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An examination of the transdiagnostic role of delay discounting in psychological inflexibility and
mental health problems

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Abstract

Delay discounting is a basic behavioral process that has been found to predict addictive behaviors, and more recently, other mental health problems. Acceptance and Commitment Therapy (ACT), is a transdiagnostic treatment that appears to alter delay discounting, possibly through reducing psychological inflexibility. The current study sought to further bridge research on delay discounting and ACT by examining the relation of delay discounting to a broad range of self-reported mental health problems and measures of psychological inflexibility. A cross sectional online survey was conducted with 389 college students. Small negative correlations ranging between .09 and .15 were statistically significant between delay discounting and self-reported depression, anxiety, eating concerns, hostility, academic distress, and student functioning (only general social functioning and social anxiety were non-significant). Similar negative correlations were also found between delay discounting and measures of psychological inflexibility. Psychological inflexibility statistically mediated all of the relations between delay discounting and mental health problems such that delay discounting was no longer related to mental health problems when including the mediator. Overall, these results suggest that delay discounting is a transdiagnostic process relevant to a range of mental health problems, potentially through its impact on psychological inflexibility.

Keywords: delay discounting, depression, anxiety, transdiagnostic, psychological inflexibility, Acceptance and Commitment Therapy

An examination of the transdiagnostic role of delay discounting in psychological inflexibility and
mental health problems

Delay discounting (DD) is a behavioral process in which reinforcers are devalued as time to receipt increases (Rachlin & Green, 1972). That is, the value of a reinforcing consequence (e.g., money) tends to decrease as a function of the delay to delivery of the consequence. The quantification of this tendency (e.g., DD rates) has been used as a measure of impulsivity, operationalized as the preference for smaller rewards that are delivered sooner over larger rewards that are delivered later (Bari & Robbins, 2013). An analogous process from the social psychology literature is delay of gratification (Mischel, Ebbesen, & Zeiss, 1972), which has been found to relate longitudinally to adaptive outcomes, such as better academic performance and ability to cope with stress (Mischel et al., 2011). DD may be a relevant behavioral process in the development and maintenance of psychopathology, given that many clinical presentations can be framed using this pattern of preference for immediate gratification over delayed larger rewards. For example, problematic substance use can be conceptualized as the consistent selection of immediate sensory stimulation from substance use over the longer-term reward of maintaining sobriety (Bickel, Odum, & Madden, 1999). Similarly, obesity may be attributed to difficulty selecting the delayed reward of long-term health over the immediate gratification afforded by high-calorie foods (Epstein, Salvy, Carr, Dearing, & Bickel, 2010).

DD research in clinical contexts initially focused on substance use. Bickel et al. (1999) found that current smokers discounted monetary outcomes to a greater degree than ex-smokers and individuals who have never smoked, which suggests greater overall impulsivity in current smokers. Similar results have been observed for individuals who are cocaine-dependent (Coffey, Gudleski, Saladin, & Brady, 2003) as well as individuals with alcohol dependence (Petry, 2001).

A recent meta-analysis across 64 studies indicated a small, but statistically significant, negative correlation of $r = .14$ between DD and addictive behaviors (Amlung et al., 2017).

More recently, DD research has been conducted with other behavioral problems, and evidence suggests that DD is a transdiagnostic process that may be relevant across a range of maladaptive behaviors (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). For example, DD has been associated with obsessive-compulsive disorder (Sohn, Kang, Namkoong, & Kim, 2014), pathological gambling (Alessi & Petry, 2003), anorexia nervosa (Steinglass et al., 2012), obsessive-compulsive personality disorder (OCPD; Pinto, Steinglass, Greene, Weber, & Simpson, 2014), and obesity (Jarmolowicz et al., 2014). Of note, excessive self-control or low DD rates were linked to anorexia nervosa and OCPD, which suggests that extreme responses in either direction on measures of DD may be related to clinical presentations. Such research raises the question of the extent to which DD might apply across other mental health concerns, such as depression, anxiety, and other psychosocial difficulties. For example, depression may occur in part due to a propensity to value smaller, immediate reinforcers such as relief from distress by staying in bed or avoiding other people, over larger, later reinforcers such as engaging in meaningful social activities. Similarly, anxiety may be due in part to a propensity to value immediate reinforcers for avoidance behavior, over larger, later reinforcers involved in approach behaviors (e.g., going to the grocery store despite anxiety).

