

## BACKGROUND

- Gambling disorder (GD) is a behavioral addiction where cue-reactivity and craving serve as central mechanisms, negatively impacting finances, work, relationships, and mental health<sup>1-3</sup>.
- Ambulatory assessments capture physiological, behavioral, and self-report data simultaneously in natural settings, enhancing ecological validity<sup>4,5,6</sup>.
- This study aims to investigate the subjective and physiological cue-reactivity to gambling-related cues in an urban real-world setting.**

## METHODS

### Sample

- Control Group ( $N=48$ ): No regular engagement in any type of gambling.
- Gambling Group ( $N=40$ ): Meets  $\geq 1$ DSM-5 criteria; non-treatment-seeking, terrestrial slot machines as the primary mode of gambling in Cologne, Germany.

|                  | Gambling Group<br>( $N=40$ ; $f=7$ ) |      |        | Control Group<br>( $N=48$ ; $f=6$ ) |      |        | $t$    | $df$ | $p$   |
|------------------|--------------------------------------|------|--------|-------------------------------------|------|--------|--------|------|-------|
|                  | $M$                                  | $SD$ | Range  | $M$                                 | $SD$ | Range  |        |      |       |
| Age              | 32.5                                 | 12.1 | 18-62  | 33.9                                | 8.71 | 20-58  | .644   | 87   | .52   |
| School years     | 12.5                                 | 1.29 | 10-16  | 12.7                                | 1.51 | 8-20   | .678   | 87   | .50   |
| Monthly income € | 1430                                 | 948  | 0-4100 | 1587                                | 1264 | 0-7000 | .651   | 87   | .52   |
| DSM-5            | 4.88                                 | 2.10 | 1-9    | 0                                   | 0    | 0-0    | -16.11 | 87   | <.001 |
| SOGS             | 5.34                                 | 4.68 | 0-16   | .104                                | .309 | 0-1    | -7.74  | 87   | <.001 |
| PGSI             | 5.85                                 | 5.39 | 0-25   | .062                                | .320 | 0-2    | -7.44  | 87   | <.001 |
| BDI-II           | 10.1                                 | 7.93 | 0-34   | 5.58                                | 4.61 | 0-23   | -3.32  | 87   | .001  |
| BIS-15           | 34.76                                | 3.37 | 29-43  | 33.44                               | 2.76 | 29-40  | -2.02  | 87   | .046  |

Table 1. Descriptive statistics and group comparison (t-test) between control and gambling group;  $f$ =female.

### Study Design

- A within-subject, counterbalanced design across three testing days.
- Conditions: Familiar (frequently visited gambling venues) vs. Novel (never-visited gambling venues) in Cologne, Germany.
- Each route included exposure to two real-world gambling venues ( $N_{totalcue}=19$ ,  $N_{totalroutes}=14$ ).

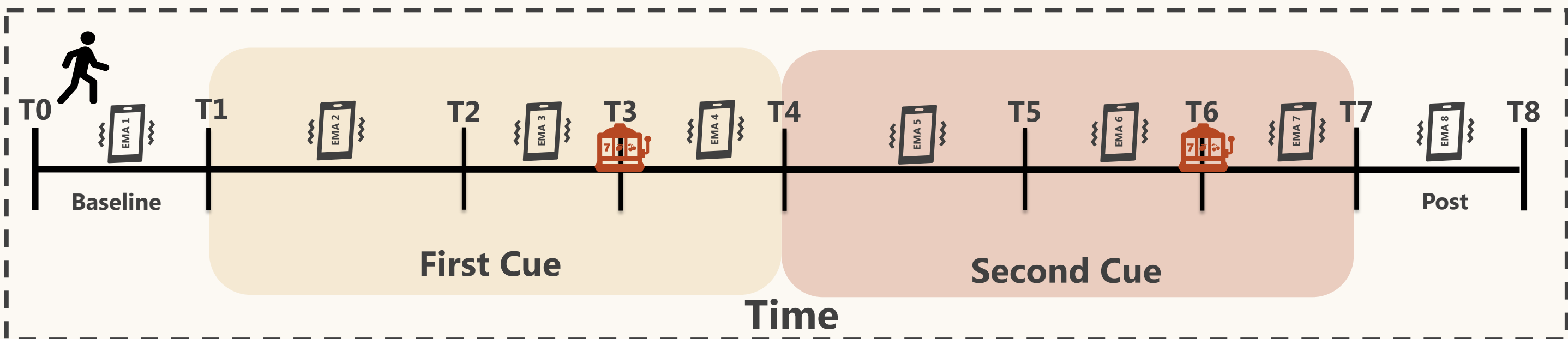


Figure 1. Schematic of the ambulatory experimental protocol. Timeline across eight time segments (T0-T8) spanning four main blocks: Baseline (T0-T1), First Cue (T1-T4), Second Cue (T4-T7), and Post-Recovery (T7-T8). Continuous physiological, GPS, and eye-tracking recordings run throughout. Slot machines icon mark cue exposures (T3, T6); EMA=ecological momentary assessments.

