

Introduction

- Currently, there are few methods available to quantify the addictive risk of nicotine products such as vapes and nicotine pouches
- In a typical **conditioned place preference (CPP)** task, a specific environment is paired with a primary reinforcer like food or drugs, while another distinct environment remains reward-free, creating a neutral association.
- Following several conditioning sessions, the subject's preference for the reward-paired environment, now a conditioned stimulus (CS), is evaluated during the test session without reward.
- This study examines the potential to establish CPP within virtual reality (VR) settings paired with nicotine vs placebo lozenges among undergraduates, aiming to assess how nicotine influence environmental preference. It provides insights in understanding and addressing the surge in e-cigarette use among young adults.

Methods

Participants

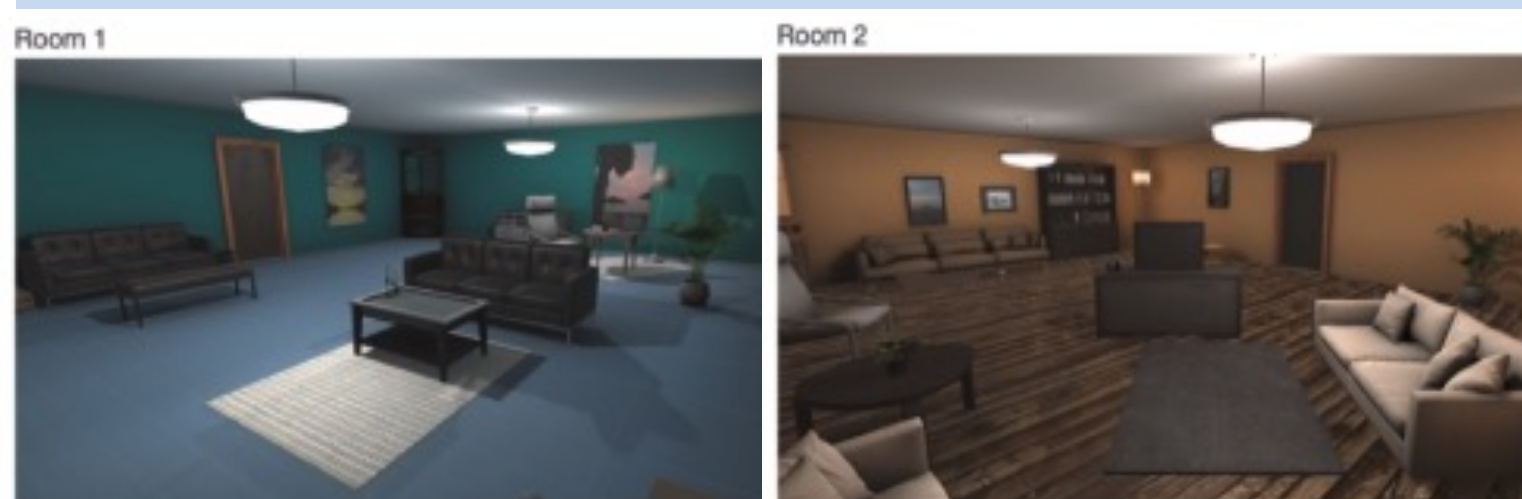
- 26 males, 17 females, 1 non-binary; mean age = 20.45 years

Procedures

- Participants underwent three sessions within a week—two for conditioning and one for testing.
- In the conditioning sessions, participants experienced two distinct VR rooms; one coupled with a nicotine lozenge (CS+), the other with a placebo (CS-).
- Each conditioning session consisted of three trials lasting three minutes each.
- To encourage exploration, a red floating arrow appeared periodically in pseudorandom locations and participants were instructed to collide with it.
- In the test session, participants had unrestricted access to both VR rooms for a single 3-minute trial, with no floating arrows and no administration of lozenges, allowing for free exploration in a cue-free setting.
- The amount of time spent in CS+ relative to CS- during the cue-free test session was recorded as an **implicit measure of CPP**.
- Participants were asked to indicate how much they enjoyed being in each VR room (0-100) and which room they preferred as **explicit measures of CPP**.

| | Conditioning Sessions | | Test Session |
|-------------|-----------------------|---------|----------------------|
| | 1 | 2 | |
| VR Room | Room 1 | Room 2 | Access to Both Rooms |
| Stimuli | Nicotine | Placebo | Neither |
| # of Trials | 3 | 3 | 1 |

