Boosting Positive Mood During Stress:

A Daily Coping Toolkit Replication in College Undergraduates

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Abstract

College students today face significant challenges. Evidence suggests mental-health burdens are substantial and resources limited. We sought to replicate prior evidence supporting a one-time daily ambulatory intervention to facilitate adaptive regulation of negative emotion and increase generation of positive emotions. The Daily Coping Toolkit (DCT) was developed at the outset of the COVID-19 Pandemic and was effective in boosting mood in front-line medical personnel (Coifman et al., 2021). This investigation aimed to replicate against a valid control condition in college students returning to campus in 2021. N = 125 college students were randomized to one of two experimental conditions (high v. low dose) or the control condition. Data analyses was pre-registered. Results indicated students in experimental groups experienced significant decreases in negative and increases in positive emotion when compared to controls, providing evidence of efficacy. This was notable because a high proportion of participants reported prior mental illness. Although, there was no difference by dose (high v. low) on emotional reports, there was preliminary evidence that low-dose condition was associated with greater adaptive coping (e.g., exercise, social support seeking). Overall, the results suggest the DCT is an efficacious emotion-regulation intervention that can boost mood during high stress.

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The COVID-19 pandemic resulted in increased psychological distress and reduced well-being in college students in the United States (Aknin et al., 2021). With limited availability and access to traditional mental health care (e.g., in-person psychotherapy; Merikangas et al., 2011), alternative ~~low-cost~~ options were needed. Indeed, improving access to efficacious psychotherapeutic interventions has been a longtime challenge for the field of college mental health (Smith-East & Neff, 2020). The importance of doing so became paramount as the COVID-19 pandemic unfolded (Lee & Singh, 2021). One solution was smartphone applications serving as intervention, as students can access them remotely and conveniently for little to no cost. Although many smartphone interventions exist with some showing efficacy, they still place significant time demands on users that can experienced as burdensome, increasing attrition (Baumel et al., 2019). Moreover, few address *both* increased distress and reduced well-being, despite each component being unique features of psychiatric risk (Kendall et al., 2015). The present study aimed to replicate and extend prior research demonstrating the efficacy of a novel brief smartphone intervention, the *Daily Coping Toolkit* initially evaluated in front-line medical personnel in May 2020 (Coifman et al., 2021), in a sample of college students returning to campus following COVID-19, in Spring 2021.

The period of emerging adulthood during college is a vulnerable time for developing psychiatric illness. Prior to the pandemic, approximately one-third of college students reported having had a psychiatric disorder (Auerbach et al., 2018). Risk clearly increased during the COVID-19 pandemic: A meta-analysis suggested the prevalence rates of clinically significant anxiety and depression increased 3-10% during that period (Chang et al., 2021), which included

a substantial number of first-onset depressive disorders (Caldirola et al., 2022). This may be the result of stifled social connection and belonging, both central to psychological well-being in emerging adults, in order to limit transmission of COVID-19 (Gopalan et al., 2022; Marler, 2021).

With high rates of distress among college students, a large portion could benefit from psychological intervention. Pre-COVID-19 pandemic, access to care via university counseling centers was already limited (Center for Collegiate Mental Health, 2016; Xiao et al., 2017). A 2016 survey of 529 college counseling centers found that 54% had imposed session limits to contend with increasing demand for mental health services (Reetz et al., 2016). This led many college students experiencing distress to not receive adequate mental health care. For example, prior to the pandemic, 12-month use of mental health services (3.3%) was only a fraction of the 12-month prevalence of psychiatric disorders (20.3%) in college students (Auerbach et al., 2016). The pandemic may have exacerbated this issue, as concerns about the transmission of COVID-19 posed a significant challenge to traditional face-to-face counseling and psychotherapy (DiCarlo et al., 2021).

One alternative solution to traditional psychiatric care are *ambulatory* interventions completed on digital devices, such as smartphones, that offer self-guided activities aimed at teaching users techniques to downregulate distress. Approximately 72 out of 89 (81%) digital mental health interventions have been identified as at least partially effective (Lattie et al., 2019). Moreover, meta-analysis of 18 studies testing 22 smartphone apps found a small effect size ($g = .22$) for ambulatory interventions against active control conditions (Firth et al., 2017). This preliminary research suggests that asynchronous virtual interventions of smartphone apps could

be a way to improve mental health in college students without further taxing limited institutional resources.

Despite their promise, there are limitations to apps-based intervention. For example, studies suggest that compliance is often low and there may be significant privacy issues with some commercial mental-health applications. Indeed, unlike in true clinical settings, there are few existing ethical and legal restrictions on the sale of mental health information within commercial mHealth applications (Kim, 2023). Moreover, 21-54% of new meditation app subscribers quickly abandon apps (Goldberg et al., 2020; Huberty et al., 2019; Puzia et al., 2020) and the average 30-day retention rate for 93 mHealth applications was 3.3% (Baumel et al., 2019). Even with greater personal investment (e.g., paying monthly subscriptions), individuals appear to use apps only 4% of days (Baumel et al., 2019; Kerst et al., 2020). This limited pattern of use may be in part due to more complex apps decreasing individuals' self-efficacy to use them correctly, thus driving down app use (Cho et al., 2014). Briefer, simpler, and more streamlined and non-commercial apps may help resolve this issue.

Importantly, not only were increases in distress or negative affect seen in college students during the COVID-19 pandemic but also significant decreases in well-being (VanderWeele et al., 2020). Positive affect, a core component of well-being, is conceptually and biologically independent of negative affect and is critically important for physical and mental health (Pressman & Cohen, 2005; Folkman & Moskowitz, 2000; Zautra et al., 2005). Positive psychological theories argue for leveraging the benefits of positive affect to improve life satisfaction, increase well-being, and help to achieve optimal functioning (Gable, 2005). As such, research in positive psychology has developed interventions that specifically target positive affect, character strengths, and other aspects of well-being (Park et al., 2015). In recent years, the

role of the positive valence system has also found its way into more mainstream personality, social, and clinical psychology as researchers recognize the importance of both reducing negative affect *and* increasing positive affect to improve treatment outcome (e.g., Positive Affect Treatment; Craske et al., 2019).

To address mental health needs during the COVID-19 pandemic, positive psychologists called for a focus on improving positive affect and well-being in addition to reducing distress (Waters et al., 2021). Indeed, positive-psychology-based ambulatory interventions already existed before the COVID-19 pandemic (Schueller & Torous, 2020). Probably the most widely used was "Happify," a smartphone app that offers brief digital activities related to savoring, thanking, aspiring, giving, empathizing, and reviving. A randomized controlled trial of the Happify app found that it increased reported resilience and decreased depression/anxiety symptoms after 8 weeks for people who completed at least two activities/week (Parks et al., 2018). Although the Happify app appears to be efficacious, like other applications targeting distress reduction, there are many different options, some of which are time-consuming and could be overwhelming or burdensome in times of elevated stress (Wasil et al., 2022).

