Initial Evaluation of Domain-Specific Episodic Future Thinking on Delay Discounting and Cannabis Use

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Episodic Future Thinking (EFT), mental simulation of personally relevant and positive future events, may modulate delay discounting (DD) in cannabis users. Whether EFT impacts cannabis use, whether DD mediates this effect, and whether EFT can be enhanced by prompting future events across specific life domains is unknown. Active, adult cannabis users (n = 90) recruited from Amazon mTurk and Qualtrics Panels were administered an Episodic Specificity Induction (ESI) to enhance quality of imagined events before being randomized to EFT, domain-specific-EFT (DS-EFT), or Episodic Recent Thinking (ERT). All participants created four, positive life events; DS-EFT participants imagined social, leisure, health, and financial events. Event-quality ratings were assessed (e.g., enjoyment). DD was assessed at baseline (Day 1), post-intervention (Days 2–4), and follow-up (Days 9–12). Cannabis use was assessed at baseline and follow-up. Differences in change in days and grams of cannabis use between conditions and mediation of changes in use by DD were examined. No differences in DD were observed between conditions. DS-EFT, but not EFT, showed significantly greater reductions in grams (d = 0.54) and days of cannabis use (d = 0.50) than ERT. DS-EFT and EFT demonstrated significantly greater event-quality ratings than ERT (d > 0.55). EFT-based interventions showed potential for reducing cannabis use. Unusually, effects on DD did not mediate this effect. Further testing with larger samples of cannabis users is needed to better understand EFT’s mechanisms of action and determine optimal implementation strategies.

Public Significance Statement
Participation in a brief online intervention that prompts the creation and imagination of positive future events across life domains may help reduce frequent cannabis use.

Keywords: Episodic Future Thinking, cannabis use, digital intervention, Episodic Specificity Induction, delay discounting

Between 2010 and 2019, past-month cannabis use increased from 6.9% to 11.5% among those 12 and older in the U.S (Substance Abuse and Mental Health Services Administration [SAMHSA], 2020). This rise in the prevalence of cannabis use is concerning given that frequent cannabis use is associated with deficits in cognitive functioning and decision-making, and that between 12% and 30% of past-year cannabis users meet criteria for cannabis use disorder (CUD; Grucza et al., 2016; Hasin et al., 2015; Volkow et al., 2014). As with other substances, delay discounting (DD), which is defined as the devaluation of future rewards (Bickel et al., 2019), is associated with more frequent and problematic cannabis use (Sofis, Budney, et al., 2020; Sofis, Lemley, et al., 2020; Strickland et al., 2020). Specifically, DD demonstrates a small but direct relationship with more frequent and problematic cannabis use, even when accounting for other influences such as other measures of impulsivity or nicotine use, cognitive functioning, and reinforcing efficacy of cannabis use (Aston et al., 2016; Lopez-Vergara et al., 2019; Sofis, Budney, et al., 2020). Generally, excessive DD is often associated with more frequent substance use, and increased risk for developing a substance use disorder (SUD), and

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tends to decrease with effective treatment (Amlung et al., 2017; Bickel et al., 2019; Rung & Madden, 2018). Hence, DD has become an important potential target of interventions seeking to reduce substance use (Bickel et al., 2019). Several clinical studies demonstrated that DD was reduced following treatment for cocaine use (Black & Rosen, 2011), opioid use (Landes et al., 2012), and nicotine use (Weidberg et al., 2015; Yi et al., 2008).

To date, there has been little attention to DD as a target of interventions to reduce cannabis use and no studies to our knowledge have directly tested whether reductions in DD contribute to reductions in cannabis use. Post-hoc evaluations of the relationship between DD and reduced cannabis use have revealed mixed findings, with secondary analyses of intervention studies showing both positive (Lee et al., 2015) and null findings (Peters et al., 2013). Testing interventions that directly target DD is needed to better examine its potential role as a mediating influence on reductions in cannabis use.

One such candidate intervention is Episodic Future Thinking (EFT), which is a brief intervention that prompts mental simulation of personally relevant, positive future events (Atance & O’Neill, 2001; O’Neill et al., 2016; Rung & Madden, 2019; Snider et al., 2016). Traditional EFT procedures iteratively prompt participants to construct and imagine positive events that take place in the future (e.g., 1 week, 1 month, 3 months, 1 year). Growing evidence suggests that EFT may engender reduction in DD among those who use substances in studies that compare EFT to Episodic Recent Thinking (ERT), a control condition that prompts participants to recollect events from the previous day (Snider et al., 2016; Stein et al., 2016; Sze et al., 2017). Such positive effects on DD have been observed in EFT studies targeting nicotine and alcohol use, and in one of these studies, the magnitude of reduction in DD was shown to mediate the relationship between EFT and reductions in cigarette use (Bulley & Guollo, 2017; Chiu & Wu, 2017; Stein et al., 2016). EFT may reduce DD by increasing the capacity to focus on the future via improvement in the ability to construct mental scenes of an event in a given time and place (Benoit & Schacter, 2019; Madore, Jing, et al., 2019; Madore, Thakral, et al., 2019; Peters & Büchel, 2010).