Consistent with a translational approach, elucidating the role of DD across various clinical presentations could help connect basic behavioral principles to applied theoretical models of psychopathology such as the psychological inflexibility model associated with Acceptance and Commitment Therapy (ACT; Hayes, Strosahl & Wilson, 2012). Such basic behavioral processes tend to have high scope, meaning that they can account for a broad range of

phenomena, and to guide prediction and influence of behavior, meaning that they readily provide implications for intervention (Vilardaga et al., 2009). Thus, exploring the broader role of DD could help inform transdiagnostic treatments by highlighting key behavioral processes to target as well as clarifying processes of change in existing treatment approaches.

Preliminary research suggests that DD is a malleable behavioral phenomenon that can be targeted with interventions such as ACT, a clinical behavior analytic approach that emphasizes methods including mindfulness (i.e., non-judgmental attention to experiences in the present moment), cognitive defusion (i.e., reducing the impact of cognitions on overt behavior by recognizing them as just thoughts), acceptance (i.e., reducing behaviors seeking to avoid/escape unwanted internal experiences), and values (i.e., identifying and engaging in behaviors consistent with verbally specified positive reinforcers). For example, a 60-90-minute ACT-based training has been found to decrease discounting of monetary rewards among college students who have a tendency toward steep discounting (Morrison, Madden, Odum, Friedel, & Twohig, 2014). In addition, a 50-minute mindful eating workshop teaching how to non-judgmentally and non-reactively attend to experiences in the present moment, such as food, resulted in less steep discounting curves for food-related outcomes, compared to a 50-minute DVD on nutrition (Hendrickson & Rasmussen, 2013). These findings highlight the potential role of acceptance and mindfulness-based approaches in targeting DD as a transdiagnostic process relevant to a range of mental health problems.

Preliminary research applying ACT to DD raises questions regarding how the processes of change in ACT relate to DD. Based on ACT's applied theoretical model of psychopathology, the core process of change is psychological inflexibility, in which internal experiences (e.g., cognitions, emotions, urges) rigidly control behavior at the expense of more effective and

personally valued actions (Hayes et al., 2006). DD may be a key behavioral process that contributes to psychological inflexibility. A propensity for steep discounting could lead to psychologically inflexible patterns in which behavior is overly controlled by immediate negative reinforcers (related to avoidance/escape from aversive inner experiences), at the expense of behaviors governed by larger, later reinforcers (related to personal values and effective action). Of note, psychological inflexibility is composed of a number of contributing sub-processes, many of which theoretically may overlap with DD. For example, experiential avoidance is a sub-process of psychological inflexibility that refers to patterns of behavior focused on escaping, avoiding, or otherwise controlling inner experiences (i.e., immediate negative reinforcers), despite long term consequences. Similarly, deficits in actions consistent with one's personal values is a sub-process of psychological inflexibility that references a lack of behavior connected to verbally specified long term reinforcers, due to more proximal nuisance variables and reinforcers for alternate behaviors. Examining whether DD contributes to psychological inflexibility in general, and to its more specific sub-processes, could help further clarify what distal, basic behavioral processes lead to psychological inflexibility and more precise behavioral conceptualizations of these constructs.

In summary, the propensity to devalue later reinforcers for more immediate reinforcers might contribute to psychological inflexibility as well as a range of mental health problems, but this has not yet been examined empirically. A further question is *how* DD might lead to a range of mental health problems. Impulsive behaviors linked to DD could, for example, lead to substance abuse patterns or financial problems that negatively impact mental health. Alternatively, a primary pathway to mental health problems may be in how DD impacts psychological inflexibility. A large body of research using self-report measures indicates that

psychological inflexibility is a robust predictor of many forms of mental health problems (e.g., Bluett et al., 2014; Hayes et al., 2006; Levin et al., 2014). Thus, a potential mediating relation may be relevant in which a propensity for steep discounting contributes to greater psychological inflexibility, which contributes to mental health problem (i.e., the impact of DD on mental health is due to its impact on psychological inflexibility). Clarifying these mediating relations could be helpful in furthering our understanding of how DD, psychological inflexibility, and mental health problems relate to each other and how best to influence these behaviors. For example, it may be that a critical feature of psychologically inflexible processes is the propensity for behavior to be more under the control of immediate negative reinforcers over long term positive reinforcers. Similarly, treatment strategies from ACT and other approaches might be examined in relation to increasing behavior under the control of later reinforcers rather than immediate consequences (e.g., increasing behaviors connected to personal values even though they increase contact with immediate, aversive internal stimuli).