The Daily Coping Toolkit

The Daily Coping Toolkit (DCT) is a novel brief ambulatory intervention developed by our research team (Coifman et al., 2021) early during the COVID-19 pandemic. The primary aim was to reduce distress *and* boost positive mood in active-duty first-line medical and emergency personnel during the early months of the pandemic. Given their work demands, the DCT was designed to be brief, taking only 3-6 minutes one-time each day to complete. At its core, the DCT integrates multiple active components including two emotion regulatory strategies (expressive writing and self-distancing to down-regulate negative affect) followed by positive

psychological interventions (prompts to up-regulate positive affect). This combination of activities is novel, and each integrated component was already well-established as efficacious prior to the first test of the DCT. For example, *expressive writing*, which involves confidential free-writing about emotional experiences (Pennebaker, 1997; Pennebaker, 2018) has been consistently shown to have a positive impact on both psychological and physical health with strong meta-analytic evidence (Toepfer & Walker, 2009; Baikie & Wilhelm, 2005). The DCT adapted the standard expressive writing intervention to make it briefer and more suitable for a smartphone app. Rather than completing 15-20 minutes of expressive writing on 3-5 days, participants using the Toolkit did 2-3 minutes of expressive writing on 14 consecutive days. Next, participants are encouraged to practice *self-distancing*, an emotion regulation strategy that involves imagining space between oneself and a stressful event(s) in order to adopt a shift in perspective (Ayduk & Kross, 2010). Decades of experimental studies suggest that this shift in perspective can reduce autonomic arousal and decrease negative affect (Guo, 2022). Moreover, self-distancing is a core component of several contemporary psychotherapies such as Cognitive-Behavioral Therapy (cognitive distancing; Alford & Beck, 1997) and mindfulness-based interventions (e.g., cognitive defusion; Hayes et al., 1999; decentering; Fresco et al., 2013). In the DCT, participants were instructed to take a "fly on the wall" approach to considering a stressful event from the current day. They were asked to replay that event again but while taking a step back and observing themselves in that situation as it unfolded.

Finally, the third component of the DCT is designed to elicit increased positive emotion through *positive emotion generating prompts*. Positive emotions tend to have an "upward spiral" effect, whereby experiencing positive emotions leads to more frequent health and self-care behaviors, leading in turn to greater positive emotions (Aurora et al., 2021; Fredrickson & Joiner,

2018; Moskowitz et al., 2017). The positive emotion generating prompts were created based on existing categories of positive psychology interventions (Parks & Titova, 2016), modules in positive psychotherapy (Rashid, 2015), and recent meta-analytic evidence (Sin & Lyubomirsky, 2009; Moskowitz et al, 2018). In the DCT, there were 8 different prompts that included opportunities to savor positive moments, to express gratitude, affection and appreciation for events and individuals in participant's lives. These prompts are randomized across toolkits to ensure variety, a key predictor of positive psychology intervention effectiveness (Lyubomirsky & Layous, 2013).

Preliminary research supports the effectiveness of the DCT in a small sample of medical and emergency responders during the beginning of the COVID-19 pandemic (Coifman et al., 2021). All participants received all the active components but were randomized to receive either two (high dose; n = 13) or one (low dose; n = 15) positive emotion generating prompts. Results after seven days of use indicated that positive affect increased by 13% and negative affect decreased by 44% on average after each toolkit session. The pilot study also found an effect of dose: Participants who completed two positive emotion generation prompts a day experienced an additional boost in positive affect compared to those who completed one a day. Moreover, a large proportion of the sample reported a positive psychiatric history, indicating that the DCT could be efficacious even in individuals with pre-existing psychiatric conditions. While promising, this initial study had a small sample and did not include a true control group. Hence, replication and further investigation is essential.

Current Investigation and Hypotheses

The current investigation tested the efficacy of the Daily Coping Toolkit (DCT)—an ambulatory intervention delivered via smartphone each day—among college undergraduates in

Spring of 2021. At this time, students were just beginning to resume on-campus activities following significant lock-down restrictions which had been evaluated to be highly stressful (Hughes et al., 2020). Building on Coifman et al. (2021), this investigation was a randomized controlled trial comparing 1) high-dose condition, 2) low-dose condition, and 3) true control condition to further test the efficacy of the DCT. Due to research suggesting some intervention effectiveness can be similar to control activities, we intentionally included an active control condition (Davies et al., 2014). Two hypotheses were pre-registered (https://osf.io/f95je/?view_only=76a867fe7eb34a0e9ac49d50f37c578d) prior to data analysis

1. We hypothesize greater momentary increases in positive emotions from the toolkit conditions (either two or one positive emotion generating prompts) compared to the control condition.
2. Based on the pilot study (Coifman et al., 2021), we hypothesize the number of daily positive prompts will have an effect on momentary positive emotions such that positive emotions will increase more in the two-prompt condition compared to the one-prompt condition.

In addition, the pre-registration included several exploratory analyses looking at various research questions related to the underlying mechanisms of action of the DCT. First, we explored the impact of the DCT intervention on momentary negative and positive emotions. Second, we explored engagement with the intervention as predictors of change through compliance and adherence. We examined whether participants who completed more days of toolkit sessions (compliance) received greater benefits as well as whether participants who correctly adhered to the toolkit instructions (adherence) experienced greater benefits. Third, we explored impacts on psychological health including outcomes that are more proximal such as changes in cognition and behavior (i.e., less perceived stress, more self-care behaviors, and more emotional self-efficacy) and outcomes that are distal (i.e., greater psychological well-being) after the two weeks

of the intervention. Although we did not make predictions about these outcomes, we did expect that the DCT would be less likely to influence broader, distal outcomes, but perhaps more likely to influence proximal outcomes given prior research suggesting that momentary positive emotions can drive increased use of health behaviors within hours (Aurora et al., 2022; Nylocks, et al., 2018) and shifts in cognition, including emotional self-efficacy (Seah & Coifman, 2020). Fourth, we began to explore which participants might benefit most from the DCT by examining the moderating influence of demographic characteristics such as gender and pre-intervention psychiatric history and well-being. In particular, we explored non-linear moderation by pre-intervention well-being since there is prior evidence that the effects of ambulatory interventions can be strongest for those with moderate levels of well-being rather than high or low levels (e.g., Bakker & Rickard, 2019).

Methods

Transparency and Openness

The data collection for this study was not pre-registered, however the data analytic plan was pre-registered (including an amendment that added sensitivity analyses) and all data and syntax are available (https://osf.io/f95je/?view_only=76a867fe7eb34a0e9ac49d50f37c578d). The sample size was determined by the number of students who signed up on Sona Systems during the Spring 2021 semester and not an a priori power analysis.