Mental event construction based on past events or imagined future events is thought to be driven by episodic memory, that is, the retrieval of contextual details related to past events (Jing et al., 2017). Episodic memory processes support the construction of mental scenes regarding future events by flexibly recombining details from past events to create novel mental scenes (Schacter & Addis, 2007). Notably, the specificity and salience (i.e., quality) of imagined future events during EFT has been shown to relate to the positivity and perceived value of future events, which tends to correspond to greater reductions in DD (Rung & Madden, 2019; Sofis, Budney, et al., 2020). Such findings support the assertion that the interaction of event specificity, future focus, and reward valuation may serve as a mechanism by which EFT changes DD. That is, the quality of event details during EFT (i.e., sometimes referred to as episodic specificity) may be important to the process of reducing DD and substance use.

Those who use cannabis regularly often demonstrate episodic memory deficits (Dupperrouzel et al., 2019; Petker et al., 2019; Smith et al., 2015; Solowij & Battisti, 2008), and thus cannabis users may have difficulty engaging or benefiting from EFT. They may be less likely to generate a range of novel and personally important future events without being prompted because of episodic memory deficits that support this ability (Jing et al., 2017). Hence, prompting creation of future events across life domains (e.g., social, leisure, financial/career, health) during EFT may enhance engagement in important elements of the future event creation process and potentially increase impact on target health behaviors. For the present study, we developed a “domain-specific” EFT (DS-EFT) prompted participants to create and imagine personally relevant and positive future events across social, leisure, financial/career, and health domains.

Episodic memory deficits may also impede the ability to construct detailed mental future scenes related to cannabis use (Dupperrouzel et al., 2019; Petker et al., 2019; Pillersdorf & Scoboria, 2019). Interestingly, Episodic Specificity Induction (ESI), a brief procedure which involves prompting the recollection of episodic details derived from a brief video, has been shown to enhance the ability to generate alternative future events and to improve the salience of mentally constructed events (Madore & Schacter, 2016). ESI, therefore, may be an effective method of priming EFT in persons with episodic memory deficits, including regular cannabis users. Indeed, in a study of frequent cannabis users, those who received ESI prior to EFT exhibited lower rates of DD and rated their created events during EFT or ERT as more vivid, enjoyable, important, and exciting than the group that received a control ESI training (Sofis, Lemley, et al., 2020).

The present study provided an initial direct test of the effects of EFT on change in cannabis consumption, compared the impact of a novel domain-specific EFT to traditional EFT on DD and cannabis use, and tested whether DD mediated the effects of the interventions on cannabis use. We anticipated that the DS-EFT training would produce greater reductions in both DD and cannabis use relative to the EFT and ERT conditions and that the magnitude of reduction in DD would mediate reductions in cannabis use.

### Materials and Method

#### Participants and Recruitment

The Institutional Review Board from Dartmouth College approved all procedures of the present study (STUDY00029652, “Episodic Future Thinking in Cannabis Users”). Participants completed the informed consent prior to beginning the baseline session (Day 1). All study activities, including the training session (Day 2–3) and the follow-up session (Day 9–11) occurred remotely using Qualtrics survey software. Participants were recruited from Amazon Mechanical Turk (mTurk), an online crowdsourcing marketplace, and from Qualtrics Research Panels. A sample size of 90 was targeted because the only published study that has tested the impact of EFT on substance use (cigarettes) included 90 participants randomized to three independent conditions and reported moderate between-condition effect sizes and a significant mediation effect of DD (Chiu & Wu, 2017). These exclusions resulted in a final sample of $n = 90$. The current exploratory study was not preregistered as a randomized clinical trial.

#### Procedures

Participants were randomized to receive ESI + EFT ($n = 35$), ESI + ERT ($n = 26$), or ESI + DS-EFT ($n = 29$). Of the 90 participants, 38 (42%) were recruited from mTurk and 52 (58%) from Qualtrics Research Panels. After informed consent, participants...
completed a brief screening that assessed lifetime cannabis use, and past 30-day use of cannabis, illicit prescription opioids, other illicit opioids (e.g., fentanyl, heroin), alcohol, and tobacco. Participants averaged 45 min total to complete all three sessions (screening, intervention, follow-up). mTurk participants who completed the study earned up to $7.50. Qualtrics Research Panel participants were compensated via standard procedures for the panels (exact amount varied and was unknown to us), however, Qualtrics representatives indicated were similar in magnitude to that of our mTurk participants.

