Response Inhibition and Error Monitoring Deficits Associated with Marijuana Use

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BACKGROUND AND SIGNIFICANCE

- Drug addiction is associated with impaired performance monitoring and behavioral inhibition, processes that are critical to adaptive behavior such as the pursuit of drug abstinence.
- Cognitive neuroscience theories have identified event-related potential (ERP) components that index response conflict and error monitoring, arising largely from the anterior cingulate cortex (ACC).
- Deficits in error monitoring and ACC hypoactivity to errors are consistently found among dependent users of numerous classes of drugs, but there is a paucity of research on neural indices of cognitive functioning and marijuana use.

AIMS AND HYPOTHESES

- To investigate the relationship between individual differences in marijuana use and behavioral indices of response inhibition.
- To determine if the relationship between marijuana use and performance monitoring are mediated by these reliable cognitive ERP components.

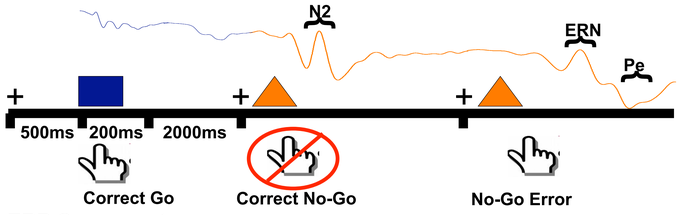
METHOD

Participants

54 undergraduate students from the University of Colorado at Boulder who varied in marijuana use. Participants reported the average number of times they smoked marijuana per month for the past year.

Go/No-Go Task

Participants viewed a series of two stimuli, a blue square or orange triangle. They were instructed to press a button (i.e., GO) to one of the stimuli or make no response to the other (i.e., NO-GO). Go stimuli appeared on 80% of trials and no-go stimuli on 20% to foster prepotent response tendencies. Instructions emphasized speed and accuracy equally.



ERP Components:

N2 reflects response conflict and the need for inhibition prior to response execution.
- peak amplitude in the negative-going component at Fz 180-300ms post-stimulus on correct trials.

ERN (error-related negativity) reflects response conflict summating post-error.
- peak amplitude in the negative-going component at Cz 0-85ms post-error.

Pe (error positivity): related to the conscious recognition or motivational significance of errors.
- mean amplitude in the positive-going component at Cz 150-350ms post-error.

To maximize power, all behavioral and N2 analyses were conducted on the full sample, whereas error-related analyses (i.e., ERN & Pe) were conducted on participants who made 4 of more errors of commission.

RESULTS SUMMARY

- Marijuana use is associated with poorer behavioral inhibition and error awareness.
- Decreased neural indices of error awareness are related to poorer task performance.
- The relationship between marijuana use and deficits in behavioral inhibition is mediated by neural indices (Pe) of error awareness or motivational significance of errors.

BEHAVIORAL RESULTS

Marijuana use was associated with deficits in behavioral inhibition

Participants demonstrated behavioral sensitivity to go vs. no-go stimuli

- Behavioral responses were quantified as d' scores, which serve as a standardized measure of sensitivity to correct go responses (hit) compared to incorrect no-go responses (false alarm).
- d' = z (False Alarm) – z (Hit)
- Successful discrimination between go and no-go stimuli was indicated by d' scores significantly greater than zero (Mean = 3.3, t (49) = 25, p < .001).

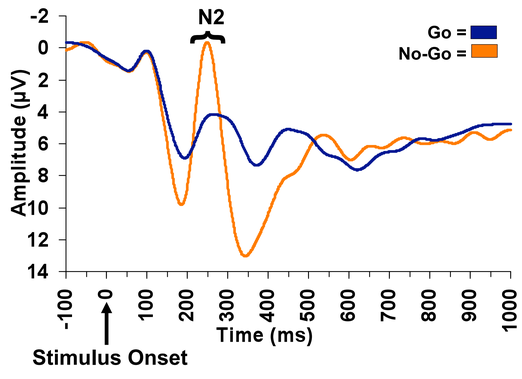
Heavier marijuana use was associated with poorer behavioral inhibition

- Marijuana use was negatively correlated with d' scores (r = -.34, p = .016).

RESPONSE CONFLICT RESULTS

Response conflict was positively related to behavioral inhibition

ERP: Stimulus Aligned Waveform at Fz



Correct no-go stimuli elicited larger N2 than go stimuli

- As predicted, a reliable N2 component occurred on no-go trials prior to successful response inhibition compared to correct go trials (t (49) = 7.14, p < .001). This indicates that the task was successful at eliciting response conflict to infrequent no-go trials.

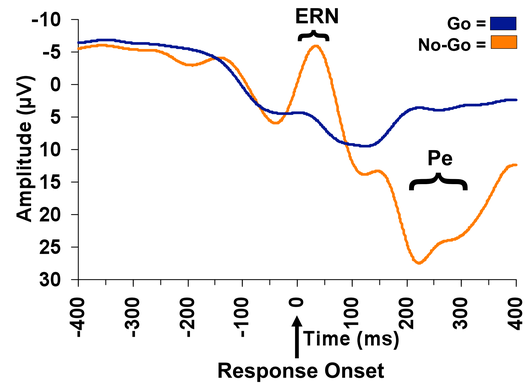
Response conflict (N2) predicted behavioral inhibition

- Individuals with larger no-go N2 effects displayed larger d' scores (r = .31, p = .029).

ERROR-RELATED RESULTS

Error awareness mediates the relationship between marijuana use and behavioral inhibition

ERP: Response Aligned Waveform at Cz



Errors of commission elicited a reliable ERN and Pe

- As predicted, an ERN and Pe occurred after no-go errors compared to correct go responses (ERN t (37) = 9.14, Pe t (37) = 13.35, p's < .001). These ERPs indicate continued response conflict (ERN) and eventual awareness or motivational significance (Pe) of errors of commission.

Error awareness (Pe) predicted behavioral inhibition (d')

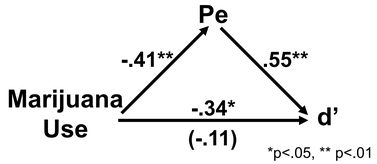
- Larger Pe to no-go errors was related to superior task performance (r = .55, p < .001).

Marijuana use was associated with diminished error awareness

- Individuals who smoked more frequently displayed reduced Pe to no-go errors, indicating they had decreased awareness or motivational significance of errors (r = -.41, p = .01).

The relationship between marijuana use and behavioral inhibition is mediated by neural indices of error awareness

- The negative correlation found between marijuana use and behavioral inhibition was mediated by the Pe (r = -.11, p = .48). Diminished error awareness or motivational significance of errors among frequent marijuana users may explain their deficits in behavioral inhibition.



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