Thus, the current study sought to test the hypotheses that DD relates to a broad range of mental health problems through its relation with psychological inflexibility. A sample of 389 undergraduate college students completed an online survey at one time-point (i.e., cross-sectional design). Self-report measures included a brief measure of DD using monetary outcomes (5-Trial Adjusting DD Task; Koffarnus & Bickel, 2014) as well as measures of mental health problems and psychological inflexibility. Based on the study hypotheses, it was predicted that DD would correlate with self-reported overall distress, depression, general anxiety, social anxiety, academic distress, eating concerns, hostility, social functioning, family concerns, as well as psychological inflexibility measures, such that steeper DD would be related to greater self-reported mental health problems and inflexibility. Furthermore, it was predicted that the relation between DD and

self-reported mental health problems would be statistically mediated through psychological inflexibility.

Methods

Participants and Procedures

The sample consisted of 389 undergraduate college students, 18 years of age or older, currently enrolled in a mid-sized university in the Mountain West region of the United States. The sample was 69.7% female with a median age of 19 ($M=20.1$ years, $SD=3.5$). The sample was largely homogeneous in race (95.4% White, 0.5% American Indian/Alaskan Native, 2.3% Asian, 0.5% Native Hawaiian/Pacific Islander, 1.3% Black, 1.5% Other) and ethnicity (only 4.1% Hispanic/Latino).

Participants were recruited via a posting on SONA, an online undergraduate research platform. All study procedures were completed remotely online through a secure survey platform, Qualtrics. Upon completion of online informed consent, participants completed the online survey, which included of a broad variety of self-report outcome measures and predictors of mental health. Those enrolled in qualifying courses received extra credit for their participation in the research study. The study was approved by the Institutional Review Board of the authors' university.

Delay Discounting Measure

5-Trial Adjusting Delay Discounting Task (DDT; Koffarnus & Bickel, 2014). The DDT was used as the measure of delay discounting. The DDT is a substantially shorter method for estimating DD relative to other methods, which is based on completing five adjusting trials to identify an approximate discounting value. Participants complete five trials in which they choose between a larger, delayed option (\$1,000) and a smaller, immediate option equal to half of the

delayed option (\$500). The first trial starts by delaying the larger reinforcer for 3 weeks, and then adjusts the delay by approximately logarithmic units over the remaining four trials contingent on previous choices (the monetary values remain constant while the time to wait changes).

Essentially, the delay either adjusts up (delayed choice) or down (immediate choice) by an index of eight delays for the next choice; a process that repeats over the course of five choice trials, with the delay index adjusting by half of the amount of the previous adjustment (see Koffarnus & Bickel, 2014 for more detailed information).

The participant's final adjusted delay in the fifth trial is used as an estimate of the Effective Delay 50% (ED_{50}). The ED_{50} score represents the delay point at which reinforcers effectively lose half of their value for the participant (delay choice range = 1 hour to 25 years; Yoon & Higgins, 2008). To calculate ED_{50} , the user's final response (trial 5) was coded according to the parameters outlined in Table 1 of the Koffarnus and Bickel's article (2014, p. 224), which displays the delay point measured in days (range = .04 to 9131 days). This measure has demonstrated adequate reliability and validity in preliminary research (Koffarnus & Bickel, 2014). In addition, previous research has shown that DD behaviors do not differ across real and hypothetical rewards in both nonclinical and clinical samples (Lawyer, Schoepflin, Green, & Jenks, 2011; Madden, Begotka, Raiff, & Kastern, 2003), supporting the validity of using hypothetical rewards in the DDT.

Mental Health Measures

Counseling Center Assessment of Psychological Symptoms (CCAPS-34; CCMH, 2012).