Participants and Procedures

Data were collected in Spring 2021 from undergraduate students at a large Midwestern public university. All were enrolled in undergraduate psychology courses and received course credit for participation. Following informed consent, participants were randomly assigned to one of three conditions, either one of the two experimental conditions involving the Daily Coping

Toolkit (the two-prompt condition or one-prompt condition) or an inert control condition. All participants completed a pre-intervention survey in Qualtrics™ at baseline. This survey asked questions related to demographics and psychological health. At the end of the pre-survey, participants received detailed instructions on how to download the ExpiWell™ app (https://www.expiwell.com/) and complete the DCT or control condition activities on their smartphone in ExpiWell. The DCT or control sessions were accessible through ExpiWell between 6:00 p.m. and 10:00 p.m. each evening for 14 consecutive days. Participants received a notification on their phone at 6:00 p.m. each day when the toolkit or control session became available and were encouraged to complete the session daily for two weeks. To assess momentary benefits of the intervention, participants in all conditions rated their emotions before and after each daily session.

After 14 days, participants were asked to complete a post-intervention survey with questions similar to those asked in the pre-survey. Additionally, the post-intervention survey included three questions intended to assess acceptability of the toolkit. Participants in all three conditions could opt to continue/start using the Daily Coping Toolkit after fourteen days. A total of 72% of participants (N = 89) went on to use the toolkit for an average of 3 additional days beyond the 14-day study period (those data are not included here). All components of the study were completed online.

Exclusion and Final Sample Demographics

Figure 1 provides a CONSORT diagram of the exclusion criteria. A total of N = 166 participants completed the pre-survey and were randomized to one of the three conditions. A total of N = 130 successfully signed up for the ExpiWell research platform and initiated the 14 days of toolkit or control sessions. Remaining consistent with compliance inclusion criteria from

the pilot study (Coifman et al., 2021), participants who completed at least two sessions – either toolkits or controls - were included in the final sample. Four participants were excluded due to not completing enough toolkits, and one participant was excluded for participating in the study twice. Those excluded did not differ meaningfully from the analyzed sample on any demographic characteristics other than sex (i.e., all n = 5 excluded participants were female). Across all three conditions, there was a total of N = 125 participants with adequate toolkit compliance were included in the primary momentary analyses (two-prompt condition: *n* = 41, one-prompt condition: *n* = 39, control condition: *n* = 45).

The final 125 participants had a mean age of 20.4, with 77% of the sample being in the 18-21 age range (*n* = 95). The sample was predominantly female (*n* = 104; 84%) and White/Caucasian (*n* = 90; 72%). 15.2% identified as Black or African-American *(n* = 19), 7.2% as Asian-American (*n* = 9), 4% as Other (*n* = 5), 0.8% as Native Hawaiian or Other Pacific Islander (*n* = 1), and 0.8% did not respond (*n* = 1). Additionally, 5.6% participants identified as Hispanic or Latino (*n* = 7).

Daily Coping Toolkit Intervention

Participants in either of the two experimental conditions were asked to complete the Daily Coping Toolkit, a very brief, daily, self-guided intervention (Coifman et al., 2021). The intervention involved three components: 1) an expressive writing task, 2) an imaginal self-distancing exercise, and 3) either one or two positive emotion generating writing prompts. Same as Coifman et al. (2021), the two experimental conditions differed by whether they included one versus two positive emotion inducing prompts. Without accounting for outliers, the one-prompt experimental condition took an average of 236.0 seconds - or – 3.93 minutes (SD = 410.95 seconds) to complete, and the two-prompt experimental condition took an average of 373.62

seconds – or- 6.22 minutes (SD = 3351.73 seconds) to complete. After excluding n = 7 signals (n = 4 in the one-prompt condition and n = 3 in the two-prompt condition) with impossibly long completion times, likely because a participant completed the toolkit but forgot to hit submit, the one-prompt experimental condition took an average of 202.82 seconds – or – 3.38 minutes (SD = 183.50 seconds) to complete, and the two-prompt experimental condition took an average of 196.80 seconds – or – 3.28 minutes (SD = 183.61 seconds) to complete. Details about the Daily Coping Toolkit are provided in the supplemental materials.

Control Condition

Participants randomized to the control condition completed a daily activity instead of the DCT. Each time, they were asked to take a deep breath and then responded to four control questions. The control questions inquired about what time participants engaged in four common college student activities (e.g., "What time did you wake up?", "What time did you talk to friends?"; see supplemental materials). Similar to the DCT, participants rated their emotions before and after completing the daily activity. This control condition took an average of 132.5 seconds (SD = 159.46, range = 39.79-3064.59) to complete.

Attrition

In terms of attrition rates from the intervention to the post-survey, n = 114 completed the post-survey (91% retention) and n = 11 did not (9% dropout). We tested for predictors of missingness in the post-survey. Table S28 presents independent-sample t-tests for the continuous variables and chi-square tests of independence for the binary variables. Compliance (i.e., number of sessions) was a significant predictor such that people who were missing on the post-survey completed M = 6.55 sessions while those who completed the post-survey completed M = 10.87 sessions. Race was also a significant predictor. Approximately 18% of participants who

identified as racial minorities (i.e., non-White) did not complete the post-survey compared with only 4% of White participants.

Measures

Momentary Measures

Positive and Negative Emotions

Participants rated their emotional experience before and after each toolkit or control session. We used emotion words identical to those assessed in the pilot study (Coifman et al., 2021) and consistent with contemporary affective circumplex models (e.g., Rafaeli et al., 2007). Participants rated to what extent they currently felt five positive emotions (happiness, amusement, affection, contentment, and relief) and five negative emotions (disgust, anger, sadness, fear, and distress) from 0 (‘not at all’) to 4 (‘extremely’). The scales showed excellent reliability both at the within-person (R_C) and between-person (R_{KF}) levels (Cranford et al, 2006). For positive emotions: R_C = .81 and R_{FK} = .99 before the sessions and R_C = .81 and R_{FK} = .99 after the sessions. For negative emotions: R_C = .74 and R_{FK} = .97 before the sessions and R_C = .76 and R_{FK} = .98 after the session.

Intervention Compliance and Adherence

We operationalized *Compliance* as the number of toolkits or control sessions that a participant completed. However, participants were only included in analyses if they completed at least two sessions. Accordingly, compliance values ranged from 2 to 14 (M = 10; SD = 3). We operationalized *Adherence* as the extent to which a participant followed the instructions for the toolkit tasks correctly. Coders evaluated each individual diary response (i.e., text participants entered in response to each prompt) and rated yes/adherent (coded as 1) or no/non-adherent (coded as 0) if participants followed versus deviated from the instructions. Adherence to the

expressive writing task directions and the positive prompts were coded separately (see supplemental materials). Average adherence was high: Expressive writing: $M = 0.97$, $SD = 0.18$; Positive prompts: $M = 0.93$, $SD = 0.25$.

Person-level Measures

Psychiatric History

Participants self-reported their psychiatric history by responding to two specific items in the pre-survey: 1) Have you ever in your lifetime sought help from a mental health professional for an emotional, interpersonal, or psychiatric problem? And 2) Have you ever in your lifetime experienced depression and/or anxiety? The majority of participants reported prior psychiatric disorder (70-95%) and prior psychiatric treatment was relatively common (39-56%). See table S1 for specifics by group.

