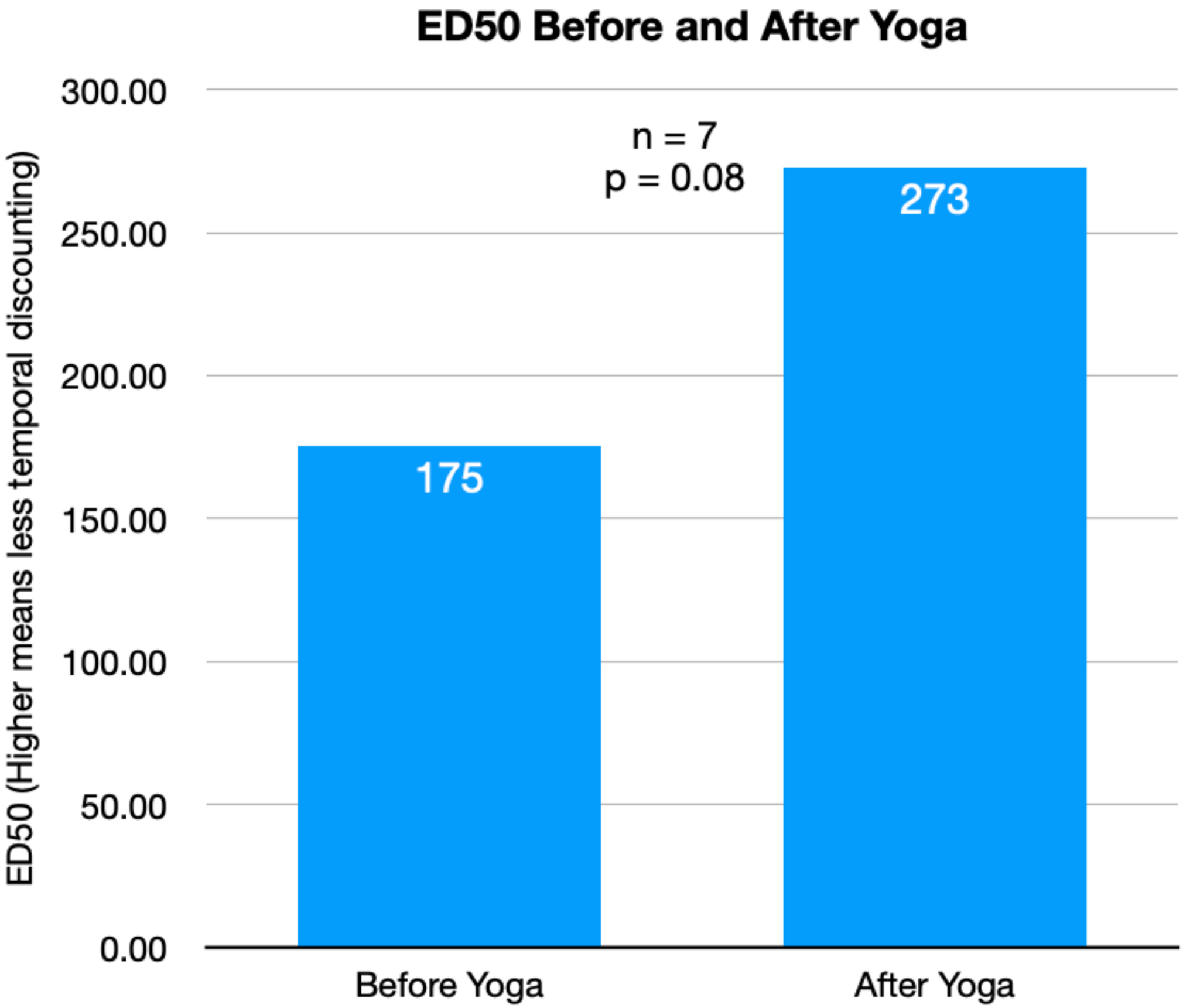


Our Hypotheses

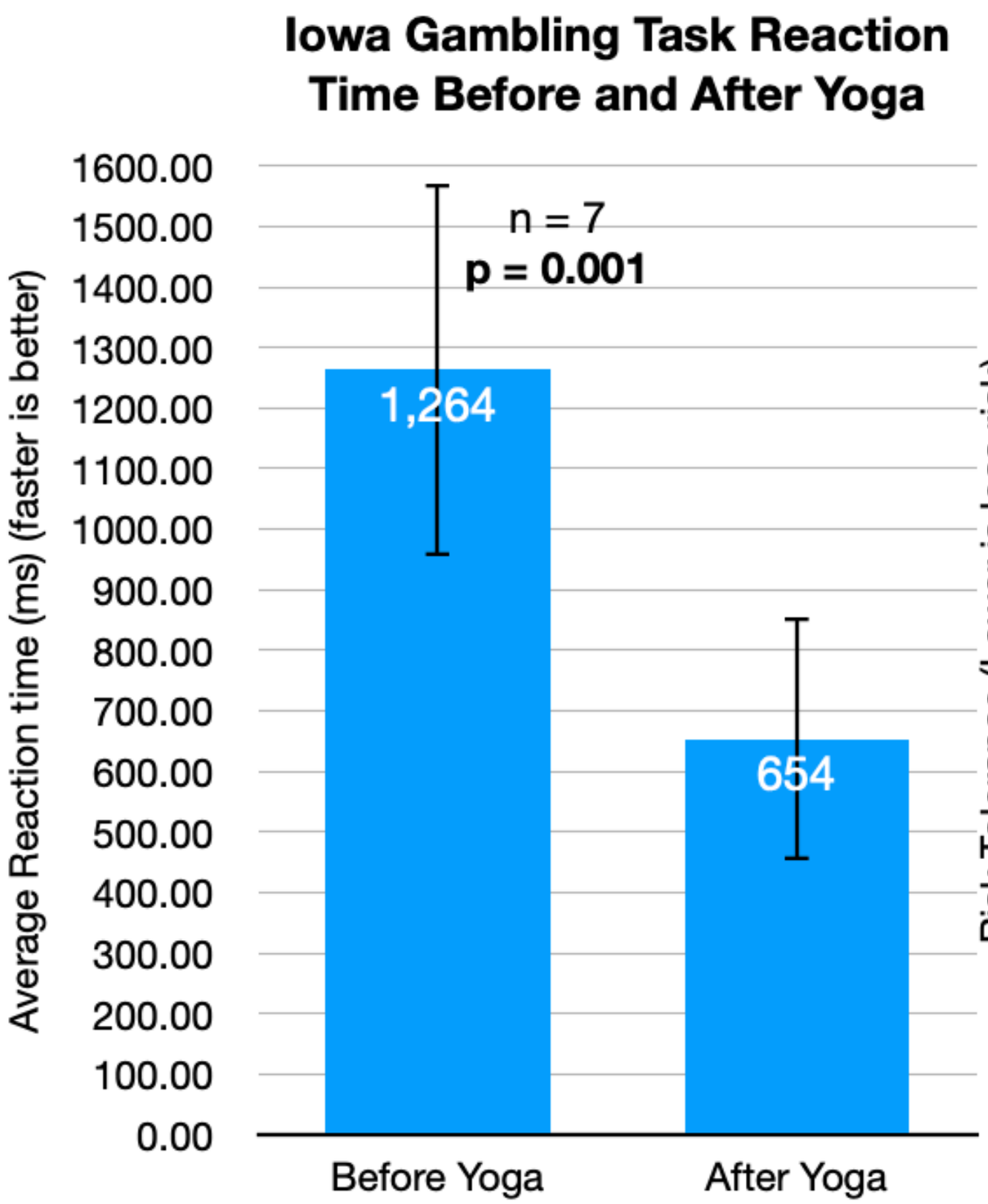
1. TD2 will show a higher ED50 than TD1, because yoga increases patience, so to speak

