



# Neurocognitive Underpinnings of Cross-Cultural Difference In Risky Decision Making

Lan Ba, Xing-jie Chen, Youngbin Kwak

Department of Psychological and Brain Sciences, University of Massachusetts Amherst, Amherst, MA, USA

## Introduction

### Cultural Difference

- Culture plays a significant role in shaping the interplay between the mind, brain and behavior (Chiao & Immordino-Yang 2013; Han et al. 2013).
- In the aspect of decision making, prior studies demonstrate greater risk taking and lower risk aversion in East Asians compared to Western Europeans (Bontempo *et al.* 1997; Du *et al.* 2002; Mandel 2003; Weber & Hsee 1999).
- According to the "cushion hypothesis", the nature of the tight social support in Asian collectivistic society makes it easier for people to receive financial help from their social network, which in turn makes Asians to be less risk averse (Weber & Hsee 1999).

### Current study:

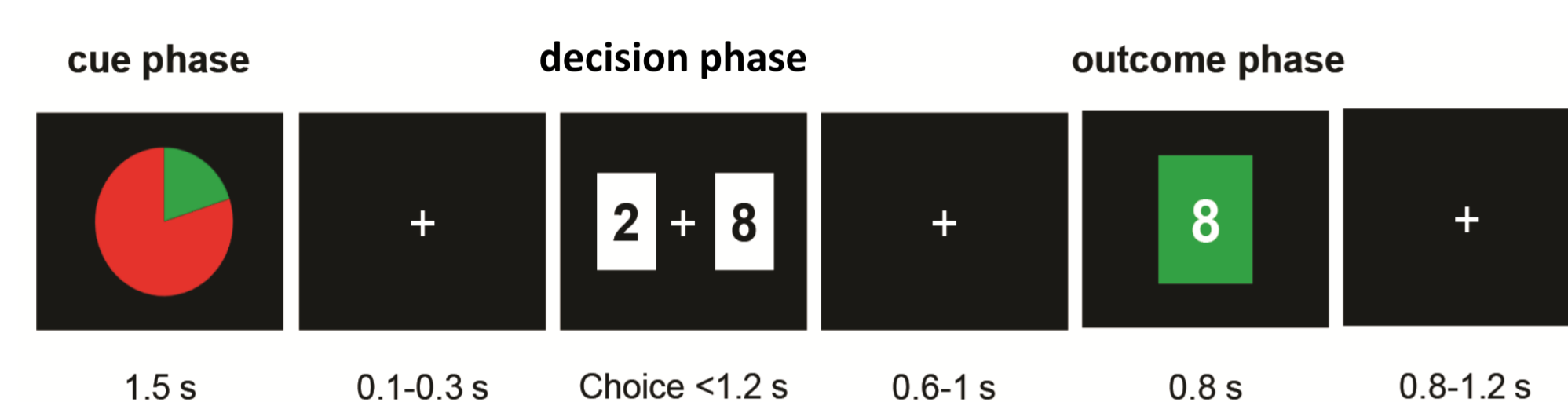
- Current study investigated the neurocognitive underpinnings of cross-cultural differences in economic decision making, by comparing the choice patterns and the event-related potential during a risky gambling task.
- East Asian and Western European participants performed a risky gambling task, which assesses one's tendency to maximize gains and minimize losses, the two well-distinguishable decision strategies.
- In order to map out the mental process of risky decision making at a neural level. Two well-established ERP component, P2, reflecting instantaneous emotional arousal (Carretié *et al.* 2001), and P3 reflecting effortful attentional allocation (Donchin & Coles 1988) were compared across the two cultural groups during pre-decisional (cue phase) and post-decisional (outcome phase) stage.

## Method

### Participants:

- 64 Adult participants (right-handed and without history of psychiatric and neurological illness)
  - East Asian: 35 (7 males; age=20.59±2.45 yrs)
  - European Americans: 32 (10 males; age=20.03±1.40 yrs)
- All East Asian participants were from families of East Asian (China, Korea and Japan) culture background.
- All European Americans identified themselves as Caucasians that are descents of Western Europeans.