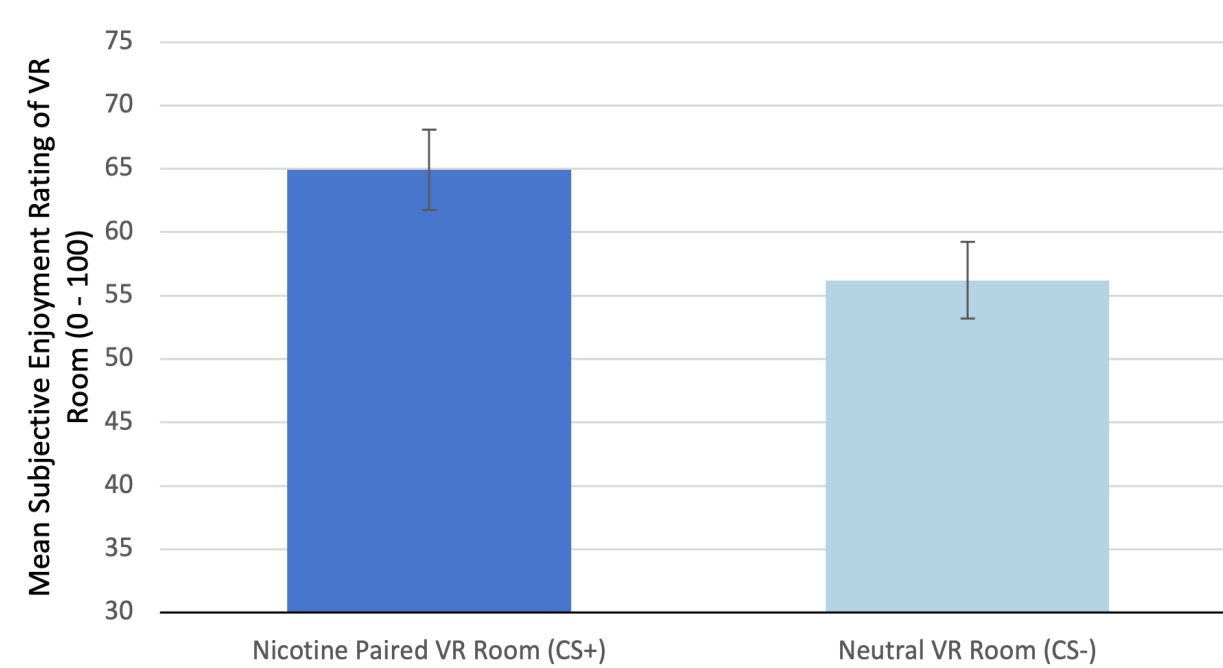
A sample testing order for 1 participant. Across participants, both the VR room paired with addictive stimuli and the order of conditioning sessions were counterbalanced.



Both VR rooms are designed like a living room, but they are made to be distinct from the other in terms of color scheme, furniture, and layout.

