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Relationship Between Cannabis Use and Immediate, Delayed, and Working Memory Performance Among Older Adults

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ABSTRACT

Cannabis is increasingly accessible and use is increasing rapidly among older adults as laws change and cannabis becomes more frequently prescribed in healthcare settings. Past research identified cognitive effects of cannabis use among adolescents and young adults that can persist for several weeks after intoxication, though little is known about how these effects generalize to older adults. Participants (N = 1348) were drawn from the Health and Retirement Study (HRS) and were categorized as current occasional users (up to once/week in the past year, n = 36), current frequent users (once per week or more in the past year, n = 92), past users (n = 334), and non-users (n = 886). Participant ages ranged from 50 to 98 (M = 67.25, SD = 10.68). Uncontrolled, one-way ANOVAs and controlled ANCOVAs were used to examine between-group differences on immediate and delayed wordlist memory and working memory (serial sevens). When controlling for age, gender, education, and minority status, current frequent users demonstrated significantly worse immediate memory performance compared to past and non-users. However, this difference could have been the result of acute, residual effects of past-month cannabis use among current users. In controlled analyses, there were no differences between groups on delayed or working memory. Findings indicate that greater than weekly cannabis use may result in attentional and short-term memory deficits. Further, these effects may be mitigated by sustained abstinence. Limitations including sample size and measures of cannabis use warrant future studies to replicate and build upon these findings.

Key words: = marijuana; cognition; aging

The cannabis plant has been used for thousands of years, yet still incites controversy today. The prevalence of cannabis use among older adults is increasing for several reasons, including cohort and period effects (Han et al., 2017; Kerr et al., 2018), and applicability in healthcare. Cannabis is being used for a variety of ailments including management of pain associated with musculoskeletal problems and other sources of chronic pain, reducing spasticity in multiple sclerosis, and promoting sleep efficiency and appetite for varying patient populations (National Academies of Sciences Engineering and Medicine, 2017). Older adults (individuals aged 65 and above) experience age-related cognitive decline (Cabeza et al., 2018) and multimorbidity (King et al., 2018) with corresponding polypharmacy (Wastesson et al., 2018). While cognitive and physiological effects of cannabis use in adolescents and young adults have been frequently investigated, little is known about the potential acute and chronic cognitive side-effects of cannabis use among older adults. In the interests of informing both public health and the eventual creation of moderate use guidelines, the current study contrasts cognitive performance

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between groups with varying patterns of cannabis use.

Taken together, previous findings that cannabis acutely impairs cognition in younger populations coupled with the inconclusive evidence of persisting cannabinoid effects after cessation of use, and very limited evidence of similar effects among older adults, suggests a gap in the literature which needs to be addressed. Some literature (Auer et al., 2016; Broyd et al., 2016; Ganzer et al., 2016; Lovell et al., 2020; Thames et al., 2014) suggests a linear relationship between extent of cannabis use and cognition. This relationship may be exaggerated by frequency of use (Broyd et al., 2016), duration of use (Stypulkowski & Thayer, 2022), and age-related cognitive decline. However, another line of research indicates there may be null effects of cannabis use on cognition in later-life, contrary to its deleterious effects on learning and processing speed in younger populations (Mueller et al., 2021; Weinstein & Sznitman, 2020). Thus, the examined hypothesis was that cannabis non-users, past users, current occasional (less than weekly) users, and current frequent (at least weekly) users would differ in performance on working memory, immediate memory, and delayed memory.

METHODS

Participants

Participants were drawn from the longitudinal Health and Retirement Study (HRS) conducted by the University of Michigan and supported by the National Institute on Aging (grant number NIA U01AG009740). The University of Central Florida's IRB therefore determined the current study exempt from review, indicating no involvement of human subjects. The HRS includes seven birth cohorts (spanning six years each) of adult respondents age 50 years and older living in the United States and assesses factors related to health, retirement, and aging via telephone and in-person interviews. Data collection in the HRS is bi-annual, beginning in 1992 and continuing today (Health and Retirement Study, 2018). Respondents are offered financial incentive for completing different survey components. Additionally, to ensure adequacy in capturing the experiences of all older Americans, minority groups (specifically, Black/African American and Hispanic individuals) and residents of Florida are oversampled (HRS Staff, 2008a, 2008b). In this study, data from the 2018 wave of participants, collected between April 2018 and June 2019, was used. A subsample of respondents was randomly selected for inclusion in a separate module assessing for cannabis use habits and attitudes. Respondents to the question "*Have you ever used marijuana or hashish?*", found in the Module 4 Questionnaire, were included for data analysis.