### Risky gambling task:



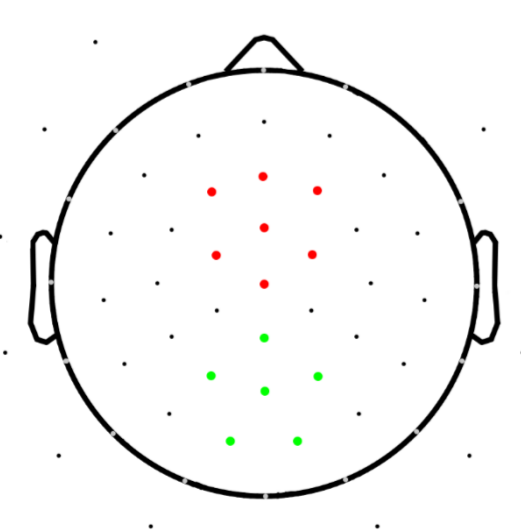
- Cue phase: 7 different probabilities of winning vs. losing
  - likely winning [ $p(\text{win}) > .5$ ]
  - neutral [ $p(\text{win}) = .5$ ]
  - likely losing [ $p(\text{win}) < .5$ ] (e.g., the above figure shows [ $p(\text{win}) = .2$ ])
- Decision phase: choice between two betting options "2" and "8"
- Outcome phase: the outcome determined by the probability is shown
  - +2/-8: the worst gain/loss
  - +8/-2: The best gain/loss
- Behavioral index of *Gain Maximization* and *Loss Minimization* calculated using the below equation
  - Gain Maximization:  $\gamma_{\text{gainMax}} = \log(p / 1 - p)$ , ( $p$  = probability of choosing "8" on the "likely winning" trials)
  - Loss Minimization:  $\gamma_{\text{lossMin}} = \log(1 - p / p)$ , ( $p$  = probability of choosing "2" on the "likely losing trials")

### Questionnaires measure socio-cultural orientation:

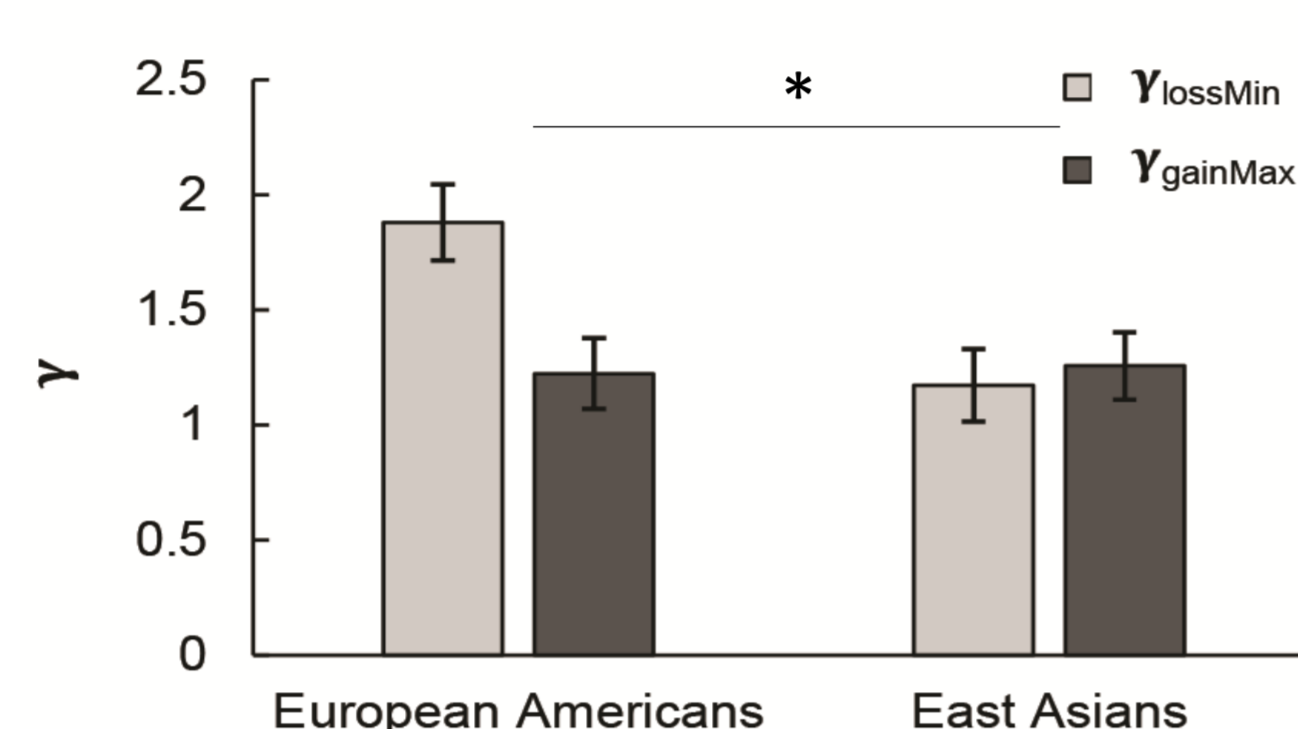
- Self-construal scale (Singelis 1994) and Asian Value scale (Kim *et al.* 1999)