**Episodic Specificity Induction**

ESI involved watching a 2-min video of a woman giving a tour of her tiny house, and participants could not move to the next step in the training until the entire 2-min had passed. They then typed in answers to each of seven questions about episodic details from the tiny house video (e.g., “What did the people in the video look like?,” “What happened in the video, in order?”). Participants typed short answers to six questions about the episodic details of each event (e.g., “What will you be doing?,” “What will you be tasting and smelling?”).

**Episodic Future Thinking**

Those assigned to traditional EFT were prompted to create four, iterative positive future events (1 week, 1 month, 3 months, 1 year). Moreover, participants who received EFT were prompted to create future events that were progressively more distant in the future (e.g., 1 week, 1 month, 3 months, 1 year) whereas all DS-EFT future events were in 1 year.

**Domain-Specific Episodic Future Thinking**

The DS-EFT, adapted from Sofis, Budney, et al. (2020) and Sofis, Lemley, et al. (2020), prompted participants to imagine an event 1 year in the future within each of the following life domains; social, leisure, financial/professional, and health. In contrast to EFT, all future events were imagined 1 year in the future to provide a sufficiently broad timeframe in which participants could realistically envision the occurrence of the domain-specific events. For example, it may be difficult to imagine an especially positive future work or financial life-event that occurs in a week because the perceived likelihood that such an event could occur would be low. Participants typed short answers to six questions about the episodic details of each event similar to the EFT condition.

**Episodic Recent Thinking**

ERT, which served as the control condition, prompted episodic thinking of recent positive events from yesterday during 3-hr intervals (4–7 p.m., 1–4 p.m., 10–1 p.m., 7–10 a.m.). Like for DS-EFT and EFT, participants in the ERT group answered the same six questions about each event.

**Event Cues**

All participants were required to create a short contextual cue summarizing each imagined event (Rung & Madden, 2019; Snider et al., 2016; Stein et al., 2016). For DS-EFT and EFT, participants completed the phrase “In X time from now, I will be . . . .” where X was the future time point. Participants in the ERT group completed the phrase, “Yesterday between Y, I was . . . .” where Y was the time interval (e.g., 7–10 a.m.) from the day before. These textual cues were then presented during corresponding timepoint choices in the DD task.

**Event Ratings**

Participants rated the excitement, enjoyment, importance, and vividness of each event on separate 100-point Visual Analogue Scales (VASs) as a measure of quality of episodic event creation to compare the quality of the events created by those who received ERT, EFT, and DS-EFT (Snider et al., 2016).

**Measures**

**Demographics and Substance Use**

Table 1 shows distributions and descriptive statistics for demographic variables and substance use measures. Participants ranged from age 19 to 75 (M = 41.0 years, SD = 13.1), and 61% were female. Most participants were not college educated (62%), and over half of the sample reported full-time employment (59%). All substance use measures regarding use during the 30 days before the baseline session were ordinal in nature. Median number of days of cannabis use was 26–29 days per month (IQR; Inter Quartile Range = 10–19, all 30 days) and the median number of times cannabis was used per day was 2 (IQR = 1, 3 times). Median number of days of alcohol use was 3–5 days (IQR 1–2, 10–19 days) and median number of alcoholic drinks was two drinks (IQR = 1, 5 drinks). Median number of days of tobacco use was all 30 days (IQR = 6–9 days, all 30 days) and median number of times using tobacco was five times per day (IQR = 1 times, 6–10 times per day).

The Timeline Followback procedure (Sobell & Sobell, 1992) was used to obtain reports of cannabis, alcohol, nicotine, and any other illicit substance use during the 7 days prior to the baseline session (see Table 1). Participants averaged 5.4 days of cannabis use (SD = 2.1), 17.6 g of cannabis (SD = 15), 2.1 days of alcohol use (SD = 2.1), 6.7 alcoholic drinks (9.0), 5 days of tobacco use (3.0), and 27.6 instances of tobacco use (SD = 20). Eighty percent of the sample used tobacco during the week prior to baseline (n = 72) and 73% used alcohol (n = 66).

**Delay Discounting**

Participants completed the five-trial DD task as a part of the screening process, given the brevity of the task (Koffarnus & Bickel, 2014), and completed the adjusting amount DD task (Estle et al., 2006) during the intervention and follow-up sessions to facilitate presentation of episodic cues during DD choices. A well-accepted index of DD rate, $k$, was obtained for both DD tasks.