Measures

Demographic data was obtained from the HRS Cross-Wave Tracker File. This data accounted for respondent age, masked race (White/Caucasian, Black/African American, Other), ethnicity (Not Hispanic, Hispanic), gender (male, female), and years of cumulative education. Race was dichotomized by minority status (White and Non-White) to elicit more meaning from group comparisons than the original small, heterogeneous race group divisions would permit.

Cannabis use was defined by respondent answers to the Module 4 Questionnaire. Prior to grouping, participants under the age of 50 (born after 1968) were filtered out of the dataset. Respondents were then divided into groups based on recency and frequency of cannabis use. A control group of *non-users* (n = 885) indicated that they had never "used marijuana or hashish", while *users* (n = 462) indicated that they had. Users who subsequently responded "NO" to the question, "Have you used marijuana or hashish within the past year?" were considered *past users* (n = 334), while those who responded "YES" were *current users* (n = 148). Current users were dichotomized based on the question "When you used marijuana or hashish most frequently, about how often did you use it?" Participants then were asked to provide a number and select a unit of time to capture their heaviest period of use, as follows: "[*number*] times per [*day*, *week*, *month*, or *year*]". To create equivalent units for every participant, each answer was converted to an estimated number of use times per year, whereby '1 time per day' was equated to '365 times per year.' *Current occasional users* (n = 36) indicated that at the time of their heaviest marijuana use, they used less than 52 times per year. *Current frequent users* (n = 92) indicated use 52 times per year or more.

Cognition data was obtained from Section D of the 2018 HRS Core file. Working memory was assessed using the Serial 7's task, in which participants must count backwards from 100 in increments of 7 and are given one point for each correct subtraction (even if a prior subtraction was incorrect) out of 5 answers in total (Folstein et al., 2001). Immediate free-recall and delayed free-recall (Ofstedal et al., 2005) were assessed using a 10-item wordlist task, where participants were read a list of 10 nouns and asked to recall from memory those words immediately, and again after a delay of 5 minutes. Final scores reflect the number of correct responses. Measures of cognition in the HRS are described in detail in prior publications (Ofstedal et al., 2005). Although reliability and validity are not indicated for individual memory subtests, the cognitive items were adapted from the Telephone Interview for Cognitive Status (Brandt et al., 1988), and despite minor methodological flaws, are generally considered to have sufficient construct validity (Herzog & Rodgers, 1999). Within this sample, test-retest reliability for serial 7s scores, obtained in 2016 and 2018, was adequate ($r = .65$, $p < .001$).

Statistical Analyses

Primary hypotheses were tested first using uncontrolled, one-way analyses of variance (ANOVA) and subsequently, analysis of covariance (ANCOVA) including age, gender, education, and race (Tabachnick & Fidell, 2013). The effect of cannabis use group status on immediate, delayed, and working memory were evaluated using this procedure. Because groups were variable in size, the Sidak post-hoc comparison procedure was employed.

RESULTS

The sample included 1,348 participants (59% female; $n = 797$). Demographic data is provided in Table 1. The sample was predominantly White (67%), and age ranged from 50-98 years (mean age = 67.25 years, $SD = 10.68$), and mean education was 13.05 years ($SD = 3.05$). Participants were categorized as cannabis non-users ($n = 886$), past users ($n = 334$), current occasional users (used less than 52 times per year; $n = 36$), or current frequent users (used 52 times or more per year; $n = 92$). Within the current occasional use group, 50% of respondents used cannabis 1-3 times per year ($n = 18$), 27.8% used 6-12 times per year ($n = 10$), and 22.2% used 2-4 times per month ($n = 8$). Within the current frequent use group, 42.4% of respondents used 1-3 times per week ($n = 39$), 35.9% used 4-7 times per week ($n = 33$), and 21.7% used 2 or more times per day ($n = 20$).