### EEG recording

- ERP component P2 was acquired from the average signal of frontocentral channels (shown in red in the figure).
- P3 was acquired from the average signal of the parietocentral channels (shown in blue in the figure)

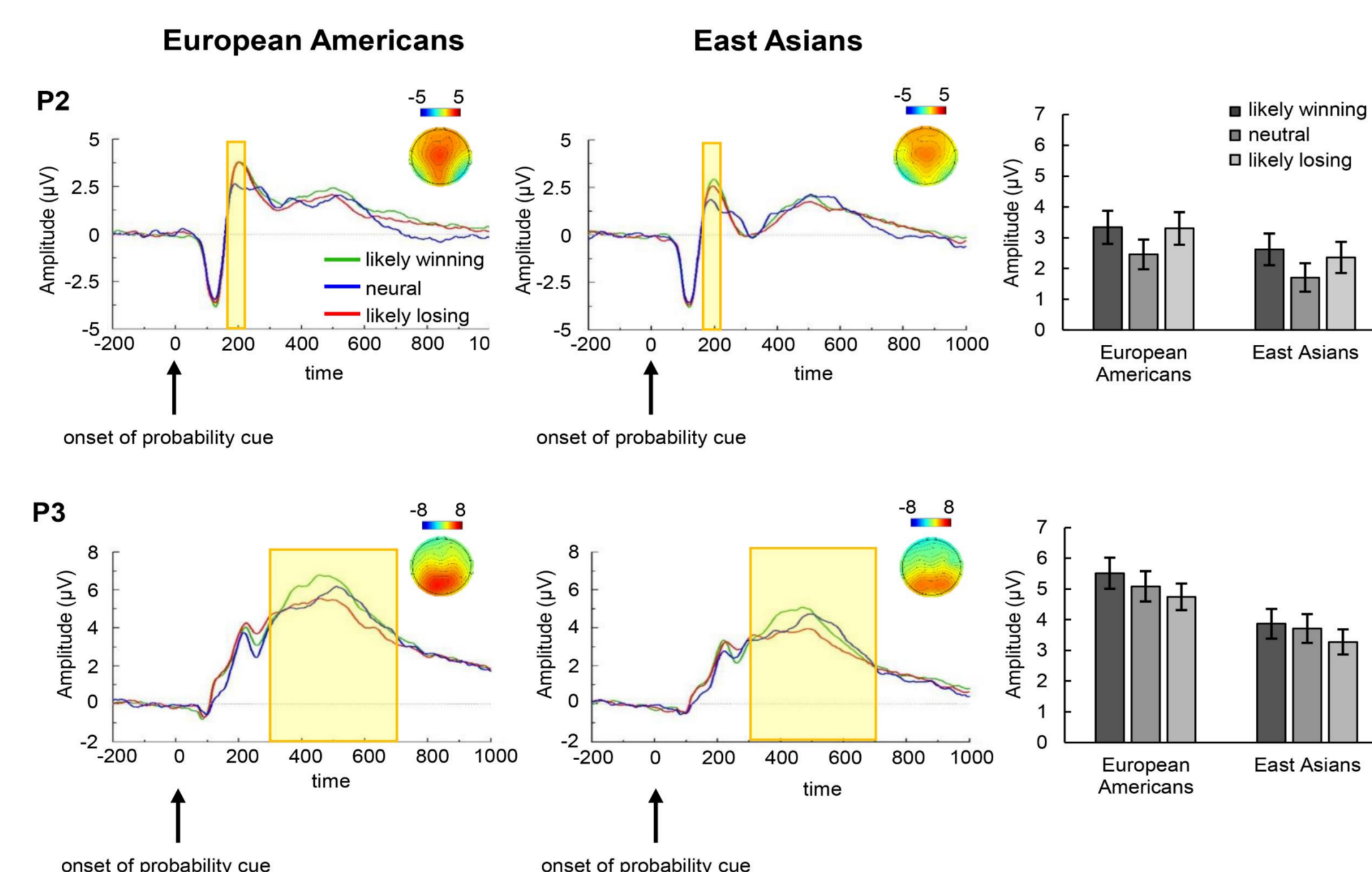


### Cross cultural differences in gain maximizing and loss minimizing strategies:



- Group (Americans, Asians) x Strategy ( $\gamma_{\text{gainMax}}$ ,  $\gamma_{\text{loseMin}}$ ) mixed ANOVA
- Main effect of strategy ( $F(1,65) = 5.71, p = .02, \eta_p^2 = .081$ )
- Group by strategy interaction ( $F(1,65) = 9.59, p = .003, \eta_p^2 = .13$ )
- Significantly higher  $\gamma_{\text{loseMin}}$  in Americans