The CCAPS was developed as a comprehensive measure for mental health issues prevalent in college populations, with the 34-item version including subscales for depression, generalized anxiety, social anxiety, academic distress, eating concerns, hostility, alcohol use, and an overall

total score of distress. The 6 items from an alternate, longer version of the CCAPS were included that assess the family distress subscale. Items are rated on a 5-point scale ranging from 0 “not at all like me” to 4 “extremely like me,” with higher total scores indicating greater levels of distress. The CCAPS has demonstrated adequate reliability and validity in previous studies with undergraduate samples (CCMH, 2012). In the current study, the internal consistency of the CCAPS was adequate: Total Distress Score $\alpha = .95$, Depression $\alpha = .89$, Eating Concerns $\alpha = .88$, Family Distress $\alpha = .85$, Hostility $\alpha = .82$, General Anxiety $\alpha = .82$, Social Anxiety $\alpha = .81$, Academic Distress $\alpha = .78$, and Alcohol $\alpha = .77$.

However, the alcohol subscale was notably skewed in the current study with 85% of students scoring 0 on the subscale and only 4% of the sample falling in the elevated range of problematic alcohol use based on recommended cutoff scores (CCMH, 2012). This is consistent with unique aspects of the university this study was conducted at, which tends to have low rates of alcohol use among students due to cultural and religious factors. The alcohol subscale could not be transformed to approximate a normal distribution and was excluded from analyses.

Social Adjustment Scale-Self Report (SAS-SR; Weissman & Bothwell, 1976). The current study utilized two subscales of the SAS-SR (the student role and social/leisure functioning subscales) to assess social functioning in these two key life domains. Combined, these subscales include a total of 15 items, each of which is ranked on a five-point. Means are taken from each subscale, with higher scores denoting greater social impairment. The SAS-SR has been found to have adequate reliability and validity in past studies (Weissman & Bothwell, 1976). Internal consistency in the current study was marginal: Social/Leisure = .68 and Student Role $\alpha = .63$.

Psychological Inflexibility Measures

Acceptance and Action Questionnaire-II (AAQ-II; Bond et al., 2011). The 7-item AAQ-II was used as the primary measure of psychological inflexibility. Items are rated on a 7-point scale ranging from 1 “never true” to 7 “always true,” with higher scores indicating increased levels of psychological inflexibility. In past studies with a college sample, the AAQ-II has displayed adequate reliability and validity (Bond et al., 2011). Within the current study, the AAQ-II reflected excellent internal consistency ($\alpha = .91$).

Cognitive Fusion Questionnaire (CFQ; Gillanders et al., 2014). The 7-item CFQ was included as a measure of cognitive fusion, a sub-process of psychological inflexibility in which thoughts have dominant control over behavior. Items are rated on a 7-point scale ranging from 1 “never true” to 7 “always true.” Higher scores indicate increased levels of fusion (i.e., increased psychological inflexibility). Research on the CFQ indicates adequate reliability and validity including specifically with undergraduate participants (Gillanders et al., 2014). Internal consistency was excellent in the current study ($\alpha = .95$).

Valuing Questionnaire (VQ; Smout et al., 2014). The 10-item VQ was included as a measure of values, another key sub-process of psychological inflexibility. The VQ includes two subscales, which assess progress in valued living (i.e., behavior consistent with one’s values) and obstruction to valued living. Each item is rated on a 7-point scale ranging from 0 “not at all true” to 6 “completely true.” Higher scores on the obstruction subscale indicates greater obstruction to valued living (i.e., greater psychological inflexibility) and higher scores on the progress subscale indicates greater progress in valued living (i.e., lower psychological inflexibility). Research with the VQ indicates adequate reliability and validity (Smout et al., 2014). The VQ displayed good internal consistency within the current study: Obstruction ($\alpha = .84$) and Progress ($\alpha = .82$).