## Ambulatory Assessment

### GPS-Location Tracking

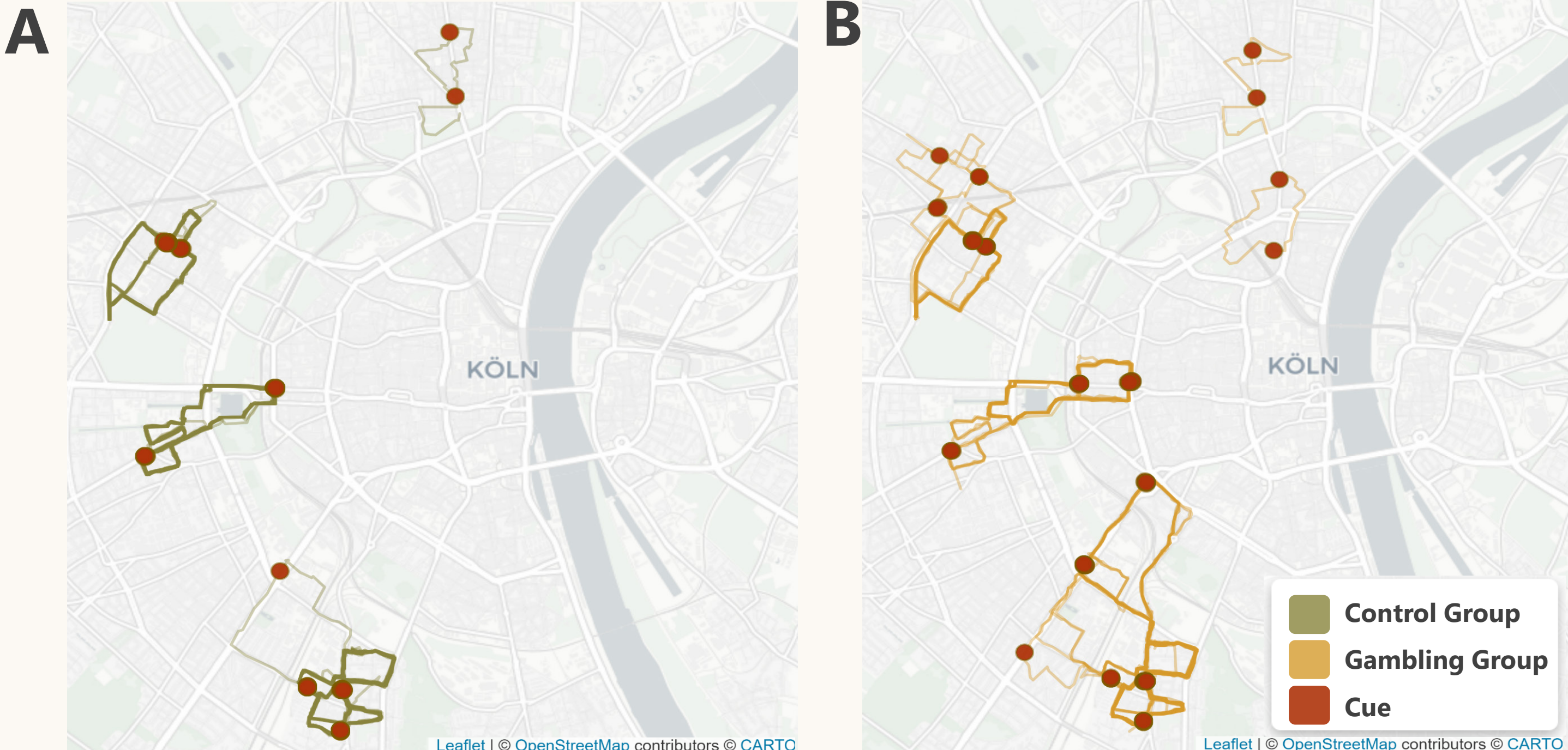


Figure 2. Illustration of the urban walking route and gambling venues (cues; red dots) in Cologne, Germany. Individual participant movement trajectories derived from GPS-based location tracking are depicted separately for (A) control group (green lines) and (B) gambling group (yellow lines).