For the five-trial task, participants made a series of five choices regarding whether to receive $500 now or $1,000 after a delay. The delay for the first choice was 3 weeks. For each trial, the delay was adjusted based on the participant’s previous choice (i.e., choosing the immediate reward shortened the delay experienced during the subsequent trial and choosing the delayed reward lengthened the delay). The combination of choices made on the five trials resulted in
one of 32 possible outcomes, each of which was assigned a pre-determined $k$ value (Koffarnus & Bickel, 2014). For the adjusting amount DD task, participants’ first choices at each delay were between receiving $500 now or $1,000 after a delay (i.e., ascending delays of 1 day, 1 week, 1 month, 3 months, 1 year); the smaller, sooner amount was titrated after each choice for six trials at each delay (Estle et al., 2006). The raw $k$ values were positively skewed; thus ln($k$) values were used for analyses.

### CUDIT-R

Participants completed the Cannabis Use Disorder Identification Test-Short Form (CUDIT-SF), a tool used to screen for CUD and as an index of problematic cannabis use (Bonn-Miller et al., 2016). Response options range from never (0) to daily or almost daily (4) for the three-item tool. In the present study, 44% screened positive for potentially having CUD (score > 1).

### Table 1

<table>
<thead>
<tr>
<th>Sample and Group Characteristics</th>
<th>Overall</th>
<th>ERT</th>
<th>EFT</th>
<th>DS-EFT</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic and behavioral economic variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age ($M$, $SD$)</td>
<td>41.0 (13)</td>
<td>42.7 (14)</td>
<td>40.7 (12)</td>
<td>39.2 (14)</td>
<td>.58</td>
</tr>
<tr>
<td>Ready to change Cann (1–10; $M$, $SD$)</td>
<td>2.4 (1.8)</td>
<td>2.5 (1.7)</td>
<td>2.3 (1.9)</td>
<td>2.2 (2.0)</td>
<td>.84</td>
</tr>
<tr>
<td>Delay discounting (ln($k$); $M$, $SD$)</td>
<td>−4.4 (1.5)</td>
<td>−4.4 (1.8)</td>
<td>−4.1 (1.4)</td>
<td>−4.6 (1.2)</td>
<td>.58</td>
</tr>
<tr>
<td>Cann demand elasticity (α; $M$, $SD$)</td>
<td>.07 (.10)</td>
<td>.06 (.09)</td>
<td>.06 (.10)</td>
<td>.08 (.11)</td>
<td>.78</td>
</tr>
<tr>
<td>Cann demand intensity ($Q_0$; $M$, $SD$)</td>
<td>24 (27)</td>
<td>18.9 (20)</td>
<td>34.9 (35)</td>
<td>18.8 (25)</td>
<td>.04</td>
</tr>
<tr>
<td>Gender (n, %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>35 (39)</td>
<td>14 (40)</td>
<td>8 (31)</td>
<td>13 (45)</td>
<td>.33</td>
</tr>
<tr>
<td>Level of education (n, %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No college degree</td>
<td>62 (69)</td>
<td>21 (60)</td>
<td>20 (77)</td>
<td>21 (72)</td>
<td>.61</td>
</tr>
<tr>
<td>Employment (n, %)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Full-time</td>
<td>53 (59)</td>
<td>18 (51)</td>
<td>17 (65)</td>
<td>18 (62)</td>
<td>.54</td>
</tr>
<tr>
<td>Part-time</td>
<td>11 (12)</td>
<td>3 (9)</td>
<td>4 (15)</td>
<td>4 (14)</td>
<td>.78</td>
</tr>
<tr>
<td>Retired/disabled</td>
<td>16 (18)</td>
<td>8 (23)</td>
<td>4 (15)</td>
<td>4 (14)</td>
<td>.78</td>
</tr>
<tr>
<td>Unemployed</td>
<td>10 (11)</td>
<td>6 (17)</td>
<td>1 (4)</td>
<td>3 (10)</td>
<td>.78</td>
</tr>
<tr>
<td><strong>Substance-related variables</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Cannabis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Readiness to change (1–10; $M$, $SD$)</td>
<td>2.4 (1.8)</td>
<td>2.5 (1.7)</td>
<td>2.3 (1.9)</td>
<td>2.2 (2.0)</td>
<td>.84</td>
</tr>
<tr>
<td>CUD (yes/no)</td>
<td>40 (44)</td>
<td>18 (51)</td>
<td>11 (42)</td>
<td>11 (38)</td>
<td>.90</td>
</tr>
<tr>
<td>Past week ($M$, $SD$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days of use</td>
<td>5.4 (2.1)</td>
<td>5.2 (2.2)</td>
<td>5.5 (2.0)</td>
<td>5.6 (2.1)</td>
<td>.78</td>
</tr>
<tr>
<td>Cannabis grams</td>
<td>17.6 (15)</td>
<td>16.3 (14)</td>
<td>17.2 (14)</td>
<td>19.7 (17)</td>
<td>.66</td>
</tr>
<tr>
<td>Past 30 days ($Mdn$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days of use</td>
<td>26–29</td>
<td>26–29</td>
<td>20–25</td>
<td>All 30</td>
<td>.84</td>
</tr>
<tr>
<td>Times/day</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>.75</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past week ($M$, $SD$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol days</td>
<td>2.1 (2.1)</td>
<td>1.7 (1.8)</td>
<td>2.0 (1.9)</td>
<td>2.7 (2.4)</td>
<td>.18</td>
</tr>
<tr>
<td>Alcoholic drinks</td>
<td>6.7 (9.0)</td>
<td>6.5 (10)</td>
<td>5.9 (6.7)</td>
<td>7.8 (9.4)</td>
<td>.74</td>
</tr>
<tr>
<td>Past 30 days ($Mdn$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days of use</td>
<td>3–5</td>
<td>3–5</td>
<td>3–5</td>
<td>6–9</td>
<td>.07</td>
</tr>
<tr>
<td>Drinks/day</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>.64</td>
</tr>
<tr>
<td>Nicotine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past week ($M$, $SD$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobacco days</td>
<td>5.0 (3.0)</td>
<td>4.9 (3.0)</td>
<td>5.2 (2.9)</td>
<td>4.9 (3.1)</td>
<td>.90</td>
</tr>
<tr>
<td>Tobacco times</td>
<td>27.6 (20)</td>
<td>27.6 (21)</td>
<td>27.5 (20)</td>
<td>27.5 (21)</td>
<td>1.0</td>
</tr>
<tr>
<td>Past month ($Mdn$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days of use</td>
<td>All 30</td>
<td>All 30</td>
<td>All 30</td>
<td>All 30</td>
<td>.99</td>
</tr>
<tr>
<td>Times/day</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>.95</td>
</tr>
</tbody>
</table>