Philadelphia Mindfulness Scale (PHLMS; Cardaciotto et al., 2008). The PHLMS is 20-item measure of mindfulness with two subscales assessing mindful awareness (i.e., flexible attention to the present moment) and acceptance. Deficits in acceptance and awareness represent key sub-processes that contribute to psychological inflexibility. Only the acceptance subscale was utilized for the purposes of these analyses given that the validity of the PHLMS awareness subscale has been questioned due to its weak correlations to other well-validated mindfulness scales (Park, Reilly-Spong, & Gross, 2013). Items on the PHLMS are rated on a 5-point scale, from 1 “never” to 5 “very often.” Higher total scores indicate lower levels of acceptance or higher experiential avoidance. The PHLMS acceptance subscale has demonstrated good reliability and validity in past studies (Cardaciotto et al., 2008). Internal consistency for the acceptance subscale in the present sample was excellent ($\alpha=0.90$).

Analysis plan

Prior to conducting analyses, skewness and kurtosis was checked for each variable, with transformations applied as needed to approximate a normal distribution. Pearson’s r correlations were conducted to examine the relation between DD and self-reported mental health problems (excluding alcohol abuse – see CCAPS measure description) as well as between DD and self-report measures of psychological inflexibility. Multiple self-report measures of psychological inflexibility were used to further explore whether specific facets of psychological inflexibility were each relevant to DD (e.g., whether both values and acceptance are relevant processes for DD). These Pearson correlation analyses were adequately powered (.80) with 389 participants to detect a r correlation coefficient of .10 in a two-tailed test with $p < .05$. This was consistent with predicted small correlations given a recent meta-analysis estimated an aggregate correlation effect size of $r = .14$ between DD and measures of addictive behaviors (Amlung et al., 2017).

The final set of analyses sought to test whether psychological inflexibility statistically mediates the relation between DD and self-reported mental health problems. As the most well-validated measure of psychological inflexibility included in this study, the AAQ-II was used as the mediator variable. The cross product of coefficients test was used to test each mediational model (Preacher & Hayes, 2008). This method tests for mediation by examining the statistical significance of the cross product of the *a* path (i.e., relation between DD and psychological inflexibility) and *b* path coefficients (i.e., relation between psychological inflexibility and mental health problems, statistically controlling for DD). The cross product of the *a* and *b* paths is commonly referred to as the indirect effect, which is mathematically equivalent to the difference between the total effect (i.e., relation between DD and mental health problems) and the direct effect (i.e., the relation between DD and mental health problems when statistically controlling for psychological inflexibility). A larger difference between the total effect and the direct effect indicates that more of the variance previously related to DD is now being statistically accounted for by the mediator (psychological inflexibility). The statistical significance of the cross product was analyzed using bootstrapping, a nonparametric method that creates a confidence interval for the indirect effect with statistically significant mediation indicated by confidence intervals that do not contain zero. The normal theory tests for each mediational pathway (i.e., the individual regression paths between DD, psychological inflexibility, and each self-reported mental health problem) are also reported to aid with interpretation of mediation findings.

Results

Correlations between delay discounting and self-reported mental health problems

A series of Pearson's *r* correlation tests were conducted to examine the relation of DD (ED_{50}) with self-reported mental health problems (see Table 1). Statistically significant negative

correlations were found between DD and overall distress, depression, general anxiety, academic distress, eating concerns, hostility, and social functioning as well as a trend with family concerns. However, correlation coefficients were notably small, albeit consistent, with correlation coefficients ranging between .09 and .15. In each case, steeper discounting was correlated with greater problems. DD did not correlate with social anxiety or general social functioning.

Correlations between delay discounting and self-reported psychological inflexibility

A second series of Pearson's r correlation tests examined whether DD correlated with self-reported psychological inflexibility (see Table 1). Statistically significant small negative correlations were found between DD and all process measures including psychological inflexibility, valued living obstruction, valued living progress, cognitive fusion, and mindful acceptance. Correlation coefficients were again notably small, but consistent, ranging between .11 and .16. In each case, steeper discounting was correlated with greater psychological inflexibility.

Mediational analysis results

A series of mediational analyses examined whether the relation between DD and each self-reported mental health problem was statistically mediated by psychological inflexibility (as measured by the AAQ-II) (see Table 2). A separate mediational analysis was conducted for each mental health measure for which DD was statistically significantly correlated (excluding only CCAPS social anxiety and SAS-SR general social functioning).