### Ecological Momentary Assessment

- Single-item Visual Analogue Scales (VAS; 0-100) measured craving, stress, positive affect, and physical exertion across 8 EMA prompts during route exposure.



### Physiological Recording

- Mobile wearables continuously recorded electrodermal activity (EDA) and cardiovascular activity (CVA) as markers of autonomic nervous system arousal.

## RESULTS

### GPS- Location Tracking

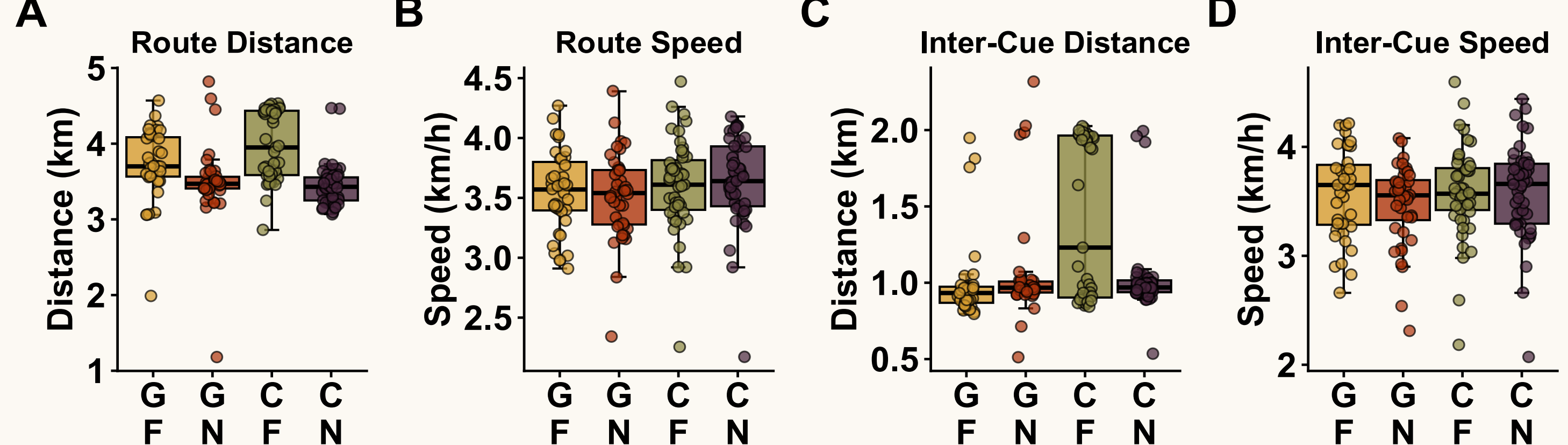
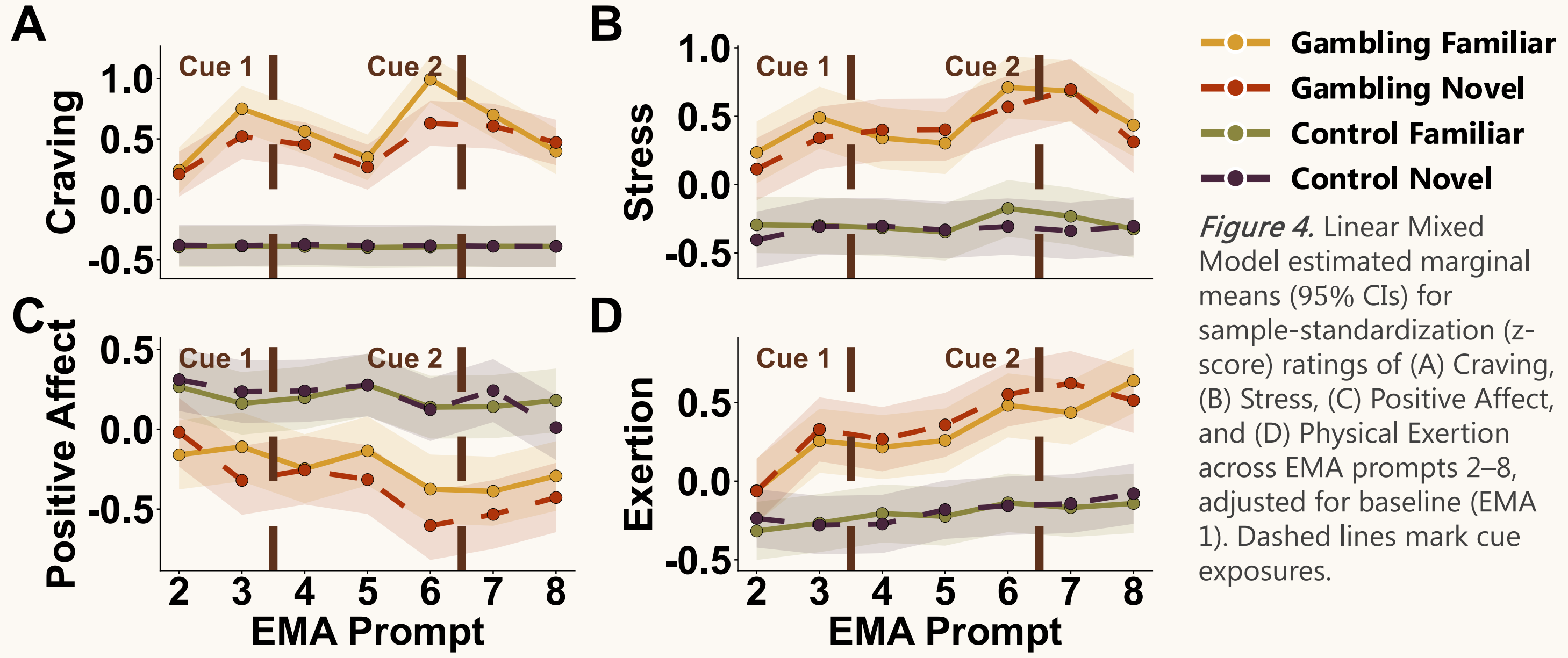