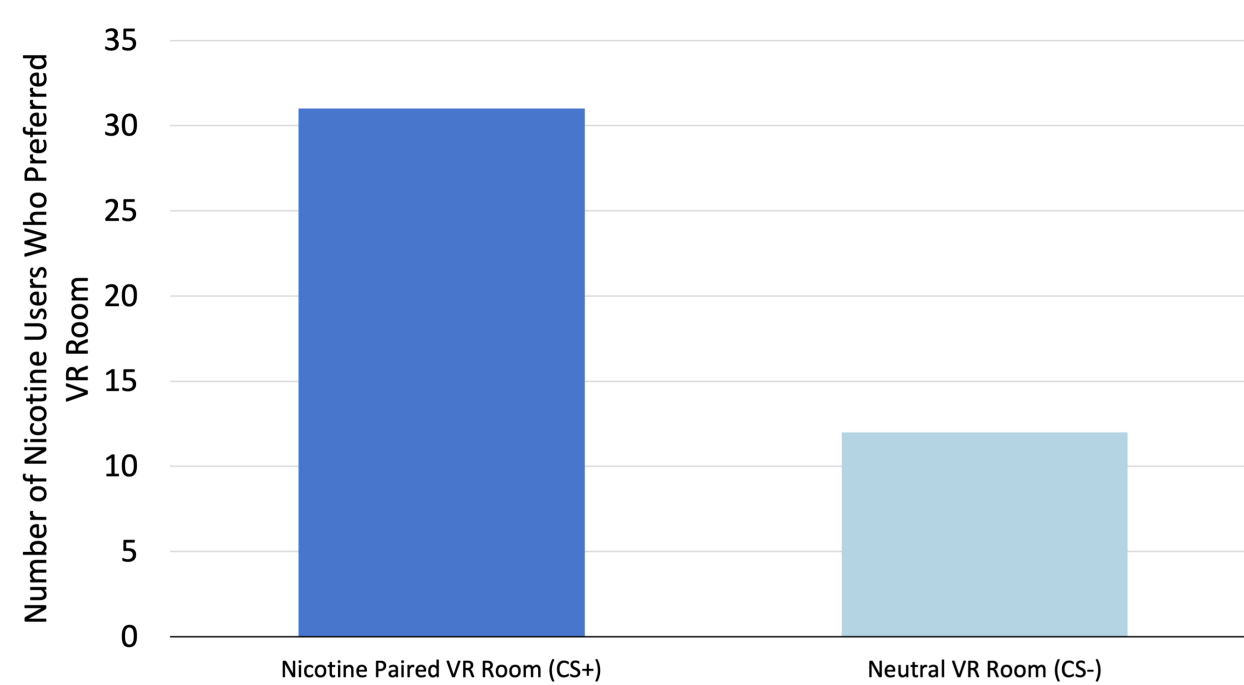
Results

Mean Subjective Enjoyment Ratings of Each VR Room



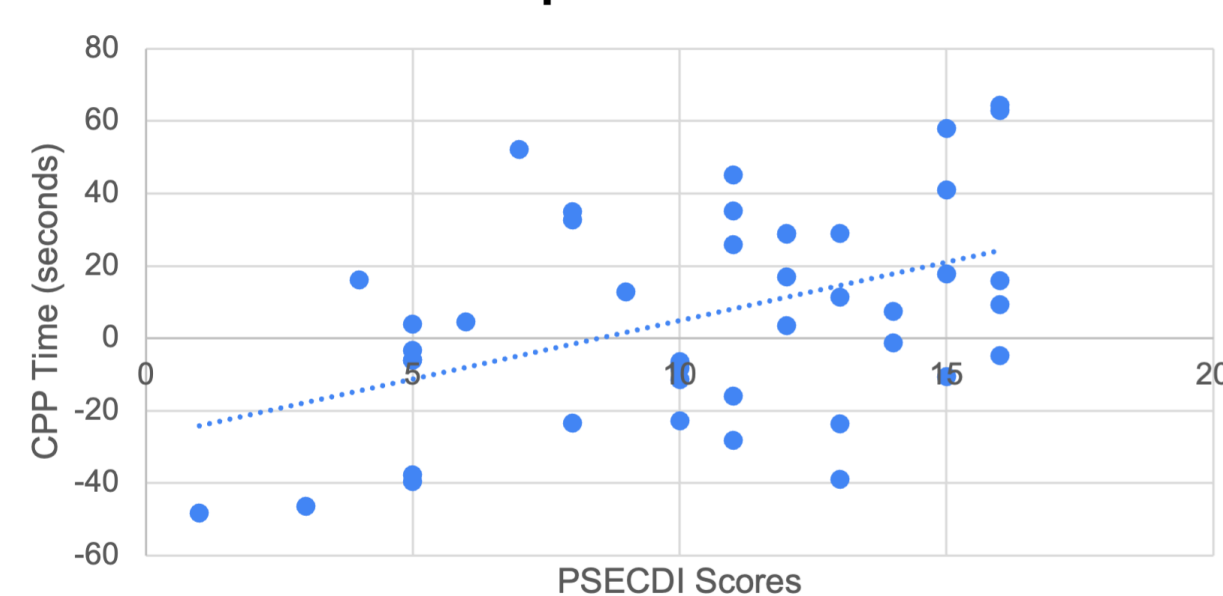
Participants (n = 43) demonstrated a significant CPP Enjoyment (M = 8.72 (SD = 23.68 s), p = 0.020) indicating that participants rate the nicotine room more enjoyable than the neutral room

Which VR Room Do You Prefer?