Note. ERT = Episodic Recent Thinking; EFT = Episodic Future Thinking; DS-EFT = domain-specific-EFT; CUD = cannabis use disorder; Cann = cannabis; $Mdn$ = median; $M$ = mean; $SD$ = standard deviation.

### Readiness to Change Cannabis Use

Participants reported their readiness to change using a tool adapted from the Readiness Ruler (LaBrie et al., 2005). Participants reported an average readiness to reduce cannabis use of 2.4 ($SD = 1.8$) on a 10-point visual analog scale (VAS; 1 = Not important, 10 = Very important).

### Marijuana Purchase Task

After completing ERT, EFT, or DS-EFT sessions, participants completed a Marijuana Purchase Task (MPT; Aston et al., 2015) to examine state-like reinforcing efficacy of cannabis. Demand intensity ($Q_0$), which represents the maximum amount of cannabis participants are willing to consume at free price, and demand elasticity ($α$), which characterizes sensitivity of cannabis consumption amidst rising prices, were calculated for each participant using the exponential demand model (Hursh & Silberberg, 2008).
The same instructions employed in Aston et al. (2015) were used in
the present study wherein participants are instructed to imagine that
they are consuming average quality cannabis on a typical day in
the last month, that they did not use cannabis beforehand, that they
cannot save the cannabis, and that they must consume all the
cannabis requested in the purchase task.

Analysis Plan

To be eligible for mTurk recruitment, participants had to have a
95% or higher approval rating on all previously submitted mTurk
HITs, and have completed at least 100 Human Intelligence Tasks
(HITs). Inclusion criteria for mTurk and Qualtrics Panels recruit-
ment included: reside in the U.S., age 18 or older, at least 100
time lifetime days of cannabis use, at least 10 days of cannabis use in
the last month, and DD rates that were not in the bottom 25% of those
observed in a prior study that involved regular cannabis users (Sofis,
Badney, et al., 2020; Sofis, Lerny, et al., 2020; ln(k) = −7.35).
Participants were eligible for the follow-up session if they com-
pleted the first (n = 671) and second session (n = 210) and did not
miss more than one attention check out of the three presented in the
first session and the two presented in the second session. Participants
were excluded if their DD rates were too low (n = 41) because of previ-
sion research suggesting that EFT-induced reductions in DD
may be more likely to occur in those with higher rates of baseline
DD (Snider et al., 2018). Participants were also excluded if their
responses on the DD tasks were too inconsistent, based on criteria
delineated by Johnson and Bickel (2008) or were so inconsistent that
valid k value could not be derived (n = 10). Participants were
excluded for inconsistent or nonsensical responding on the hypo-
thetical cannabis purchase task which was informed by Stein et al.
(2015; n = 24). Specifically, 10 participants were excluded for not
meeting the Stein et al. (2015) bounce criteria, one was excluded for
not meeting the Stein et al. (2015) trend criteria, and the remaining
13 were excluded for study specific unrealistic consumption criteria
(i.e., no consumption at free price at baseline, consumption >100,
or consumption at free price that was equal to consumption at the
maximum price assessed ($20/unit).