Psychological Wellbeing

A brief three-item scale of psychological well-being was developed: one item was adapted from the Satisfaction with Life Scale ("I was satisfied with my life"; Diener, Emmons, Larsen, & Griffin, 1985), one item from the Meaning in Life Questionnaire - Presence subscale ("My life was full of meaning"; Steger, Frazier, Oishi, & Kaler, 2006), and one item from the Positive and Negative Affect Schedule - Positive Affect subscale ("I felt very happy"; Watson, Clark, & Tellegen, 1988). Response options were tailored to reflect the frequency of well-being over the past week, as research suggests that frequency is more important than intensity (Diener, Sandvik, & Pavot, 2009). Participants provided ratings between 1 = 'Never' and 6 = 'All of the time.' The average pre-survey score was 4.17 ($SD = 1.06$; range = 1.00 - 6.00). Cronbach's alpha was .85 in the pre-survey and .91 in the post-survey.

Perceived Stress Scale

Perceived stress experienced during the past week was measured using the ten-item version of the Perceived Stress Scale (PSS-10; Cohen et al., 1983). Each item was rated on a Likert-type scale (from 0 = 'never' to 4 = 'very often') and summed. Scores on the PSS range from 0-40, with higher scores denoting greater perceived stress. The average pre-survey score was 20.4 (*SD* = 7.0; range = 2.0 - 40.0), reflecting higher stress levels than has been found in college-aged samples previously (Cohen & Janicki-Deverts, 2012). Traditionally, scores in the range of 14-26 meet the threshold for moderate perceived stress and scores in the range of 27-40 qualify as high perceived stress (Lee, 2012). Cronbach's alpha was .87 in the pre-survey and .85 in the post-survey.

Self-Care Behaviors

Participants reported past-week frequency of engaging in five self-care activities previously demonstrated to be commonly enacted in response to emotion in both high and low stress contexts, as well as in clinical and non-clinical samples (Disabato et al., 2022; Nylocks et al., 2019). Importantly, these behaviors were being recommended broadly by regional and national public health organizations throughout the pandemic (CDC, 2020). Assessed behaviors included: 1) "Ate healthily (This refers to consuming a mixed diet including fruits and vegetables at regular intervals)," 2) "Relaxation/Meditation activities (This refers to doing activities that most people find to be relaxing or calming)," 3) "Exercised (This refers to any kind of athletic activity)," 4) "Spent time with a supportive person (This refers to choosing to be in contact (call or text) or to be with someone who you feel cares for you in a supportive way)," and 5) "Engaged in a hobby (This refers to doing activities that you often enjoy)." Participants reported the number of days in the past week they did each self-care behavior. After averaging the items,

scores could range from 0 to 7. The average pre-survey score was 3.35 (*SD* = 1.39; range = 0.80 – 7.00), suggesting participants tended to engage in each behavior on approximately half the days. Internal consistency was not calculated (e.g., Cronbach's alpha) because self-care behaviors were conceptualized as a formative variable (Edwards, 2001).

Emotional Self-Efficacy

Additionally, participants were asked to indicate how capable they felt in recognizing and handling their emotions over the past week (Seah & Coifman, 2020; Seah & Coifman, in prep). Two items were used to gauge their emotional self-efficacy: "How confident and competent did you feel to handle your feelings?" and "How comfortable were you with your feelings?". Ratings for these items were made using a Likert-type scale (from 1 = 'not at all' to 5 = 'extremely'). After averaging the items, possible emotional self-efficacy scores ranged from 1 to 5. The average pre-survey score was 3.15 (*SD* = 0.93; range = 1.00 – 5.00). Cronbach's alpha was .70 in the pre-survey and .74 in the post-survey.

Data analytic plan

Given the nested data structure (observations within persons), our primary analyses utilized multilevel modeling to account for the non-independence of observations (Pinheiro & Bates, 2000). The multilevel models were conducted using R version 4.1.1 and package `nlme` version 3.1-152 (Pinheirso et al., 2020), which allowed us to apply a continuous autoregressive error structure to models when appropriate. Within-condition changes were tested with the intercepts from unconditional models of momentary change scores, analogous to dependent-samples t-tests. Effects of the intervention were tested by condition predicting residualized change in momentary emotions, analogous to an analysis of covariance (ANCOVA). The ANCOVA approach to testing intervention trials tends to have greater statistical power than the

mixed ANOVA approach (O'Connell et al., 2017). Separate models were conducted to evaluate the effects of the DCT (i.e., *either* the two- or one-prompt condition) vs. control condition (total $N = 125$) and then for the effect of dose (two-prompt vs. one-prompt condition; total $N = 80$). We adjusted for the following pre-registered covariates: 1) time between session, 2) number of sessions (i.e., compliance), 3) pre-intervention perceived stress, 4) pre-intervention well-being, 5) history of a psychiatric disorder and/or psychiatric treatment, 6) gender, 7) age.

The exploratory analyses aimed to examine the underlying mechanisms driving, secondary outcomes, and moderators of change. Engagement with the Daily Coping Toolkit was tested by including compliance (i.e., number of sessions) and adherence (i.e., following intervention instructions) as predictors of residualized change. Growth curve analyses were used to capture change in momentary emotions across the 14 days of the intervention. Both linear and quadratic trajectories were considered; likelihood ratio tests were used to determine the best fitting trajectory over time (Pinheiro & Bates, 2000). Additional analyses involved the secondary outcomes of psychological health and self-care behaviors. Because these outcomes were only assessed once pre-intervention and once post-intervention, traditional linear regression models were used. Dependent sample t-tests were used to capture within-condition changes and ANCOVAs were used to test the impact of the intervention. Multiple imputation was used for the psychological health and self-care behaviors outcome analyses to help de-bias the results from missing data (Enders, 2010). To account for the predictors of missingness in the dataset, we included both compliance and race as auxiliary variables in the imputation models. Details about the multiple imputation models are provided in the supplemental materials. Lastly, moderation with condition was used to test whether the Daily Coping Toolkit was more effective for certain individuals, considering both gender and level of pre-intervention well-being.

Results

Tests of Randomization

We first confirmed successful randomization of participants across the three study conditions (Table S1). One-way analyses of variance (ANOVAs) revealed no significant group differences on pre-intervention psychological well-being, perceived stress, self-care behaviors, and emotional self-efficacy as well as age and compliance (i.e., number of sessions completed), *p*s ≥ .311. Chi-square tests of independence also revealed no significant group differences in gender, race, and prior psychiatric treatment (*p*s ≥ .212) but not prior psychiatric disorder ($X^2(2) = 8.34$, $p = .015$). Most participants in the one-prompt toolkit condition reported history of a psychiatric disorder (95%) in contrast to participants in the two-prompt toolkit condition (76%) and control condition (70%)[1].