### ERPs during pre-decisional stage:



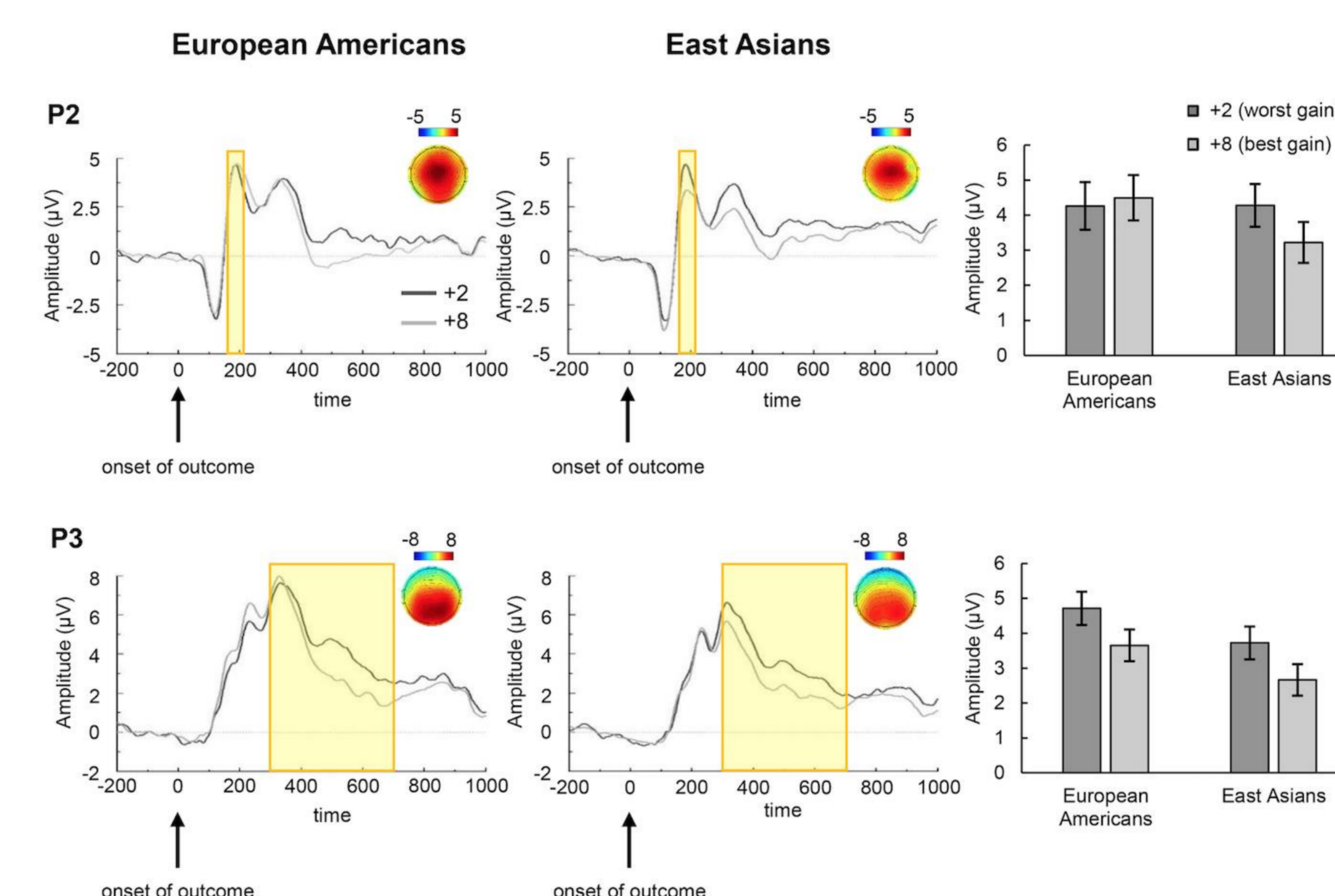
- Group (Americans, Asians) x Cue (likely winning, neutral, likely losing) ANOVA showed no Group by Cue interaction in either P2 or P3 suggesting that the two cultural group varied little in the way they dissociated the different risk levels.
- Greater P2 magnitude in [ $p(\text{win}) > .5$ ] and [ $p(\text{win}) < .5$ ], than [ $p(\text{win}) = .5$ ], suggesting that P2 tracks the degree of uncertainty
- Greater P3 magnitude [ $p(\text{win}) > .5$ ] than [ $p(\text{win}) < .5$ ], suggesting that P3 tracks degree of the likelihood of winning