Cannabis demand elasticity and intensity were included in the
present study but the indices of $O_{max}$, $P_{max}$, and $breakpoint$ were
not included. Specifically, when examining baseline correlations
between all five demand indices and measures of recent cannabis
use, the cannabis use measures were significantly correlated with
elasticity, intensity, and $breakpoint$, but $P_{max}$ and $O_{max}$ were not.
Although elasticity, intensity, and $breakpoint$ were each correlated
with the cannabis use measures, elasticity and $breakpoint$ were
correlated at $r = .85$, which suggests that very little variance would
be accounted for by adding either $breakpoint$, $P_{max}$, or $O_{max}$ as
separate covariates or together with elasticity to form the persistence
factor (Aston et al., 2017). Further, when replicating the methods of
the Principal Component Analysis for demand indices from Aston
et al. (2017) using the current data (e.g., including the oblim rotation
and using the eigenvalue >1 and scree plot methods for
determining the number of factors), a one-factor solution was the
best solution. We were therefore not confident in using the two-
factor solution for this study.

To test for baseline differences between the three groups, Chi-
squared tests and one-way Analysis of Variance; ANOVAs
(Lempert et al., 2020) were performed on demographics, substance
use (cannabis, alcohol, tobacco), DD, cannabis demand elasticity
and intensity, and readiness to reduce cannabis use (Table 1). The
only statistically significant difference between groups was for
demand intensity ($p = .04$), such that the EFT group reported
that they would smoke more cannabis joints if they were free
than the ERT ($p = .02$) and DS-EFT ($p = .03$) groups. Further,
demand intensity and elasticity demonstrated moderate strength
correlations with correlated demonstrated a strong negative corre-
lation with cannabis use both demand intensity and elasticity were
used as covariates for comparative analyses between groups on
event ratings, DD, and cannabis use. Age and gender were used as covariates because men and older
individuals often demonstrate deficits in episodic memory relative to
women and younger individuals (Addis et al., 2008; Asperholm
et al., 2019). Both demand indices were included as covariates
given the significant group differences found in demand intensity at
baseline ($p = .04$). Further, elasticity demonstrated moderate
strength correlations with both cannabis use grams ($r = −.37,$
$p < .001$) and days ($r = .31, p < .01$) and intensity was signifi-
cantly correlated at a similar strength to grams of cannabis use
($r = .37, p < .001$). The sum of CUDIT-SF items was also used as
a covariate to control for initial level of problematic cannabis use.

Five one-way analyses of covariances (ANCOVAs) were used to
examine between-group differences in quality ratings for enjoy-
ment, vividness, excitement, importance, and realism, respectively.
Age and gender were entered into each model as covariates because
men and older individuals are more likely to demonstrate deficits in
episodic memory processes important to quality of event con-
struction (Addis et al., 2008; Asperholm et al., 2019; Fuentes &
Desrocher, 2013). Subsequent pairwise comparisons of groups were
planned to test for specific between intervention differences for each
quality of event rating.

Latent Change Score Models (LCSMs), a subset of Structural
Equation Modeling (SEM) was used to: (a) test whether DS-EFT
engendered greater latent reductions in cannabis use than the EFT
and ERT while controlling for covariates, (b) examine whether change in DD mediated the relationship between interventions and
change in total cannabis grams and total cannabis days, and (c) test
whether DS-EFT engendered greater latent reductions in cannabis
use than the EFT and ERT while controlling for covariates.
Notably, LCSMs allow for the flexibility and benefits associated
with SEM, including a reduction in measurement error (Hamaker
et al., 2015; Kiebit et al., 2018). This test allows for the incorpo-
ration of an examination of reliable change within intervention
condition on change in these outcomes, while incorporating subject
specific differences by explicitly modeling the variation in the
latent change factor. LCSMs also allow one to control for initial
starting conditions (Kiebit et al., 2018). Model fit was assessed
based on the observed $\chi^2$, Root Mean Square Error of Approxima-
(PSMSEA), Comparative Fit Index (CFI), and the Tucker–
Lewis Index (TLI). Good fit was determined based on commonly
accepted indicators for fit indices with RMSEA ≤ 0.05, CFI ≥ 0.95,
and TLI ≥ 0.95, and acceptable fit is indicated when
RMSEA ≤ 0.08, CFI ≥ 0.90, and TLI ≥ 0.90 (Brown, 2015;
Marsh et al., 2004; Sharma et al., 2005). The robust maximum
likelihood was utilized to account for the non-normal structure of
the data.
Results

Event Ratings

Figure 1 shows the adjusted mean ratings for each type of quality rating and each intervention after controlling for gender and age. Significant between-group differences emerged for enjoyment, $F(2, 85) = 10.35, p < .001, d = .99$, importance, $F(2, 85) = 6.90, p < .01, d = .81$, excitement, $F(2, 85) = 15.30, p < .001, d = 1.20$, and realism, $F(2, 85) = 3.25, p = .04, d = .55$, but not for vividness, $F(2, 85) = 1.60, p = .21, d = .39$. For enjoyment, importance, and excitement ratings, both EFT and DS-EFT engendered significantly greater quality ratings than ERT ($p < .01$), but no differences were observed between EFT and DS-EFT ($p > .48$). For realism, those who received ERT perceived their events as more realistic than those who received DS-EFT ($p < .05$). No other significant pairwise differences were observed.