Preliminary Analyses: Average Momentary Emotional Change within each Condition

Table 1 presents results from the multilevel dependent-samples t-tests examining the average momentary change in reported positive emotions (PE) and negative emotions (NE) within each condition, from pre- to post-session each day. The top of Table 1 shows the combined toolkit conditions (both two- and one-prompt conditions) vs. control condition (*N* = 125). PE significantly increased in the toolkit conditions (*Standardized Mean Difference [SMD]* = +.20), but not in the control condition (*SMD* = -.03). NE significantly decreased in both the toolkit conditions (*SMD* = -.18) and control condition (*SMD* = -.08). Although decreases in NE were significant in both conditions, the effect size for the toolkit conditions was more than twice that of the control condition. The bottom of Table 1 shows the comparison of the two-prompt vs. one-prompt Toolkit conditions (without controls; *N* =80). PE significantly increased in the two-

[1] Given these unexpected findings, we pre-registered an amendment (https://osf.io/a7m6w) to conduct sensitivity analyses controlling for prior psychiatric disorder and prior psychiatric treatment separately.

(*SMD* = +.18) and one-prompt (*SMD* = +.19) conditions. Similarly, NE significantly decreased in the two- (*SMD* = -.17) and one-prompt (*SMD* = -.16) conditions. Notably, the effect sizes were similar across both toolkit conditions.

Pre-registered Hypotheses: Impact of the DCT on Momentary Emotional Change

Table 2 presents the results of the linear mixed effects models predicting post-session PE and NE. After adjusting for a number of covariates, compared to the control condition, the toolkit conditions significantly predicted greater increases in PE. The toolkit conditions also significantly predicted greater decreases in NE. Models without any covariates found the same significant effects. Consistent with our first hypothesis, the DCT led to greater momentary emotional change than the control activity.

We next examined the effect of dose on post-session PE and NE by contrasting the two- and one-prompt conditions (Table 3). Unlike Coifman et al. (2021), the two-prompt condition did not predict greater increases in PE or decreases in NE compared to the one-prompt condition. This is consistent with the similar within-condition effect sizes across the two- and one-prompt conditions (see Table 1). Models without any covariates found the same significant effects. Therefore, there was no effect of dose on the magnitude of emotional change.

The intervention effects of the toolkit conditions (Table S2) and number of positive prompts (Table S3) were similar for the sensitivity analyses controlling for prior psychiatric disorder and prior psychiatric treatment separately. However, interestingly, history of psychiatric treatment was associated with greater decreases in NE.

Exploratory Analyses: Impact of DCT Compliance and Adherence on Outcomes

Using only data from the two toolkit conditions (N = 80), we explored how compliance and adherence to instructions might be associated with average change in PE and NE.

Completing a greater number of sessions (higher compliance) was associated with larger increases in PE but did not reach significance (B = .02, SE = .01, p = .054; Table 3). There was no effect of compliance on NE. There were no significant effects of adherence on PE/NE (see Tables S16 and S17). Although statistical power was likely weak due to the relatively small percentage of non-adherence (3% for expressive writing and 7% for positive prompts), we could not conclude that adherence to the Daily Coping Toolkit resulted in greater momentary emotional change. Results from the sensitivity analyses were similar (Tables S18 and S19).

Trajectory of Emotions During the Daily Coping Toolkit

Finally, we modeled growth trajectories of emotions over the 14 days of the intervention. The full results are summarized in the supplemental materials (see Tables S20, S21, S22, S23, S24, S25, S26, and S27). Although, both pre-session reports of PE and NE decreased throughout the 14 days across all three conditions, momentary change (increases) in PE remained stable and consistent throughout the 14 days while momentary change (decreases) in NE decreased over time. This suggests that the therapeutic effect of the Daily Coping Toolkit on NE was largest in the first few days of the intervention and became gradually weaker as the days went on. This is consistent with the gradual decreases in momentary change (decreases) of NE when only analyzing participants in the toolkit conditions (see Tables S26 and S27). No significant differences in growth trajectories were found for pre-session emotions or momentary emotional change across conditions. Although some models found interactions between condition and growth trajectory, none of the interactions replicated across pre-registered sensitivity analyses[2] and are therefore not interpreted (see Tables S24 and S25).

[2] We pre-registered sensitivity analyses quantifying time in a slightly different way. The first, primary way we quantified time was an integer sequence of the days a participant provided diary data starting with 1 and ending with the number of days of data. The second, alternative way we quantified time was the day of diary administration from 1 to 14. Results were very similar across the two ways of quantifying time, except for the significance of the cross-

Impacts on Self-care Behaviors

Table 4 presents the average change in self-care behaviors within each condition. There were no significant changes in self-care behaviors within the control and toolkit conditions. The toolkit conditions also did not significantly predict changes in self-care behaviors with (p=.379) or without (p=.334) covariates (Tables S29 & S30). Surprisingly, significant increases in self-care behaviors (M_D = 0.33, SE = 0.16, t = 2.04, p = .049) were observed in the one-prompt condition but not the two-prompt condition (M_D = 0.12, SE = 0.19, t = 0.65, p = .517). However, increases in the one-prompt condition were not significantly greater than the two-prompt condition with (p = .397) or without (p = .270) covariates (Tables S31 & S32).

Broader Impacts on Psychological Health

We first determined the average change in psychological health by comparing scores from measures (well-being, perceived stress, and emotional self-efficacy) completed in the pre- and post-intervention surveys within each condition. Table 4 presents the dependent-samples t-tests as well as the unstandardized mean differences, standardized mean differences (i.e., Cohen's d), and percentage changes within each condition. Perceived stress significantly decreased in the active toolkit conditions (M_D = -1.34, SE = 0.66, t = -2.02, p = .047), as well as in the control condition (M_D = -2.07, SE = 0.83, t = -2.49, p = .017), suggesting it was likely a history artifact (e.g., time in the semester). Second, we tested the impact of the Daily Coping Toolkit on psychological health change (Tables S29-S32). The toolkit conditions did not significantly predict changes in any of the psychological health outcomes with or without controlling for a number of covariates and there was no effect of dose.

level interactions between time and pre-intervention well-being differing by how time was quantified. As mentioned later, these interactions were not interpreted due to their failure to replicate across pre-registered sensitivity analyses.

Who benefits the most from the Daily Coping Toolkit? Participant characteristics and acceptability.

We explored participant characteristics, such as gender and pre-intervention well-being as moderators of the DCT. We first examined momentary emotions as the outcome. Neither gender nor pre-intervention well-being moderated the effects of the intervention or dose on PE or NE (Tables S4-S15). Although some models found interactions between pre-intervention well-being and growth trajectory, none of the interactions replicated across pre-registered sensitivity analyses and are therefore not interpreted. Next, we tested moderation for the secondary outcomes of psychological health or self-care behaviors. Gender moderated the effect of the intervention on perceived stress (B = -8.28, SE = 2.93, t = -2.83, p = .006) such that the toolkit was stress-reducing for men (B = -6.68, SE = 2.67, t = -2.51, p = .014) but not for women (B = 1.63, SE = 1.10, t = 1.49, p = .139). While men in the control condition had slight *increases* in perceived stress, men in the toolkit conditions displayed decreases (Figure 2). Regarding dose, gender moderated the effect of the number of prompts on emotional self-efficacy (B = -1.28, SE = 0.54, t = -2.39, p = .020) such that the additional dose was effective for women (B = 0.44, SE = 0.21, t = 2.12, p = .038) but not for men (B = -0.84, SE = 0.51, t = -1.65, p = .103). While women in the one-prompt condition had slight *decreases* in emotional self-efficacy, women in the two-prompt condition displayed increases (Figure 3). Therefore, the intervention was more effective at improving perceived stress for men and emotional self-efficacy for women. All other moderation effects for gender (ps ≥ .062) and pre-intervention well-being (ps ≥ .114) were non-significant.