### ERPs during post-decisional stage: Group (Americans, Asian) x Preference (Worst, Best) x Valence (Gain, Loss) ANOVA on P2 and P3

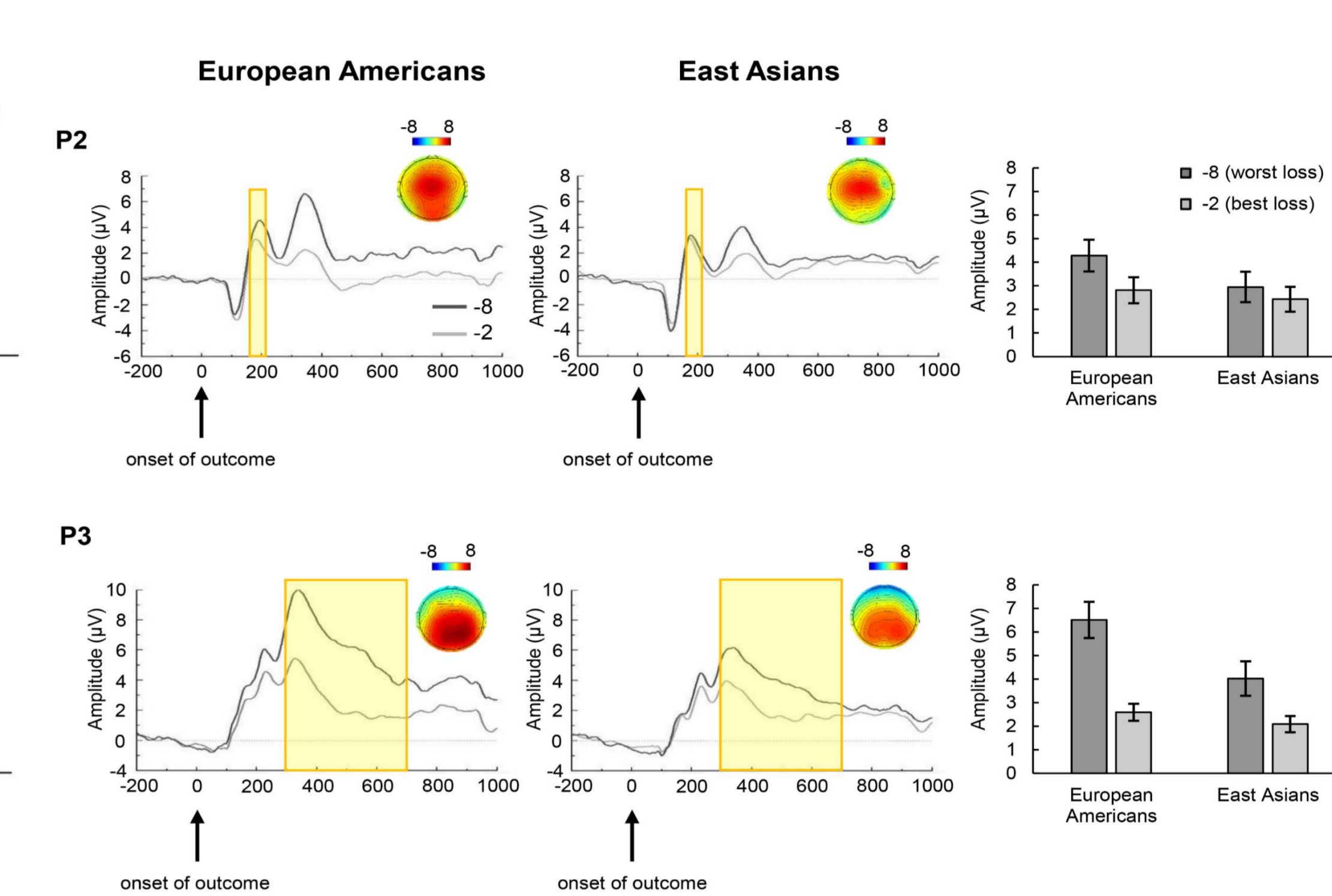
- Group by Preference by Valence interaction in both P2 ( $F(1,65) = 9.40, p = .003, \eta_p^2 = .13$ ) and P3 ( $F(1,65) = 5.01, p = .029, \eta_p^2 = .07$ ).
- A follow up Group x Preference two way ANOVA was performed in gain and loss trials separately.