Figure 3. GPS-derived movement metrics by group and condition. Panels show distributions for (A) total route distance, (B) mean route walking speed, (C) inter-cue distance, and (D) mean inter-cue walking speed. G-F = Gambling Familiar, G-N = Gambling Novel, C-F = Control Familiar, C-N = Control Novel. Boxes = IQR; whiskers = min-max; circles = individual participants.

### Ecological Momentary Assessment

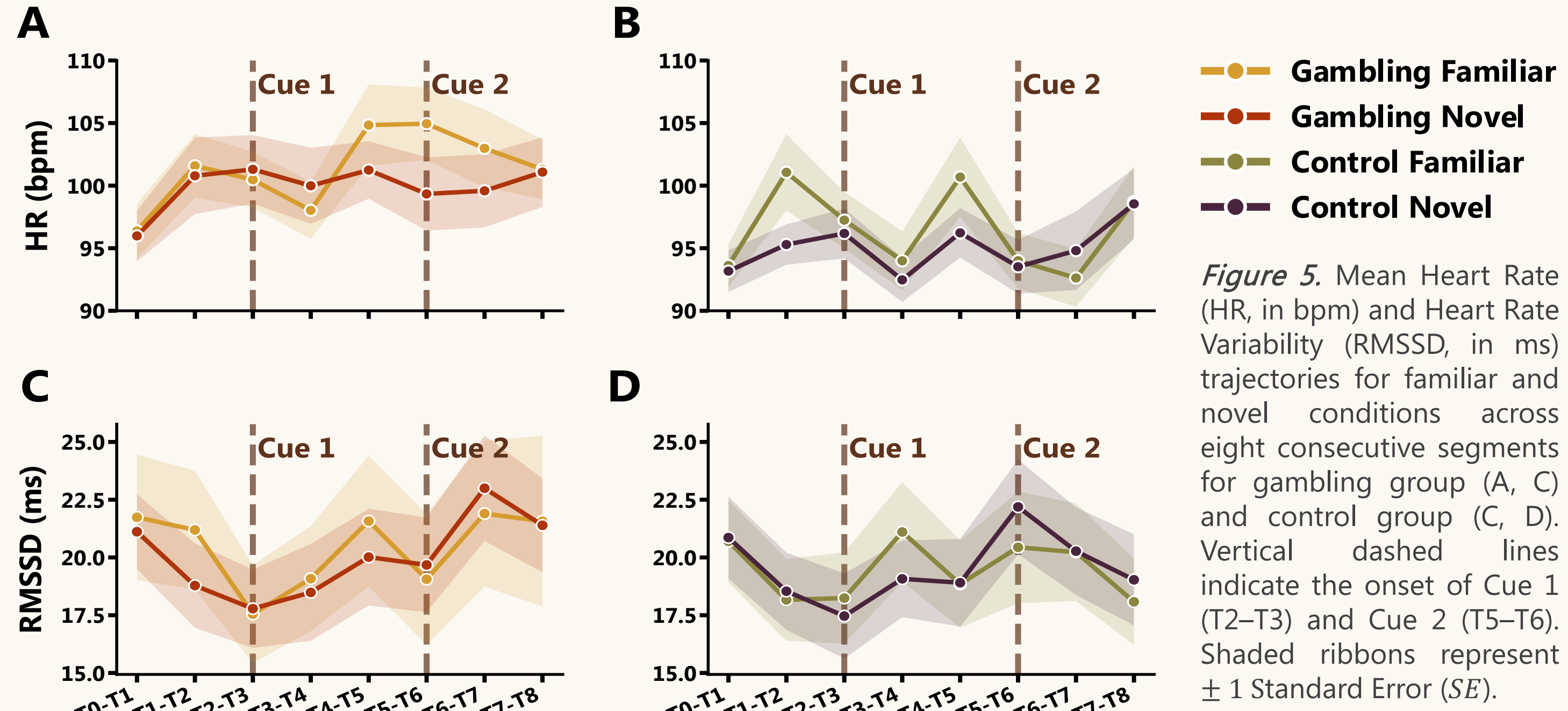


- Group:** Real-world gambling cues triggered immediate, significant craving surges in the gambling group (all  $p<.001$ ), compared to controls ( $p=1$ ).
- Group x Condition:** Craving in the gambling group was significantly higher in the familiar route compared to the novel route ( $\beta=2.76$ ,  $p=.001$ ).
- Group x Timepoint:** Craving in the gambling group increased significantly at both cue exposures, with an greater response to the second cue (Familiar: Cue1:  $\Delta=.51$ , Cue2:  $\Delta=.75$ ; Novel: Cue1:  $\Delta=.31$ , Cue2:  $\Delta=.42$ , all  $p<.001$ ).

| Outcome         | Group | Condition | Timepoint | Group x Condition | Group x Timepoint | Group x Condition x Timepoint |
|-----------------|-------|-----------|-----------|-------------------|-------------------|-------------------------------|
| Craving         | ***   | n.s.      | ***       | *                 | ***               | n.s.                          |
| Stress          | ***   | n.s.      | ***       | n.s.              | **                | n.s.                          |
| Positive Affect | ***   | n.s.      | ***       | n.s.              | n.s.              | n.s.                          |
| Exertion        | ***   | n.s.      | ***       | n.s.              | ***               | n.s.                          |