Consistent with the Pearson correlation findings, normal theory tests indicated that DD was related to each self-reported mental health problem, with the exception of only a statistical trend for family concerns (see c path results in Table 2). DD was also related to psychological inflexibility, such that steeper discounting was related to being more psychologically inflexible

(see *a* path in Table 2). Psychological inflexibility was also found to relate to each self-reported mental health problem, such that being more inflexible was related to greater problems (see *b* path in Table 2). Finally, none of the relations between DD and mental health problems were statistically significant after including psychological inflexibility as an additional predictor variable (see *c'* path in Table 2).

Cross product of coefficients tests were conducted to test for the statistical significance of the indirect effect (whether mediation was significant) for each self-reported mental health problem. A statistically significant indirect effect was found for each mental health problem as indicated by the confidence intervals not including 0. These results indicate that the psychological inflexibility mediating pathway statistically accounted for the relation between DD and a range of mental health problems. In every case DD was no longer statistically significantly related to self-reported mental health when including the mediational path, suggesting full mediation (i.e., psychological inflexibility fully accounts statistically for the relation between DD and mental health problems). The proportion of variance statistically accounted for by the mediator varied substantially across outcomes, ranging between 32% and 98%.

Discussion

This study sought to test the transdiagnostic role of DD across a range of self-reported mental health problems as well as the relation of this behavioral process to psychological inflexibility. A sample of 389 college students completed an online survey including questionnaires assessing each of these variables. Small negative correlations were found between DD and self-reported distress, depression, general anxiety, academic distress, eating concerns, hostility, social functioning, and family concerns, such that steeper discounting was related to greater mental health problems. Similar small negative correlations were found between DD and

measures of psychological inflexibility including valued living obstruction, valued living progress, cognitive fusion, mindful acceptance, and overall psychological inflexibility. Finally, psychological inflexibility consistently mediated the relations between DD and mental health concerns, statistically accounting for a large portion of the variance. These results suggest that DD is a behavioral process relevant to a wide range of mental health problems, and that this may be due in part to its impact on psychological inflexibility. However, due to the notably small size of correlations between DD and mental health problems, it is unclear the degree to which DD is a clinically significant factor in mental health problems.

This study expands on previous DD research, which has primarily focused on substance use and related behavioral addictions such as pathological gambling and eating disorders (Bickel et al., 2012). This is the first study to-date we are aware of to examine DD in relation to an expanded range of mental health problems. Based on these results the process of valuing smaller, sooner reinforcers over larger, later reinforcers, appears relevant to other problems beyond behavioral addictions such as depression, anxiety, anger, relationship problems, and academics.

The current study suggests that DD may be particularly relevant for mental health problems with regard to overvaluing the short-term reinforcement for avoidance behaviors over long-term reinforcement for meaningful actions that would approach avoided situations. Findings indicated that steeper DD was related to being more experientially avoidant, cognitively fused, and struggling with valued action. In other words, it appears that individuals who more steeply discount smaller, sooner rewards have a greater propensity to engage in avoidant and fused actions for short term reinforcement, despite long term costs for valued action. Consistent with the proposed theory, it appears that this pattern of psychological inflexibility (overvaluing short term reinforcement for avoidance over long term valued activities), may contribute to the

effects of DD on mental health outcomes. Thus, it appears that psychological inflexibility is a relevant clinical target that is supported by DD and might be focused on in treatment to reduce the impact of DD on mental health. These results also suggest that DD might be targeted in interventions to reduce psychological inflexibility. For example, improving sensitivity to larger later positive reinforcers over smaller sooner negative reinforcers could reduce a propensity to engage in behaviors like experiential avoidance.

The link between DD and psychological inflexibility suggests an alternate conceptualization for how acceptance- and mindfulness-based interventions, such as ACT (Hayes, Strosahl, & Wilson, 1999), impact psychological inflexibility and mental health problems. First, acceptance and mindfulness methods aim to reduce behaviors seeking to control or avoid internal states by taking an open, present, and non-judgmental stance. This might function to reduce the value of immediate negative reinforcers linked to avoiding/escaping aversive internal states. Second, values methods increase access to delayed, meaningful rewards in the moment by linking current behaviors to freely chosen desired life directions (Hayes et al., 1999). Values function as formative and motivative augmental rules that establish consequences as reinforcing or punishing as well as alter the reinforcing strength of a consequence (Hayes, Barnes-Holmes, & Roche, 2001). In other words, stimuli take on a different function in the context of values, and delayed consequences (e.g., social connection) that do not initially function as reinforcers become reinforcing or more reinforcing to the individual, thereby increasing the probability of behaviors (e.g., going to a party) now linked to these newly reinforcing consequences (Jackson et al., 2016). Thus, ACT may improve mental health outcomes by altering DD specifically in relation to reducing behavior under the control of immediate negative reinforcers (avoiding/escaping aversive internal states) while increasing