## Results

### Gain trials



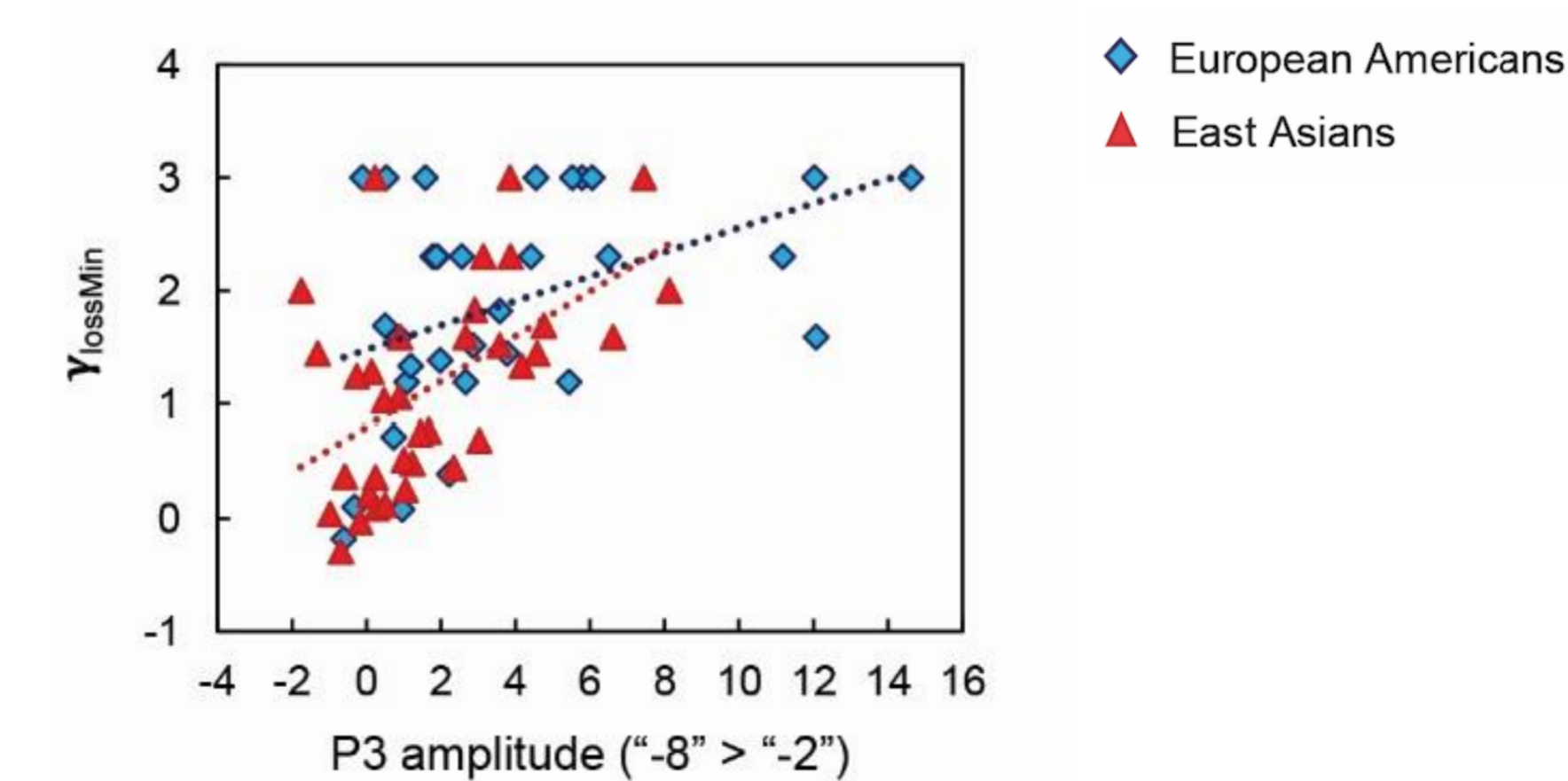
### Loss trials



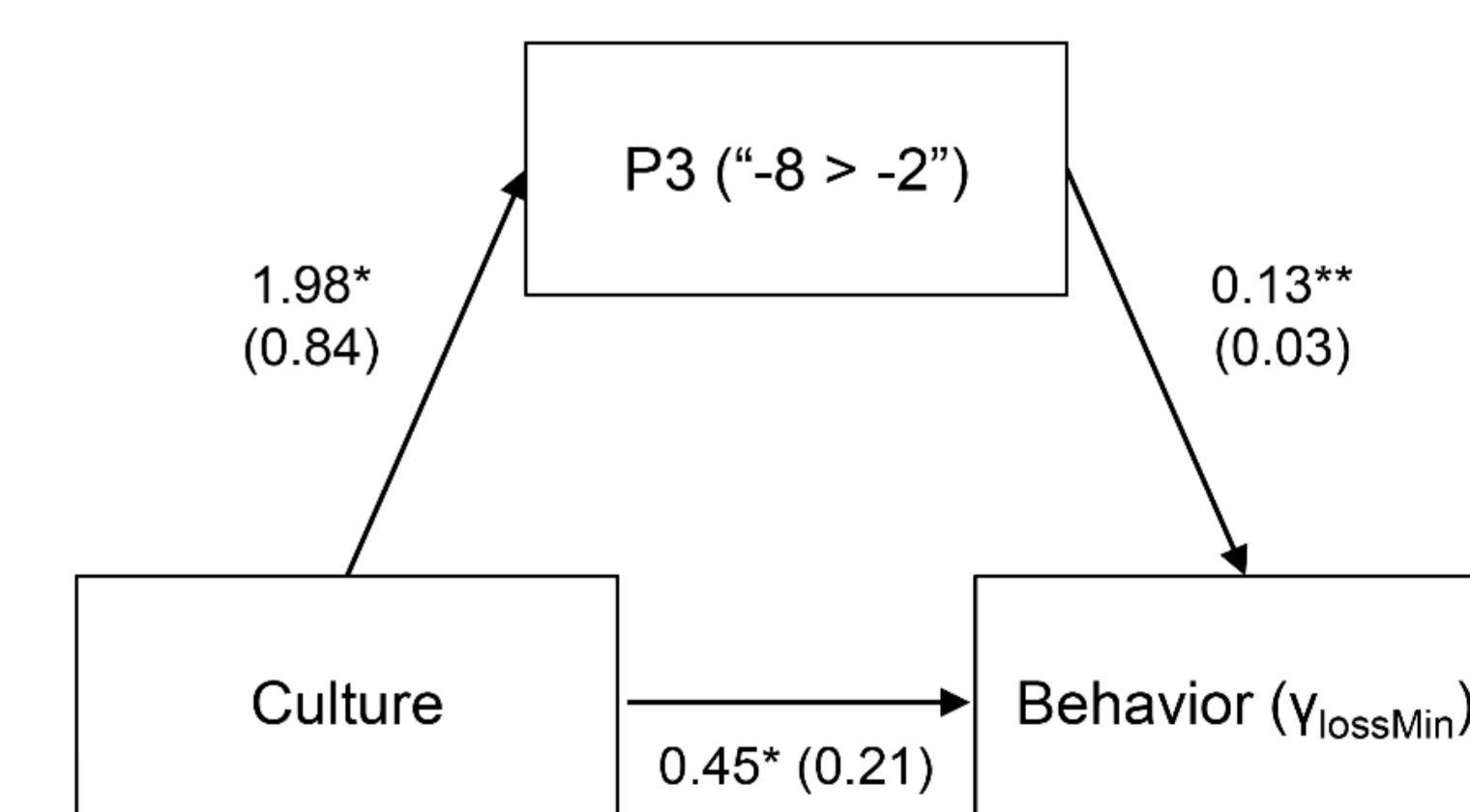
- P2: Group by Preference interaction ( $F(1,63) = 9.42, p = .003, \eta_p^2 = .13$ ), suggesting a greater dissociation of the different gain outcomes in Asians than Americans
- P3: No significant cultural modulation on preference observed

- P2: No significant cultural modulation on preference observed
- P3: Group by Preference interaction ( $F(1,63) = 5.79, p = .019, \eta_p^2 = .08$ ), suggesting a greater dissociation of the different gain outcomes in American than Asians

### ERP-behavior correlation and culture-ERP-behavior mediation:



- The degree to which P3 dissociated the worst and best losses ("-8 > -2" contrast) was associated with the behavioral index of loss minimization ( $\gamma_{\text{loseMin}}$ ) ( $r = .52, p < .001$ ).
- Furthermore, the P3 "-8 > -2" contrast partially mediated the cultural effect on loss minimization behavior (unstandardized indirect effect = .25, SE = .11, 95% CI [.06, .47]).