Change in Cannabis Use

Grams

Figure 2 shows the Violin plots of latent change in total cannabis use grams such that without controlled for any covariates (i.e., unadjusted model) and when controlling for age, gender, cannabis demand intensity and elasticity, and the CUDIT-SF score (i.e., adjusted model). Values greater than 0 on the y-axis indicate reductions in cannabis use and negative values indicate increase in use. The LCSM analyses showed that DS-EFT showed a greater reduction in grams of cannabis use than ERT for the unadjusted ($d = .47, p = .03$) and the adjusted model ($d = .55, p = .009$). No significant differences in reductions in grams were found between EFT and ERT for the unadjusted ($d = .27, p = .21$) or the adjusted model ($d = .28, p = .18$), or between DS-EFT and EFT for the unadjusted ($d = .15, p = .47$), or the adjusted model ($d = .19, p = .36$).

Days

Figure 3 shows the Violin plots of latent change in total cannabis use days without controlled for any covariates (i.e., unadjusted model) and when controlling for age, gender, cannabis demand intensity and elasticity, and the CUDIT-SF score (i.e., adjusted model). Values greater than 0 on the y-axis indicate reductions in cannabis use and negative values indicate increase in use. For days of use, DS-EFT also showed a greater reduction in days of cannabis use for both unadjusted ($d = .49, p = .02$) and adjusted models ($d = .50, p = .019$) than ERT. Like for grams of use, no significant differences in reductions in days of use were found between EFT and ERT for the unadjusted ($d = .07, p = .73$) or adjusted models ($d = .18, p = .39$) or between DS-EFT and EFT for unadjusted ($d = .36, p = .09$) and adjusted models ($d = .26, p = .22$).
and intensity. Figure 4 depicts the adjusted mean DD rates after controlling for age, gender, demand elasticity and intensity, and CUDIT-SF score at the baseline, training, and follow-up. As seen in Figure 4, DD decreased across sessions for all groups (p = .003) but no session × Intervention interaction effect on DD was found (p = .11), suggesting that change (reduction) in DD across conditions did not differ. A second repeated measures ANCOVA was performed to compare the EFT and DS-EFT conditions to the ERT condition, and did not reveal a significant session × Group interaction effect on DD (p = .33).

Discussion

The present study was designed to compare an initial test of a novel DS-EFT intervention on cannabis use and DD with that of a traditional EFT and an ERT control condition. We anticipated that DS-EFT would enhance the potency of the positive future thinking intervention by prompting imagined events across a wider range of life situations, and that greater reductions in DD would mediate such effects. However, no differences across conditions in DD were observed. DS-EFT did however engender greater reductions in both grams and days of cannabis use relative to ERT, but not EFT. When comparing change in cannabis use grams and days within each condition, DS-EFT participants averaged a 35% reduction in grams and a 13% reduction in days of cannabis use, whereas those in the EFT and ERT conditions averaged small increases for both grams and days. The effect size of the comparisons in cannabis use between DS-EFT and EFT for cannabis grams and days was d = .19 and d = .26, respectively, but these effects were not statistically significant. Replication with larger samples and greater statistical power are needed to provide more stringent comparisons of the effects of DS-EFT and EFT on cannabis use.

The failure to observe a clear effect of either EFT condition on reductions in DD relative to the ERT condition, and hence a mediation effect, was unexpected based on prior studies suggesting that EFT produces moderate effect-size reductions in DD in both clinical and healthy samples (Jun-yan et al., 2020). In the present study, participants in all three conditions showed reduced DD across sessions. Several possible explanations for this finding merit discussion. We used different DD tasks for the baseline and intervention sessions to present EFT cues during the DD task as is typical in traditional EFT and an ERT control condition. We anticipated that novel DS-EFT intervention on cannabis use and DD with that of a traditional EFT and an ERT control condition. We anticipated that DS-EFT would enhance the potency of the positive future thinking intervention by prompting imagined events across a wider range of life situations, and that greater reductions in DD would mediate such effects. However, no differences across conditions in DD were observed. DS-EFT did however engender greater reductions in both grams and days of cannabis use relative to ERT, but not EFT. When comparing change in cannabis use grams and days within each condition, DS-EFT participants averaged a 35% reduction in grams and a 13% reduction in days of cannabis use, whereas those in the EFT and ERT conditions averaged small increases for both grams and days. The effect size of the comparisons in cannabis use between DS-EFT and EFT for cannabis grams and days was d = .19 and d = .26, respectively, but these effects were not statistically significant. Replication with larger samples and greater statistical power are needed to provide more stringent comparisons of the effects of DS-EFT and EFT on cannabis use.