Finally, acceptability analyses (ratings made using a Likert-type scale from 1 “Very unacceptable/unlikely” to 7 “Very acceptable/likely”) suggested that most participants found the

toolkit acceptable (M = 5.33; SD = 1.53), thought it was more likely than not to be effective (M = 4.43; SD = 1.58), and thought it was unlikely to cause negative side effects (M = 1.87; SD = 1.26).

Discussion

This investigation aimed to replicate the effects of a brief, novel, smartphone-based intervention: The Daily Coping Toolkit (Coifman et al., 2021) on mood and psychological health in a sample of college students during the latter stages of the COVID-19 pandemic. We tested the DCT with college students returning to a campus with clear evidence of elevated perceived stress and considerable mental health needs (Hughes et al., 2022). While there has been a proliferation of smartphone apps that seek to promote psychological health, recent work suggests that most are only moderately helpful and can be quite burdensome with low retention rates (Baumel et al., 2019; Fleming et al., 2018). Results from the current investigation suggests that the DCT is a promising intervention for momentarily increasing PE and reducing NE. The effect sizes found here are consistent with the original investigation, suggesting clinically meaningful changes in reported affect (+13% positive emotion; -22% negative emotion) even when tested in a rigorous randomized control design against an inert control condition. Moreover, additional analyses provided some clarity on optimal dosing (i.e., the low-dose, 1 positive prompt condition may be best) and potential secondary benefits (e.g. adaptive health behaviors increased in the low-dose condition) and moderators (sex/gender influenced changes in cognitions; prior therapy influenced greater degree of negative emotional change) impacting for whom this intervention may be best suited. Finally, this investigation also demonstrated very low attrition (9%) and high engagement by participants (i.e., adherence to instructions was 93-97%). Together, these findings far outstrip evidence supporting most existing ambulatory interventions and suggest

clear pathways for future refinement and additional testing to support the use of the Daily Coping Toolkit in at-risk populations.

As time passes, reports of negative emotion and distress shift, often decreasing in intensity (Walentynowicz et al, 2018). Indeed our own trajectory analyses indicated that the momentary NE decreases across all conditions (including control) were less pronounced as the 14 days went by. Hence, this underscores the importance of also assessing positive emotions independently – and – to begin to explore secondary outcomes such as health behaviors and key shifts in cognition indicating coping and adaptation (perceived stress, emotional self-efficacy). Prior research has suggested that these domains may be most susceptible to state-level shifts in emotion, much more so than broader symptom-based assessments. For example, momentary increases in positive emotions have been shown to precede engagement in health behaviors such as exercise, or support-seeking, across clinical samples and community adults (Aurora et al., 2022; Nylocks et al., 2018). Moreover, reports of affect both influence and are influenced by the experience of emotional self-efficacy (Seah & Coifman, 2020). Our findings here appear to be somewhat consistent with this prior evidence, with some key caveats. First, increased use of adaptive health behaviors was only partially evident in the low-dose (1 prompt) condition. This may be because the higher dose taxed participants more, perhaps reducing the motivational benefits of positive emotion but it is not entirely clear, and further replication is needed to explicate this interesting finding. Next, gender moderated the impact of the Daily Coping toolkit on shift in cognition, whereas males tended to report decreases in perceived stress, females reported increases in emotional self-efficacy. These moderation effects are fascinating and may reflect differing impacts on how the toolkit is experienced by gender – or- may reflect socio-cultural differences in reporting on the outcome questionnaire indices. Again, future research

must unpack this potentially important finding. Finally, that participants with a history of psychotherapy appear to experience the greatest momentary decreases in negative emotion is important and suggests that the toolkit may also serve as a reminder of tools already learned in prior treatment for those perhaps most vulnerable. Indeed, this particular finding suggests that the Daily Coping Toolkit may have some utility in post-treatment maintenance and relapse-prevention. Another important target for future research.

In this investigation, we also carefully assessed engagement with the DCT both in terms of completion rates and adherence to instructions. A key weakness of existing applications is burden on participants that may drive higher rates attrition (Dao et al., 2021). In this investigation we also found that intervention engagement mattered. For example, participants who completed more toolkit sessions trended towards larger PE increases (p = .054). However, adherence to instructions was high (93-97%). Indeed, adherence was so high it was not possible to statistically test the impact of non-adherence. However, importantly we can infer that instructions were easy to follow and that participants were interested in completing all activities.

This investigation did have key limitations. First, our sample was adequate for testing between-group or intervention effects but was likely too small to truly begin to understand how individual differences might have impacted effects within-intervention groups. This is a key limitation that can only be addressed with far larger samples. Indeed, understanding the degree to which individuals vary in their responses to intervention is a exciting next step in improving mental health care, with an increasing emphasis on *precision* medicine by dominant institutions and agencies (Insel, 2014). Next, college students as a sample population are typically considered a limitation, however, here we targeted this group explicitly because of the clear gap between mental-health care needs and available care, as the well as the relevance of this

developmental period for first onset of mental illness. However, our sample was lacking in diversity and therefore we were unable to better understand some key findings, such as the source of relatively higher attrition in non-white participants (18% versus 4%). Hence, this is a limitation that must be addressed in future large-scale replication. Finally, as is increasingly evident in research examining more traditional psychotherapeutic interventions, reliance exclusively on self-reported outcomes can limit the understanding of the underlying therapeutic processes at play given the influence of demand characteristics and placebo on reporting (Lilienfeld, 2008). Hence, future research on the DCT should incorporate other indicators by relying on video capture technology. This will allow for objective indices of emotion such as emotional facial expressions to be added as supplemental outcome indicators helping to shape the understanding of the precise targets by which the Daily Coping Toolkit exerts its therapeutic benefit.

In conclusion, this investigation successfully replicated prior findings indicating that the DCT, a brief smartphone activity utilizing evidence-based emotion regulation strategies, has beneficial effects on mood in high-risk samples. The evidence suggests that the DCT improves mood even in those who complete the lowest dose, and that it could also impact key secondary outcomes like health behaviors and cognition relevant to coping and adaptation. Despite its limitations, the DCT demonstrates promise and has potential for scalability given the relatively low burden and high acceptability for users. Altogether, the evidence here supports the continued use of the DCT in high-risk samples as an efficacious and accessible intervention for boosting positive mood in times of high-stress.

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Tables

Table 1. Average Momentary Emotional Change Within Each Condition.