behavior under the control of more distal, verbally specified positive reinforcers (values-based behaviors). This suggests ACT may be effectively applied to target DD in clinically relevant domains and that the impact of ACT on psychological inflexibility and mental health outcomes could be at least in part due to altering DD patterns.

It is worth noting that other methods have been identified in the literature for altering DD. For example, episodic future thinking asks participants to visualize and experience a realistic future event as fully as they can, which has been found to reduce DD (Peters & Büchel, 2010; Snider, LaConte, & Bickel, 2016; Stein et al., 2016). Decreases in DD were observed for hypothetical alcohol and cigarette self-administration behavior in individuals with alcohol dependence and nicotine dependence, respectively (Snider et al., 2016; Stein et al., 2016), suggesting that episodic future thinking affects condition-specific targets. One possible process through which episodic future thinking influences DD is increased attention to future outcomes or an expansion of temporal awareness (Snider et al., 2016). Such intentional attentional flexibility is a key component of psychological flexibility, and the body of episodic future thinking suggests that this process alters DD. Therefore, interventions that incorporate these elements as well as those that target overall psychological inflexibility may be a viable therapeutic approach for an array of conditions influenced by DD.

Although the observed correlations with DD were small, it is worth noting these are similar to the aggregated correlation effect sizes ($r = .14$) observed in a recent meta-analysis of DD with continuous measures of substance use (Amlung et al., 2017). These small effect sizes in the current study as well as meta-analysis might be due to the use of non-clinical samples, which could reduce sensitivity to detecting the clinical impact of steep discounting, particularly on the more severe end of predicted problems. Alternatively, these small correlations might be due in

part to the impact of measurement error given that DD rates were estimated in the current study using both a relatively brief measure (with 5 adjusting items to estimate DD values) and one focused on discounting of money over time, as opposed to more clinically relevant content.

Alternatively, it is worth considering that the observed small correlations between DD and self-reported mental health problems may suggest that this behavioral process is clinically insignificant. This study had adequate power to detect quite weak correlation coefficients ($r = .10$), which is a common issue in large survey studies. However, the presence of a statistically significant correlation does not demonstrate that there is a practically and clinically meaningful relationship. It may be that DD is only relevant to a sub-sample of individuals struggling with mental health problems, with substantial heterogeneity in the broader population attenuating the observed correlation coefficient. Alternatively, DD may just be weakly related to problems like depression and anxiety, potentially to such an extent that it is not clinically meaningful to focus on in assessment or intervention. Ultimately further research is needed to examine whether alternate factors account for the weak correlation coefficients and if larger relations can be found with more sophisticated methods (e.g., examining moderators, using more precise measurement methods). Of even more importance, research is needed examining whether directly influencing DD leads to improvements in such mental health problems through ACT or other clinical behavior analytic methods.

Although this study provides preliminary evidence for the broader applicability of DD to a wider range of mental health problems, there are also notable limitations. First, the study used a cross sectional design, which substantially limits conclusions that can be drawn with regards to the temporal relations between DD, inflexibility, and mental health. For example, it may be just as likely that mental health problems lead to greater inflexibility and steeper discounting. This

study chose to test a mediational model in which psychological inflexibility was the mediator between DD and mental health problems. This model was chosen based on past research and theory, but future research is needed using longitudinal designs to test whether the temporal relations between variables is confirmed. It is also important to note that there are conceptual issues in exploring relations between behavioral processes, particularly with less directly observable constructs (e.g., psychological inflexibility as measured by the AAQ-II), and with statistical methods that traditionally imply causal relations. However, the aims of this study are not to treat such behavior-behavior relations as causal, but to clarify the nature of these behavior-behavior relations given the theoretical role DD might have in both psychological inflexibility and mental health problems. Identifying these relations might help clarify and guide identification of causal contextual factors and manipulable variables that can be used to influence these behaviors.