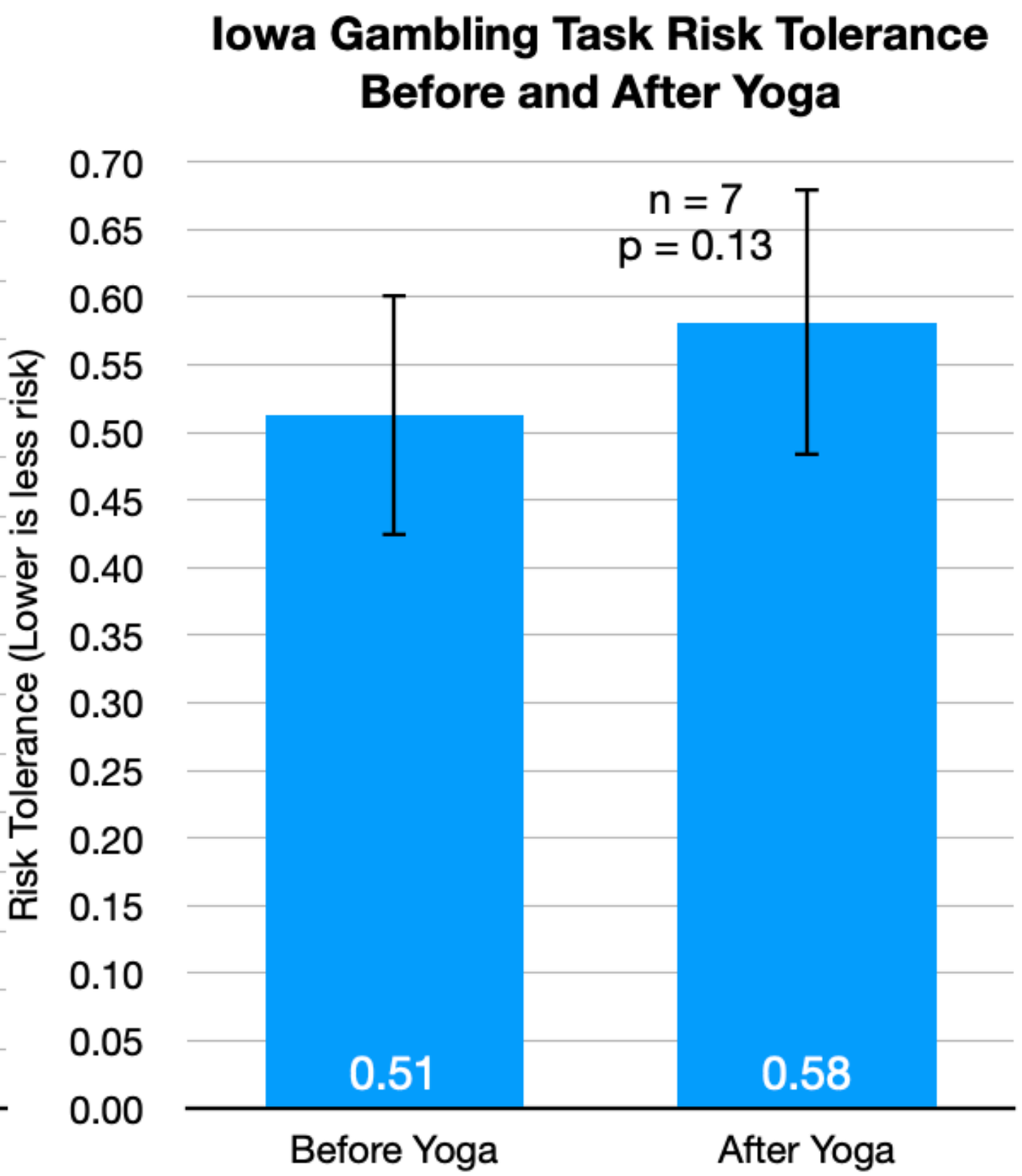
2. IGT2 will show lower risk seeking than IGT1, because yoga reduces impulsivity