Table 1. *Descriptive Statistics by Cannabis Use Group*

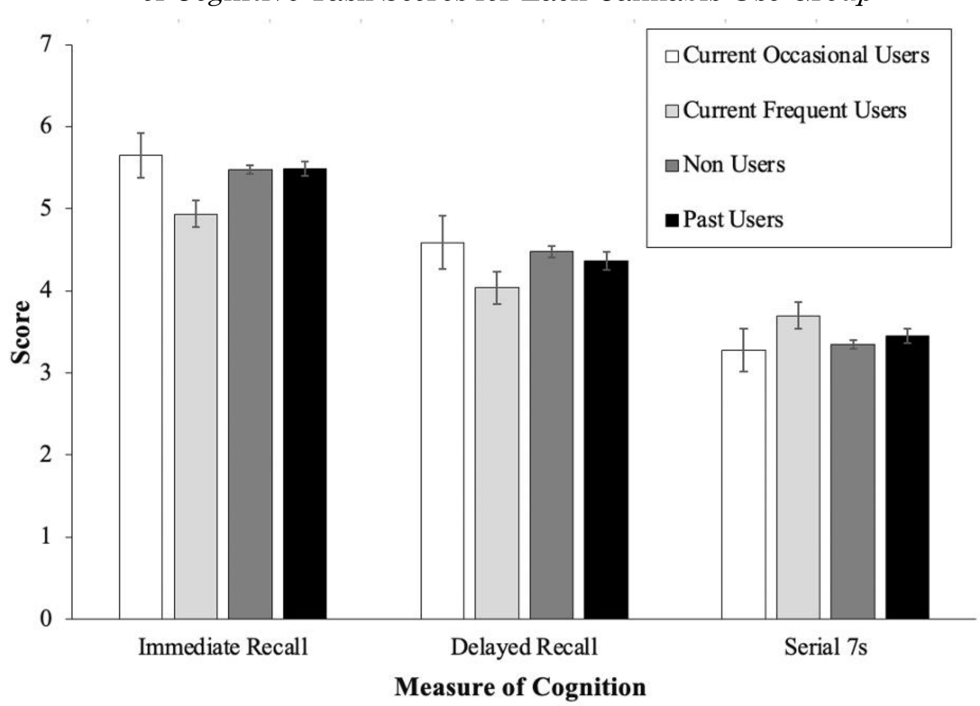
Variables	Mean (SD) or %				
	Full Sample (*N*=1348)	Current Frequent (*N*=92)	Current Occasional (*N*=36)	Past Users (*N*=334)	Non-Users (*N*=886)
Age	67.25 (10.68)	60.58 (6.22)	61.89 (9.31)	62.47 (7.80)	69.96 (11.03)
Gender (% Female)	59.1%	41.3%	58.3%	47.0%	65.6%
Race (Masked)					
White/Caucasian	66.8%	64.1%	77.8%	64.1%	67.6%
Black/African American	22.0%	27.2%	13.9%	25.1%	20.5%
Other	11.1%	8.7%	8.3%	10.5%	11.7%
Hispanic Ethnicity	13.9%	5.4%	8.3%	5.4%	18.3%
Cumulative Years of Education	13.05 (3.05)	13.51 (2.46)	13.94 (2.16)	13.56 (2.53)	12.78 (3.27)
Immediate Recall	5.53 (1.63)	5.34 (1.80)	6.19 (1.58)	5.80 (1.56)	5.43 (1.62)
Delayed Recall	4.58 (1.97)	4.57 (2.20)	5.32 (1.87)	4.80 (1.90)	4.46 (1.96)
Serial 7s	3.51 (1.69)	4.04 (1.50)	3.69 (1.74)	3.72 (1.60)	3.36 (1.72)

Regarding assumptions of ANOVA-based statistical procedures, immediate and delayed memory scores were essentially normal upon visual inspection. Serial 7's task scores were negatively skewed, and a perfect score of 5 was the modal score. Given the shape of the distribution, data transformations did not improve compliance with parametric assumptions. We examined the analysis using logarithmic, cube-root, and squared transformations (all appropriate for left skew). Analyses were conducted on all of these outcomes. While this did tend to result in more normally distributed residuals, there was no difference in the interpretation of the model parameters. Thus, for ease of interpretation, we present the non-transformed analyses, however, where possible, non-parametric analyses were employed.