	Positive Emotions (PE)						Negative Emotions (NE)					
Overall Toolkit	M_{Pre}	M_{Post}	M_{diff} ***(SE)***	***t-value***	***SMD***	***%Δ***	M_{Pre}	M_{Post}	M_{diff} ***(SE)***	***t-value***	***SMD***	***%Δ***
Toolkit	1.48	1.67	+.19 (.03)	7.06***	+0.20	+13%	0.54	0.42	-.12 (.01)	-8.02***	-0.18	-22%
Control	1.50	1.46	-.03 (.02)	-1.78	-.03	-2%	0.63	0.57	-.05 (.01)	-4.31***	-0.08	-8%
Number of Prompts	M_{Pre}	M_{Post}	M_{diff} ***(SE)***	***t-value***	***SMD***	***%Δ***	M_{Pre}	M_{Post}	M_{diff} ***(SE)***	***t-value***	***SMD***	***%Δ***
Two-Prompt	1.37	1.55	+.19 (.04)	4.52***	+.18	+13%	0.54	0.43	-.12 (.02)	-5.59***	-0.17	-22%
One-Prompt	1.61	1.80	+.19 (.04)	5.49***	+.19	+12%	0.53	0.42	-.11 (.02)	-5.64***	-0.16	-21%

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$; *SMD* = standardized mean difference (Cohen's d); *%Δ* = percentage change from pre-session.

Table 2. Testing the impact of the overall daily coping toolkit on momentary emotional change.

N = 124 *n = 1295*	**Positive Emotions (PE)**		**Negative Emotions (NE)**	
Within-person	***B (SE)***	***p-value***	***B (SE)***	***p-value***
Pre-session emotion	.90 (.01)	< .001	.85 (.01)	< .001
Time between sessions	.01 (.02)	.444	.01 (.01)	.304
Between-person	***B (SE)***	***p-value***	***B (SE)***	***p-value***
Toolkit vs. Control Conditions	**.25 (.04)**	**< .001**	**-.08 (.02)**	**< .001**
Number of sessions (compliance)	**.02 (.01)**	**.006**	< -.01 (.004)	.768
Pre-intervention perceived stress	.05 (.04)	.194	-.01 (.02)	.663
Pre-intervention well-being	**.06 (.03)**	**.031**	-.01 (.03)	.603
Psych/Treatment history	.01 (.06)	.854	-.01 (.03)	.734
Male	-.03 (.06)	.573	.04 (.03)	.204
Age	< -.01 (.005)	.875	< -.01 (.002)	.724

Note. B = unstandardized fixed effect; SE = standard error; N = number of participants; n = number of daily sessions

Table 3. Testing the impact of the number of positive prompts on momentary emotional change.

N = 80 *n = 813*	**Positive Emotions (PE)**		**Negative Emotions (NE)**	
Within-person	***B (SE)***	***p-value***	***B (SE)***	***p-value***
Pre-session emotion	.86 (.02)	< .001	.77 (.02)	< .001
Time between sessions	.01 (.03)	.570	.031 (.02)	.094
Between-person	***B (SE)***	***p-value***	***B (SE)***	***p-value***
Two- vs. One-Prompt Conditions	-.03 (.06)	.630	-.003 (.03)	.923
Number of sessions (compliance)	**.02 (.01)**	**.054**	-.001 (.01)	.844
Pre-intervention perceived stress	.08 (.06)	.167	-.02 (.03)	.440
Pre-intervention well-being	**.10 (.04)**	**.013**	-.01 (.02)	.680
Psych/Treatment history	-.02 (.09)	.812	.03 (.05)	.526
Male	-.04 (.09)	.676	.01 (.05)	.756
Age	.01 (.01)	.392	-.007 (.01)	.284

Note. B = unstandardized fixed effect; SE = standard error; N = number of participants; n = number of daily sessions

Table 4. Average Psychological Health and Self-Care Behaviors Change Within Each Condition.

	PSYCHOLOGICAL WELL-BEING						PERCEIVED STRESS					
Overall Toolkit	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*
Toolkit	4.06	4.19	+.13 (.08)	+1.55	+0.12	+4.3%	20.23	18.89	-1.34 (.66)	-2.02*	-0.18	-6.6%
Control	4.38	4.36	-.02 (.13)	-0.18	-0.02	-0.7%	20.05	17.98	-2.07 (.83)	-2.49*	-0.32	-10%
Number of Prompts	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*
Two-Prompt	4.14	4.21	+.07 (.11)	0.63	+.06	+2.1%	19.15	18.28	-.87 (.86)	-1.02	-0.12	-4.5%
One-Prompt	3.98	4.18	+.20 (.13)	1.50	+.21	+6.6%	21.43	19.57	-1.86 (1.0)	-1.80	-0.27	-8.7%
	SELF-CARE BEHAVIORS						EMOTIONAL SELF-EFFICACY					
Overall Toolkit	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*
Toolkit	3.31	3.53	+.22 (.13)	+1.77	+0.17	+6.6%	3.20	3.19	-.01 (.11)	-0.06	-0.01	-0.3%
Control	3.37	3.38	+.01 (.18)	+0.56	+.01	+0.2%	3.09	3.27	+.18 (.14)	1.28	+0.18	+8.3%
Number of Prompts	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*	M_{Pre}	M_{Post}	M_{diff} (SE)	*t-value*	*SMD*	*%Δ*
Two-Prompt	3.23	3.35	+.12 (.19)	0.65	+.09	+3.8%	3.17	3.32	+.15 (.15)	+1.01	+0.18	+7.1%
One-Prompt	3.40	3.73	+.33 (.16)	2.04*	+.25	+10%	3.24	3.06	-.19 (.15)	-1.21	-0.21	-8.2%

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$; *SMD* = standardized mean difference (Cohen's d); *%Δ* = percentage change from pre-intervention (adjusted for non-ratio units).