3. Changes in TD will correlate with change in IGT because yoga affects the same underlying decision-making systems

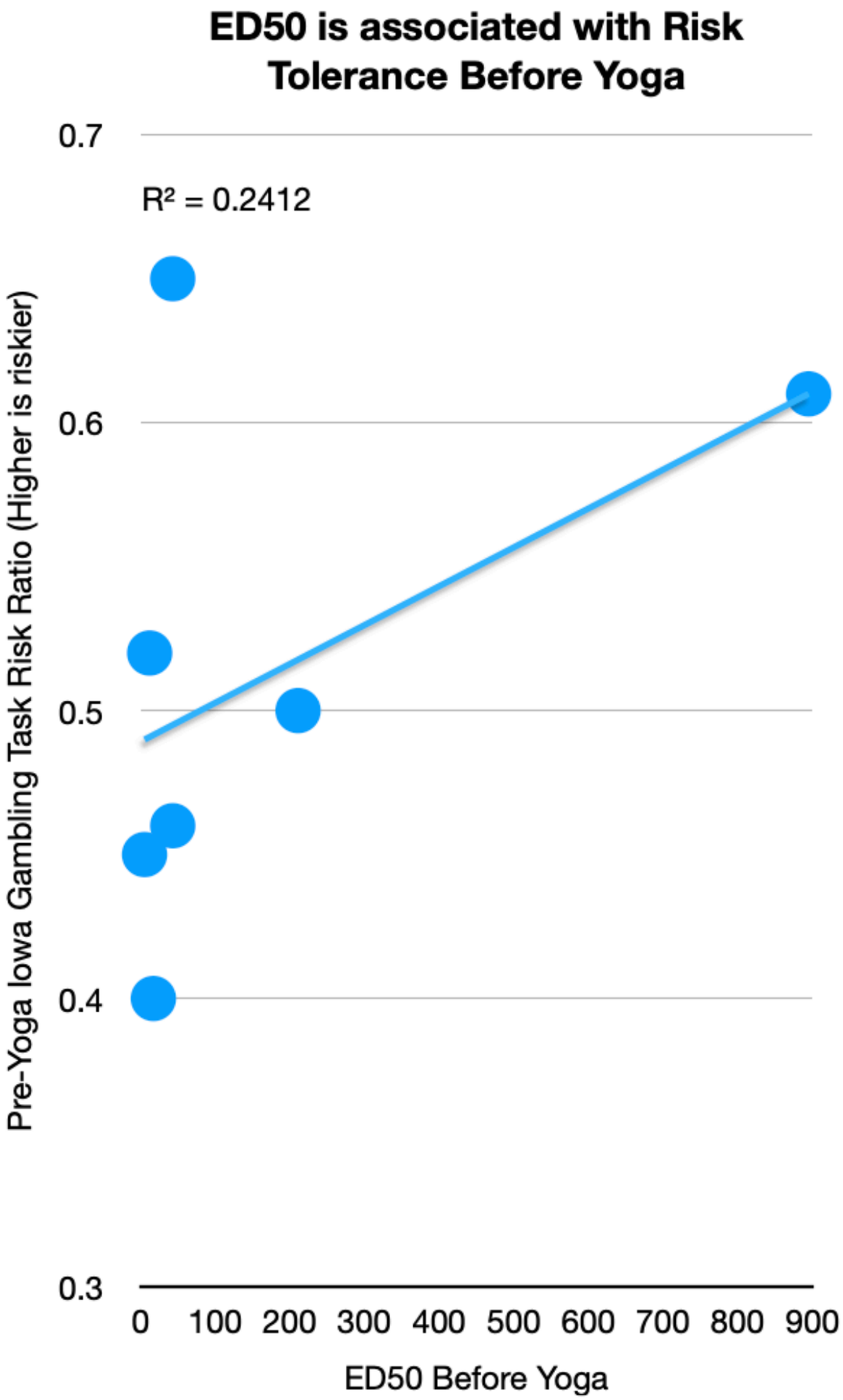