Table 2. Summary of Linear Mixed Model fixed effects across Ecological Momentary Assessment outcomes adjusted for baseline (EMA 1). Group = Gambling vs. Control; Condition = Familiar vs. Novel route; Timepoint = EMA Prompts 2-8. \* $p<.05$ ,  $p<.01$ , \*\*\* $p<.001$ , n.s. = not significant.

## Physiology



## CONCLUSION

- Familiar gambling venues trigger significantly stronger gambling urges than novel cues, demonstrating that personal environmental context actively drives reactivity.
- In-situ measures reveal non-linear cue-reactivity in problem gambling, characterized by immediate craving spikes at cue onsets that compound across sequential exposures.
- Ambulatory methods can capture real-time, gambling-relevant processes, such as cue-reactivity, underscoring the need for further real-world research to refine real-time interventions.

## REFERENCES

- Mugleton, N., Parpart, P., Newall, P., Leake, D., Gathergood, J., & Stewart, N. (2021). The association between gambling and financial, social and health outcomes in big financial data. *Nature Human Behaviour*, 5(3), 319-326.
- Antons, S., Brand, M., & Potenza, M. N. (2020). Neurobiology of cue-reactivity, craving, and inhibitory control in non-substance addictive behaviors. *Journal of the Neurological Sciences*, 415, 116952.
- Kober, H., Lacadie, C. M., Wexler, B. E., Malison, R. T., Sinha, R., & Potenza, M. N. (2016). Brain Activity During Cocaine Craving and Gambling Urges: An fMRI Study. *Neuropsychopharmacology*, 41(2), 628-637.
- Trull, T. J., & Ebner-Priemer, U. (2013). Ambulatory assessment. *Annual review of clinical psychology*, 9, 151-176.
- Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4, 1-32.
- Korkmaz, D., Knauth, K., Brands, A., Schmeck, M., Büning, P., & Peters, J. (2025). Ambulatory physiological measures obtained under naturalistic urban mobility conditions have acceptable reliability. *Scientific Reports*, 15(1), 28940.