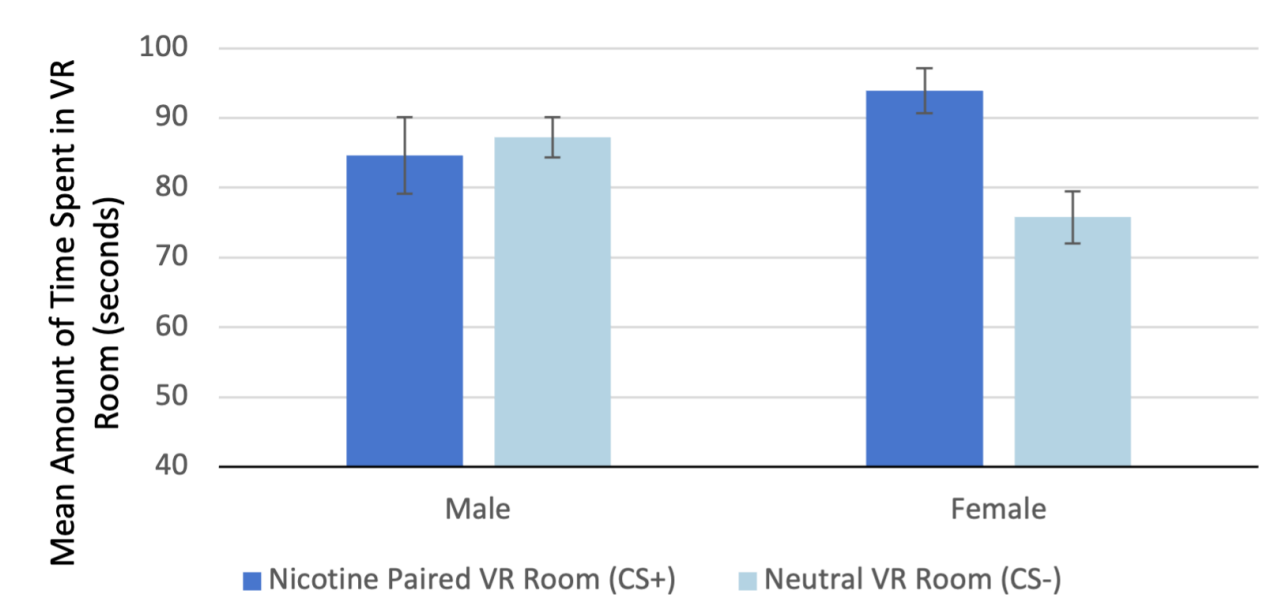
In a forced choice of room preference, significantly more people chose nicotine room as their preferred room (p < 0.001).

Nicotine Dependence and Time Spent in VR Room Coupled with Nicotine



CPP Time is significantly positively correlated with PSECDI scores (r = 0.452, p = 0.002) indicating that higher the e-cig dependence is associated with more time spent in the nicotine paired VR room.

Mean Amount of Time Spent in Each VR Room During Test Session Based on Sex



Females (n = 17) demonstrated a significantly greater CPP Time (M = 18.11 s (SD = 27.70 s) compared to males (n = 26; p = 0.023). Females also show a significant CPP Time overall (p = 0.016). This indicates that females spend more time in the nicotine-paired room than the neutral room.

Conclusions

| Key Finding | Details |
|---|--|
| Nicotine Administration and VR Preference | Administered nicotine lozenges were found to significantly increase the preference for specific VR settings, indicating a direct pharmacological effect of nicotine on preference formation. |
| Enjoyment Enhancement by Nicotine | The increase in enjoyment scores for the VR setting coupled with nicotine suggests that nicotine may amplify the positive psychological response to the VR exposure. |
| PSECDI and CPP Time Correlation | The positive correlation between CPP time and the Penn State Electronic Cigarette Dependence Index (PSECDI) highlights the influence of nicotine dependence on conditioned preferences in VR environments. |
| Gender-Based Preferences | Females displayed a higher CPP time than males, indicating sex differences in responses to nicotine-cued environments, despite similar levels of enjoyment and nicotine use across sexes. |
| Subjective vs. Conditioned Response | While subjective enjoyment was heightened for the nicotine-paired VR setting, the CPP time did not significantly differ, indicating that enjoyment and the desire to remain in a nicotine-associated environment may be influenced by different factors. |
| CPP in Addiction | This study suggests that CPP is an effective tool for assessing addiction risk and holds potential for future interventions. The study also demonstrates VR's efficacy in evaluating conditioned responses to administered nicotine, thus expanding VR's application in behavioral research. |