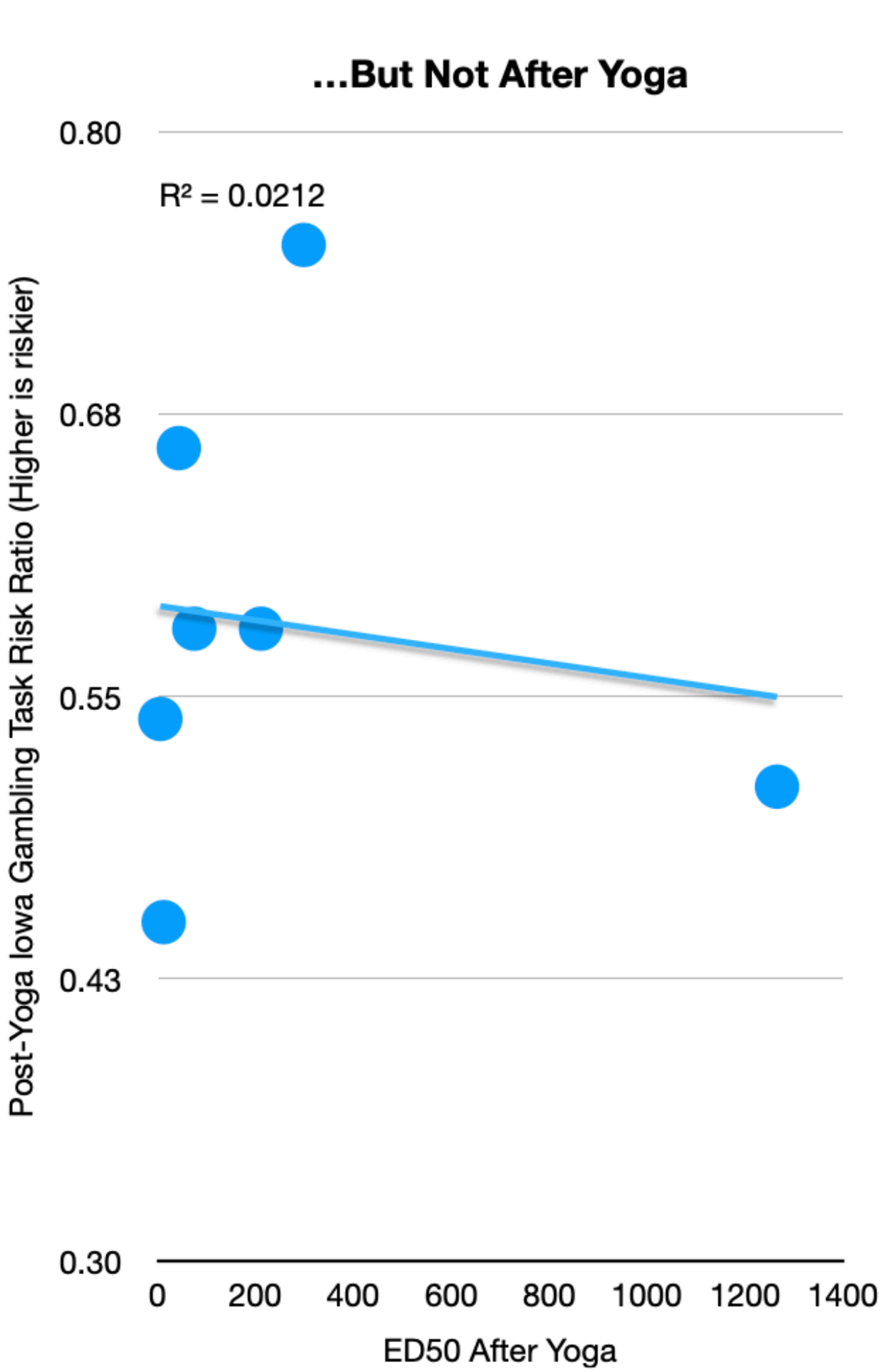
Interpretation: after yoga, participants tended to temporal discount less