Figure 1

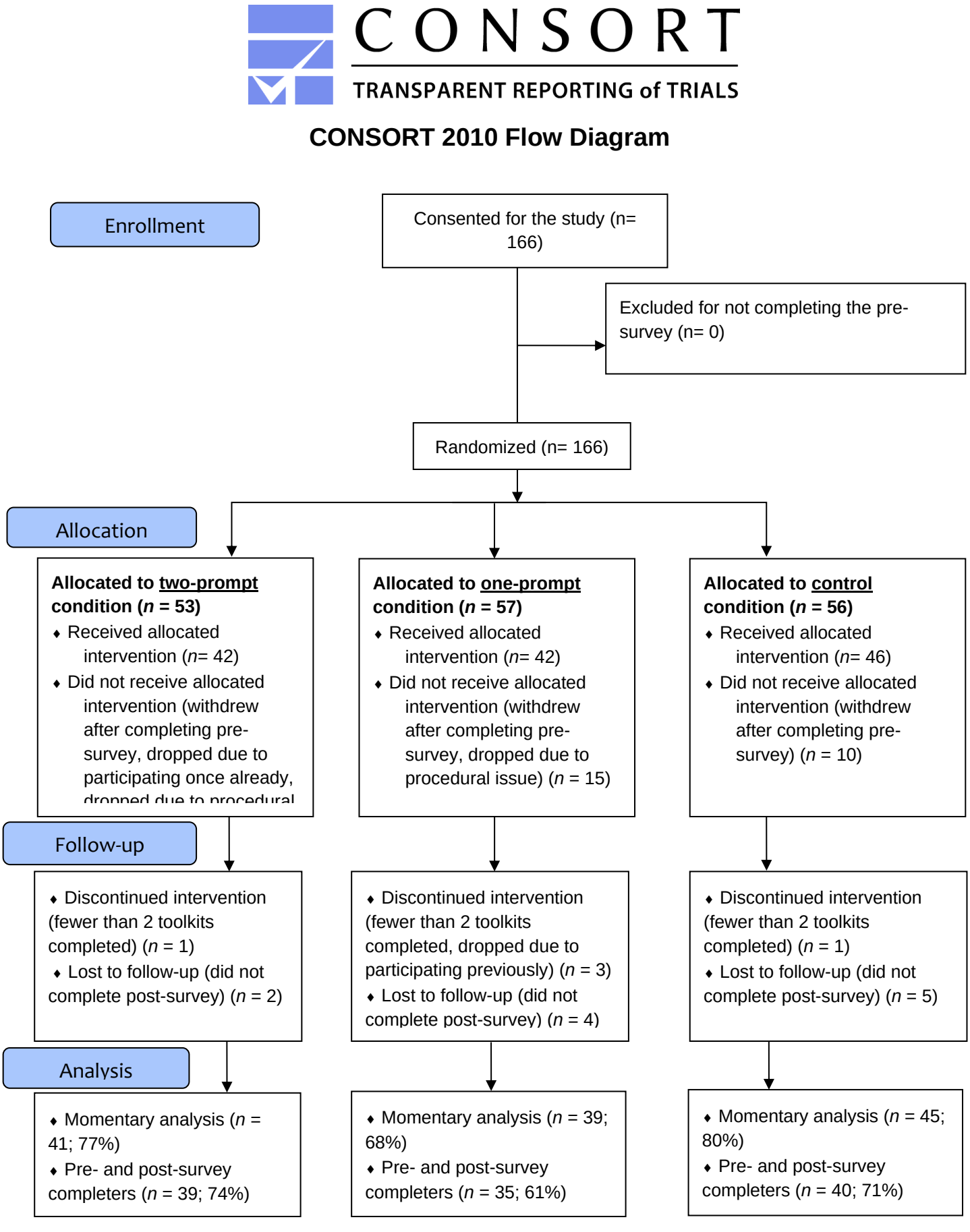
CONSORT
TRANSPARENT REPORTING of TRIALS
CONSORT 2010 Flow Diagram
Enrollment
Consented for the study (n= 166)
Excluded for not completing the pre-survey (n= 0)
Randomized (n= 166)
Allocation
Allocated to two-prompt condition (n = 53)
♦ Received allocated intervention (n= 42)
♦ Did not receive allocated intervention (withdrew after completing pre-survey, dropped due to participating once already, dropped due to procedural
Allocated to one-prompt condition (n = 57)
♦ Received allocated intervention (n= 42)
♦ Did not receive allocated intervention (withdrew after completing pre-survey, dropped due to procedural issue) (n = 15)
Allocated to control condition (n = 56)
♦ Received allocated intervention (n= 46)
♦ Did not receive allocated intervention (withdrew after completing pre-survey) (n = 10)
Follow-up
♦ Discontinued intervention (fewer than 2 toolkits completed) (n = 1)
♦ Lost to follow-up (did not complete post-survey) (n = 2)
♦ Discontinued intervention (fewer than 2 toolkits completed, dropped due to participating previously) (n = 3)
♦ Lost to follow-up (did not complete post-survey) (n = 4)
♦ Discontinued intervention (fewer than 2 toolkits completed) (n = 1)
♦ Lost to follow-up (did not complete post-survey) (n = 5)
Analysis
♦ Momentary analysis (n = 41; 77%)
♦ Pre- and post-survey completers (n = 39; 74%)
♦ Momentary analysis (n = 39; 68%)
♦ Pre- and post-survey completers (n = 35; 61%)
♦ Momentary analysis (n = 45; 80%)
♦ Pre- and post-survey completers (n = 40; 71%)

Figure 2

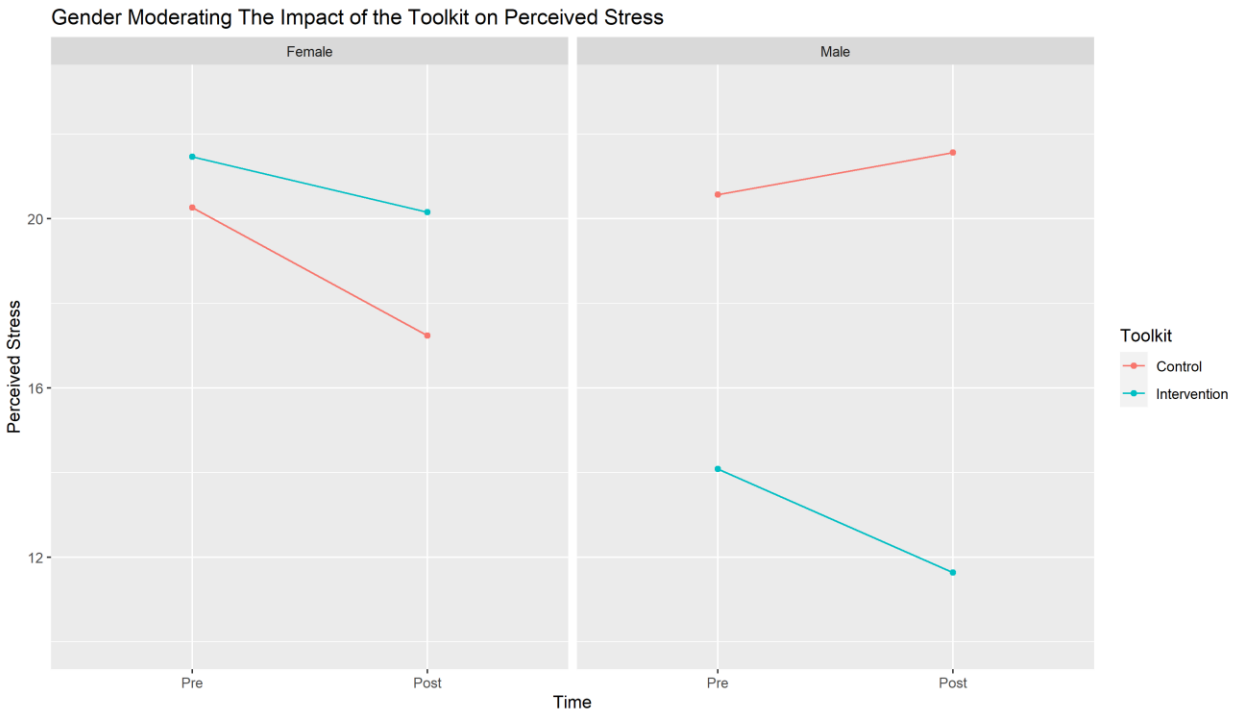

Figure 3