Uncontrolled, one-way ANOVAs and controlled ANCOVAs were used to examine the effects of cannabis use on immediate memory, delayed memory, and working memory. Uncontrolled analyses found that cannabis use group was associated with immediate memory, $F(3,1246) = 6.09$, $p < .001$, $\eta_p^2 = .014$. Past users ($M = 5.80$, $SE = 0.09$) were found to have slightly better immediate memory performance than those who had never used ($M = 5.43$, $SE = 0.06$). By contrast, multivariate analyses found that when controlling for gender, $F(1,1234) = 11.84$, $p < .001$, $\eta_p^2 = .010$; education, $F(1,1234) = 87.02$, $p < .001$, $\eta_p^2 = .066$; age, $F(1,1234) = 112.68$, $p < .001$, $\eta_p^2 = .084$; and minority status, $F(1,1234) = 17.27$, $p < .001$, $\eta_p^2 = .014$, cannabis use was still associated with immediate memory, $F(3,1234) = 3.68$, $p = .012$, $\eta_p^2 = .009$ (See Figure 1). Controlling for demographic variables, post-hoc findings were that current frequent users' ($M = 4.94$, $SE = 0.16$) immediate memory was worse than that of both non-users ($M = 5.48$, $SE = 0.06$) and past users ($M = 5.49$, $SE = 0.09$; $p < .05$ for both).

Uncontrolled analyses suggested a significant main effect of cannabis use on delayed memory $F(3,1245) = 3.71$, $p = .011$, $\eta_p^2 = .009$. Post hoc findings revealed a non-significant trend whereby non-users ($M = 4.47$, $SE = 0.07$) had slightly worse delayed memory scores than past users ($M = 4.80$, $SE = 0.11$, $p = .063$) and current occasional users ($M = 5.32$, $SE = 0.35$, $p = .097$). Multivariate analyses controlling for gender, $F(1,1233) = 7.21$, $p = .007$, $\eta_p^2 = .006$; education, $F(1,1233) = 85.89$, $p < .001$, $\eta_p^2 = .065$; age, $F(1,1233) = 112.87$, $p < .001$, $\eta_p^2 = .084$; and minority status $F(1,1233) = 50.56$, $p < .001$, $\eta_p^2 = .039$, found that cannabis use group was no longer associated with delayed memory, $F(3,1233) = 1.63$, $p = .182$, $\eta_p^2 = .004$.

Figure 1. *Summary of Covariate Adjusted Means and Standard Errors of Cognitive Task Scores for Each Cannabis Use Group*



Uncontrolled analyses suggested a significant main effect of cannabis use on working memory based on the serial sevens task $F(3,1344) = 6.76$, $p < .001$, $\eta_p^2 = .015$. Post hoc findings showed that non-users' ($M = 3.36$, $SE = 0.06$) working memory was worse than both past users ($M = 3.72$, $SE = 0.09$) and current frequent users ($M = 4.00$, $SE = 0.18$; $p < .01$ for both). Given that serial sevens data were heavily skewed, this analysis was repeated using a Kruskal-Wallis nonparametric test. Interpretation of those results, $H(3) = 24.76$, $p < .001$, did not differ from interpretation of the ANOVA. Multivariate analyses controlled for gender, $F(1,1332) = 14.54$, $p < .001$, $\eta_p^2 = .011$; education, $F(1,1332) = 160.16$, $p < .001$, $\eta_p^2 = .107$; age $F(1,1331) = 5.59$, $p = .018$, $\eta_p^2 = .004$; and minority status $F(1,1332) = 78.27$, $p < .001$, $\eta_p^2 = .055$, found that cannabis use group was no longer associated with working memory $F(3,1332) = 1.67$, $p = .171$, $\eta_p^2 = .004$.

DISCUSSION

This study aimed to examine the relationship between cannabis use and immediate, delayed, and working memory in older adults. Univariate findings were that past users' immediate memory, delayed memory, and working memory were better than those of non-users. Multivariate findings controlling for age, gender, education, and minority status were that current frequent users had worse immediate memory than did non-users or past users, but no differences were found for delayed memory or working memory. Occasional (less than weekly) and past users, however, performed comparably to non-users on all three measures of cognition, suggesting that past use does not adversely impact current functioning among older adults. The disparity between univariate and multivariate findings is not surprising in the substance use literature (Delker et al., 2016), and underscores the critical importance of controlling for demographic characteristics in future research on cannabis use with older adults.