Interpretation: reaction time significant decreased, while risk ratio actually tended to increase





Interpretation: at first glance, there appears to be an association before yoga, but this is driven by outlier, and not a meaningful finding

Conclusions

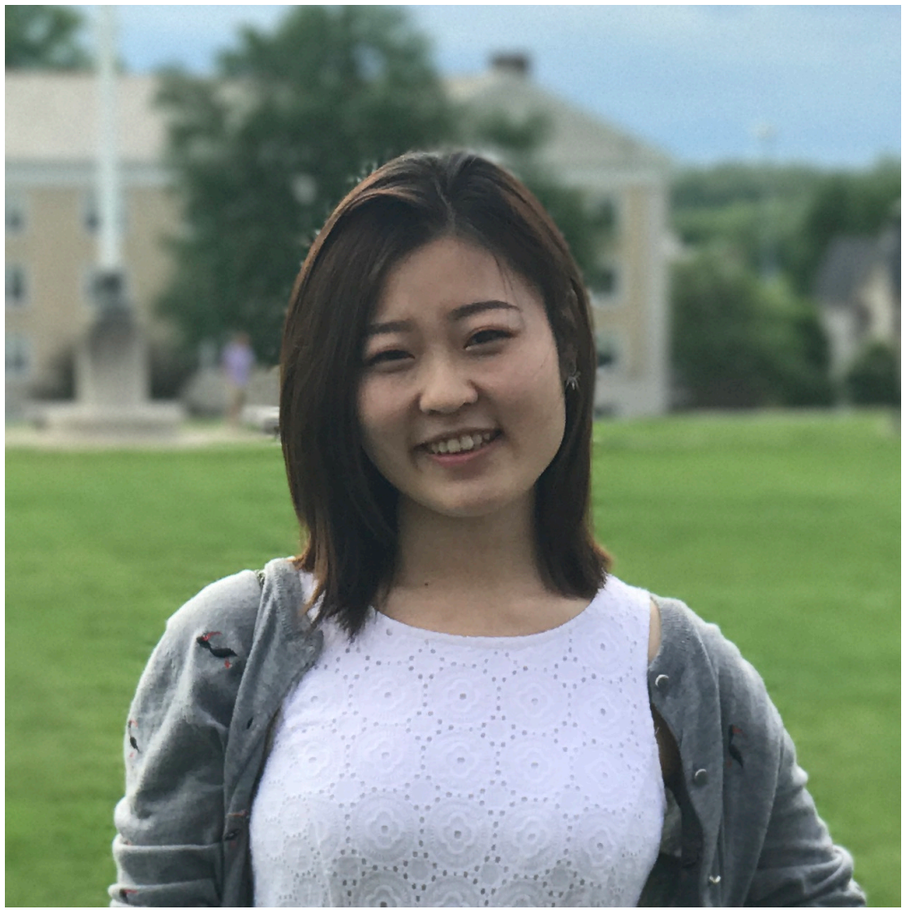
1. TD2 will show a higher ED50 than TD1, because yoga increases patience, so to speak
    - **Verdict**: ✅ yup! ED50 trended to increase after yoga by about 100 days, meaning money took 100 days longer to lose 50% of its value after yoga. This could be thought of as more patience, so to speak