## References

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## Summary/Discussion

- Behaviorally, cultural difference was found only in loss minimization suggesting a greater loss aversion in Americans.
- ERP data showed that culture does not shape the underlying cognitive process during pre-decisional stage, but have a significant influence in post-decision phase.
- Americans were more attentionally engaged with the loss outcomes, as marked by a greater P3 to losses, while Asians were more emotionally aroused by the gain outcomes, as marked by a greater P2 to gains.
- P3 sensitivity to losses partially mediated the cultural effects on loss minimization.
- These results invites a refinement to the current theoretical propositions about cultural influence on decision making such as the "cushion hypothesis".
- American's greater sensitivity in losses at P3 but not P2 suggest that their processing of losses was enhanced deliberately at the level of effortful attentional allocation, as part of an explicit effort to face and resolve the negative outcome in a self-reliant manner.
- Asian's greater sensitivity in gain at P2 but not P3 suggest that Asian's enhance risk taking may be driven by cultural influence that pervades at a more inherent and primitive level than what the cushion hypothesis assumes.
- Our results provide a deeper understanding of the roots of cultural difference in economic decision making, which may have further implications in the current era of global commercial development.

- **Hypothesis:**

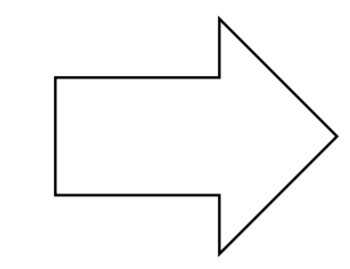
- Each culture would prefer their distinctive strategy on decision making. East Asian exhibit a greater gain maximization, while European Americans will exhibit greater loss minimization.
- If culture shapes an individual's automatic processing of arousal associated with the prospect or the experience of winning or losing, cross-cultural differences should be observed in P2.
- If culture shapes an individual's effortful processing of options or outcomes, cross-cultural difference should be observed at P3

- **Gain Maximization and Loss Minimization**

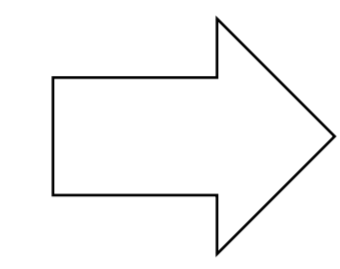
- Gain Maximization:  $\gamma = \log (p / 1 - p)$ , ( $p$ =probabilities of choosing larger bet on "likely win trail")
- Loss Minimization:  $\gamma = \log (1 - p / p)$ , ( $p$ = probability of choosing smaller bet on "likely lose trail")
- (Since as presented previously, this difference is more obvious in P3 of American but P2 of Asian)

	Approach	Avoidance
Relief	ApRf +8	AvRf -2
Regret	ApRt +8	AvRt +2

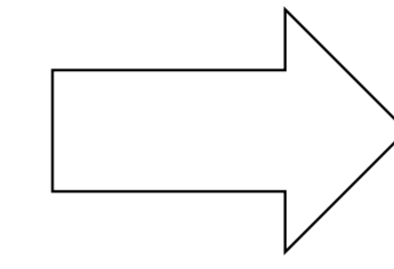
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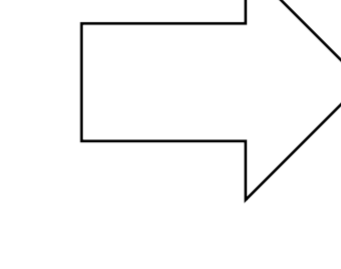
Choices



Result



Alternative  
outcome



Counterfactual  
Thought

Pwin X

Approach  
8

Avoidance  
2

Win  
+8

Loss  
-8

Win  
+2

Loss  
-2

+2

-2

+8

-8

Approach  
Relief

Approach  
Regret

Avoidance  
Regret

Avoidance  
Relief