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prior tests of EFT effects on DD (Snider et al., 2016). The two types of DD tasks used here, the adjusting amount procedure and the five-trial DD task, may evoke different discounting levels on average, thus potentially obscuring relative changes in DD between conditions. However, the type and order of DD tasks administered were identical across conditions and the 5-trial, the adjusting amount tasks tend to demonstrate strong within-subject correlations, (Cox & Dallery, 2016; Koffarnus & Bickel, 2014), and no differences in DD were observed at baseline ($p = .52$), which together suggest it is unlikely that the varied DD procedure was responsible for the similar DD rates observed between conditions throughout the study.

The lack of differences in DD observed between conditions in the present study could have also been impacted by a loss of sensitivity of DD due to repeated assessments across a relatively short period of time (Mellis et al., 2019; Reynolds et al., 2006), however, the use of the different DD tasks during baseline and intervention sessions should have decreased this concern. Alternatively, those with particularly low rates of DD (i.e., $< -7.35$) were not included in the study, which may have contributed to a regression to the mean (Snider et al., 2018). Another explanation is that, as observed, the ESI training received by participants in all conditions produced comparable reductions in DD, and the three experimental conditions were not sufficient to add to this effect. Of note, the only study to our knowledge to demonstrate that DD mediated the relationship between EFT and reductions in substance use did not deliver an ESI prior to EFT (Chiou & Wu, 2017). ESI engendered reductions in DD would be congruent with evidence demonstrating that episodic memory processes contribute to individual differences in DD (Lempert et al., 2020). Further, episodic memory processes that underlie the quality of event construction for imagined future or present events have both been shown to correspond with reductions in DD (Ciaramelli et al., 2019) potentially by reducing the salience of smaller sooner rewards such as immediate cannabis use (Sellitto, 2020). Additional research is needed to isolate the effects of ESI and EFT on event quality ratings and DD.

The current findings provided mixed support for the hypothesis that DS-EFT would engender greater reductions in cannabis use through enhancing the quality and generality of mental event construction. Prior studies suggest that future focus and quality of personally relevant event-construction during EFT both impact DD and health behaviors (Rung & Madden, 2019; Thakral et al., 2020). In the present study, it was not possible to identify whether the domain-specific characteristics or the more distant timeframes imagined during the DS-EFT condition compared with traditional EFT contributed to the observed reductions on cannabis use. DS-EFT prompted participants to create more temporally distant timeframes than EFT because of concerns that prompting positive thinking related to health or work/financial events only 1 week into the future (as done in traditional EFT) would be perceived as unrealistic and challenging, thereby limiting the impact of the DS-EFT condition. Future studies are needed to examine the relative contributions of time, domain-specific characteristics, and their interaction to better understand the potential mechanism of the current effects of DS-EFT on cannabis use.

Additional limitations and considerations of this initial exploration of the impact of DS-EFT on reductions in DD and cannabis use warrant brief mention. First, the present study employed a relatively small sample size ($n = 90$) for the use of latent change score models, and participants that were not seeking clinical treatment, which may limit the generality of the current findings. Second, a relatively large number of inclusion and exclusion criteria were used, which also may affect the likelihood the current findings generalize to studies that do not use the same exclusion and inclusion criteria. Third, change in cannabis use was assessed after only 1-week follow-up. Longer duration studies are needed to assess potential clinical importance and to provide enough time to observe clinical change. Fourth, most participants in the present study used cannabis and tobacco daily. The effects of DS-EFT on cannabis use may differ based on whether samples include patterns of mono or polysubstance use. Fifth, the study was not designed to test whether the ESI component significantly interacts with DS-EFT training to enhance the effect on reductions in cannabis use or whether the DS-EFT produces these effects independently of the ESI training. Lastly, if the observed reductions in cannabis use engendered by DS-EFT observed here are replicated in larger samples, future research might explore whether a facilitator-guided approach strengthens the impact of the intervention on cannabis use. Such an investigation could provide initial insights into the contexts or mode of delivery wherein DS-EFT provides clinical utility.

Conclusions

Accessible, more potent interventions for those with problematic cannabis use or CUD are sorely needed. Our findings suggest remotely delivered EFT interventions may hold promise. Future research that identifies the relative contributions of ESI and various EFT implementation procedures components, and that better our understanding of their mechanisms of action may lead to more potent adaptations and applications.

References


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