2. IGT2 will show lower risk seeking than IGT1, because yoga reduces impulsivity
    - **Verdict**: 🚫 no, the opposite actually! This is why research is fun. After yoga, there was a trend towards MORE risk tolerance, even though it was detrimental. Perhaps this is due to changes in fear processing after yoga?

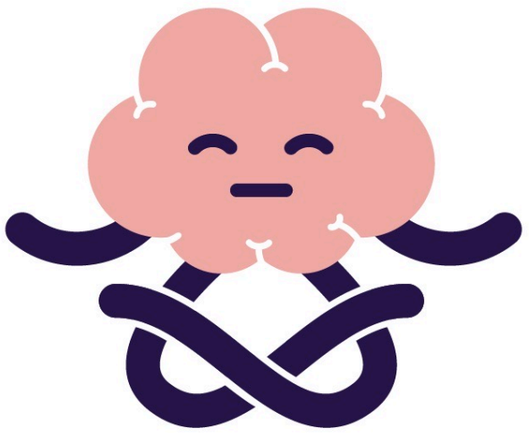
3. Changes in TD will correlate with change in IGT because yoga affects the same underlying decision-making systems
   Verdict: 🚫 nope. We did not see any evidence for such a correlation.

Questions?

Special thank you to Rukmini Roy, Claire Sun, Ekaterina Lebayle, and Jenn Perusini for so expertly analyzing these data!!



Our upcoming conference



Yoga + trauma

Yoga + empathy

Yoga + neurological conditions (stroke, epilepsy, multiple sclerosis, Parkinson’s)

www.neuroyoganyc.com/?source=yogaalliance

References:

Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. Philadelphia, PA: Lippincott Williams & Wilkins, 2007. Print.

Bickel, Warren K., et al. "The behavioral-and neuro-economic process of temporal discounting: A candidate behavioral marker of addiction." *Neuropharmacology* 76 (2014): 518-527.

Borelli, Wyllians Vendramini, et al. "Operationalized definition of older adults with high cognitive performance." Dementia & Neuropsychologia 12 (2018): 221-227.

Cohen, Ronald A., Michael M. Marsiske, and Glenn E. Smith. "Neuropsychology of aging." Handbook of clinical neurology 167 (2019): 149-180.

Hüttermann, Stefanie, and Daniel Memmert. "The influence of motivational and mood states on visual attention: A quantification of systematic differences and casual changes in subjects' focus of attention." Cognition and Emotion 29.3 (2015): 471-483.

Kovács, Ildikó, et al. "Decision making measured by the Iowa Gambling Task in alcohol use disorder and gambling disorder: a systematic review and meta-analysis." Drug and Alcohol Dependence 181 (2017): 152-161.

Madden, David J., and Zachary A. Monge. "Visual attention with cognitive aging." Oxford Research Encyclopedia of Psychology. 2019.

McEwen, Bruce S. "Physiology and neurobiology of stress and adaptation: central role of the brain." *Physiological reviews* 87.3 (2007): 873-904.

Nelson, Charles A., et al. "Adversity in childhood is linked to mental and physical health throughout life." bmj 371 (2020).

Okonkwo, Ozioma C., et al. "Dissociations in visual attention deficits among persons with mild cognitive impairment." Aging, Neuropsychology, and Cognition 15.4 (2008): 492-505.

Patel, Naresh Kumar, L. Nivethitha, and A. Mooventhan. "Effect of a yoga based meditation technique on emotional regulation, self-compassion and mindfulness in college students." Explore 14.6 (2018): 443-447.

Scholz, Urte, et al. "Go no-go performance under psychosocial stress: Beneficial effects of implementation intentions." Neurobiology of learning and memory 91.1 (2009): 89-92.

Tyagi, Anupama, and Marc Cohen. "Yoga and heart rate variability: A comprehensive review of the literature." *International journal of yoga* 9.2 (2016): 97.