Frequent users' relative deficits in immediate memory may be explained by residual effects of cannabinoids in the system. Past research indicates that cognitive consequences of cannabis use can be attributed to residual cannabinoids or withdrawal and appear to resolve with approximately 25 days of abstinence (Schreiner & Dunn, 2012), a threshold not met by the frequent use group. The immediate free-recall task evaluates two primary cognitive components: attention and short-term episodic memory (Gavett & Horwitz, 2012). The findings that immediate memory was associated with recent frequent use, but delayed and working memory were not, suggest attentional deficits as a likely explanation.

While cognitive impairments seen in cannabis users are somewhat inconsistent across literature, overall, findings support the idea that attentional impairments are present with acute cannabis use and persist mainly as a residual effect (Broyd et al., 2016; Ganzer et al., 2016; National Academies of Sciences Engineering and Medicine, 2017). Deficits in immediate, delayed, and working memory are known to occur with acute use, and often resolve after periods of abstinence (Broyd et al., 2016; National Academies of Sciences Engineering and Medicine, 2017). Interestingly, aside from immediate memory, the current study contradicts past findings of delayed and working memory deficits. These findings may suggest that older adults are somehow less sensitive to adverse cognitive effects of cannabis use, that other dynamics of cognitive aging obscure these effects, or that limitations imposed via use of this large secondary dataset prevent measurement of these effects. In any case, future research should further examine cognitive, social, neuroanatomical, and later-life developmental impacts of cannabis use.

Given these results, older adults should be advised that frequent (at least weekly) cannabis use likely has negative effects on immediate memory. Due to the unclear parameters of cannabis use available for this study, this finding could be interpreted in three ways. It is presently unclear if poorer immediate memory performance among frequent users is due to a cumulative effect of cannabis consumption over time, a pre-existing deficit in immediate memory performance among the self-selected population of individuals who subsequently initiate frequent cannabis use, or whether this effect reflects lingering sequalae of recent cannabis intoxication. These results suggest that, if no pre-existing difference exists between groups, cognitive effects of frequent use may be mitigated by sustained abstinence over time. Older adults should consider that deficits in attention and short-term episodic memory may impede both social functioning (Faraone et al., 2000) and performance of tasks associated with independence, including driving (Barkley & Cox, 2007). However, the prominence and practical application of such effects in older adult populations needs corroboration through future. Current findings do not speak to perceived quality of life in older adults and its association with cannabis use (Goldenberg et al., 2017). Given the various medicinal and recreational purposes of cannabis consumption, such cognitive effects may be an acceptable tradeoff. Older adults who are past cannabis users performed comparably to non-users and therefore may not need to consider past cannabis use as a threat to present cognitive functioning. Similarly, occasional (less than weekly) users do not differ from non-users, although this finding should be cautiously interpreted due to various limitations of the present study including variant sample size, measurement imprecision regarding cannabis use, and lack of control for certain confounding factors.

The primary limitation to this study was its sample size – although cannabis use was assessed among many respondents, cannabis use groups were largely variant in size. This study was also limited by the measures of cannabis use collected from respondents. Participants were asked if they had used cannabis within the past year, but nothing further denoting more recent cannabis use. Assessment of use within recent hours, days, and/or weeks may better differentiate use patterns and residual effects among current users (Schreiner & Dunn, 2012). Frequency of use was the only quantifiable dimension of cannabis use addressed in the Module 4 HRS data. Lack of standard “serving sizes” as in alcohol research is a known methodological challenge in cannabis research, especially prior to 2021 (National Institutes of Health, 2021) and future research should attempt to address dosage and/or cumulative lifetime use to further characterize cannabis use patterns. Finally, although the present study controlled for age, gender, minority status, and education, other control variables not addressed by this study may influence cognitive performance between groups. Depression (National Academies of Sciences Engineering and Medicine, 2017) and alcohol use (Topiwala & Ebmeier, 2018) are both known to be associated with cognitive function and cannabis use, and thus should be considered for examination in future research.

With cannabis legalization at the forefront of imminent policy changes worldwide, examination of its implications for public health and wellbeing is warranted. Historically, the ability to obtain trustworthy research on the impact of cannabis on public health and safety has been severely limited by cannabis illegality and a lack of corresponding funding. In combination with other works, these findings may inform individual healthcare decision making, guidelines on medical cannabis use to minimize undesired side effects, and moderate use guidelines for recreational use for diverse populations including aging adults.

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