Another limitation was the use of a homogeneous college student sample, which limits generalizability of study findings. Although the development of transdiagnostic treatments for college students is important (e.g., Hayes, Pistorello & Levin, 2012), it is important that future studies test the replicability of findings in broader and diverse populations. Future studies with clinical populations are particularly indicated to further determine how DD relates to clinically elevated and diagnostic classification of various specific disorders.

The study used a brief measure of DD, which estimates DD values based on responses to five adjusting items (Koffarnus & Bickel, 2014). Although statistically significant correlations have been observed between the five-trial adjusting delay task and a more intensive, adjusting amount task ($r = .67$ for same delayed amount), DD rates were consistently higher in the former task, indicating that the two measures of DD do not perfectly overlap (Koffarnus & Bickel,

2014). In addition, the five-trial adjusting delay task precludes identification and elimination of nonsystematic responders, which can be problematic as such data may reflect inconsistent or illogical responding related to factors such as inattentiveness and lack of understanding of task demands (Johnson & Bickel, 2008). Thus, the use of a briefer DD measure likely introduced additional measurement error that weakened the observed correlations with mental health and inflexibility.

Although the results indicated statistical mediation with the AAQ-II, this might be due to limitations with measurement. It is not necessarily surprising that the AAQ-II, which references mental health problems and is known to correlate highly with mental health (e.g., Bluett et al., 2014; Hayes et al., 2006; Levin et al., 2014), would statistically account for a large portion of variance in mental health, including the portion predicted by DD. This is even more the case given the delay discounting measure was brief and referenced monetary discounting (rather than discounting relevant to mental health). Use of a DD measure more specifically relevant to mental health concerns, or of a psychological inflexibility measure that overlapped less directly with mental health, may have reduced the portion of variance between DD and mental health that was statistically accounted for by the AAQ-II.

In conclusion, this study adds to a growing literature indicating the transdiagnostic application of DD for understanding and treating a wide range of mental health problems. Furthermore, it highlights the potential relation between DD and psychological inflexibility as well as methods that might be used to target these processes such as ACT. Further research is needed to examine how DD applies to various mental health problems and its role as a process of change or moderator in treatments.

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Table 1. *Pearson correlations between delay discounting, self-reported mental health problems, and psychological inflexibility processes.*

Measure	Correlation (<i>r</i>) with Discounting ED ₅₀
<i>Mental Health Problems</i>	
CCAPS – Total Distress	-.13*
CCAPS – Depression	-.11*
CCAPS – General Anxiety	-.11*
CCAPS – Social Anxiety	-.05
CCAPS – Academic Distress	-.12*
CCAPS – Eating Concerns	-.12*
CCAPS – Hostility	-.13*
CCAPS – Family Concerns	-.09†
SAS – Social Functioning	-.08
SAS – Student Functioning	-.15**
<i>Psychological Inflexibility Processes</i>	
AAQ – Psych. Inflexibility	-.15**
VQ-O – Valuing Obstruction	-.14**
VQ-P – Valuing Progress	.11*
CFQ – Cognitive Fusion	-.16**
PHLMS-Acc – Mindful Acceptance	-.15**

†*p* < .10, **p* < .05, ***p* < .001. VQ-P was scored in the opposite direction as other psychological inflexibility measures such that higher scores indicate greater progress in valued living (less psychological inflexibility).

Table 2. Cross product of coefficients tests with psychological inflexibility mediating the relation between delay discounting and self-reported mental health problems.

Mental health variable	<u>a path</u>	<u>b path</u>	<u>c path</u>	<u>c' path</u>	<u>Product of coefficients</u>		Proportion mediated (1 - c' / c)
	X-M	M(X)-Y	X-Y	X(M)-Y	Point estimate	Bootstrapping 95% CI	
CCAPS – Total Distress	-2.89**	24.78***	-2.47*	-.32	-.11	[-.19, -.04]	87%
CCAPS – Depression	-2.89**	20.43***	-2.11*	-.04	-.13	[-.23, -.05]	98%
CCAPS – General Anxiety	-2.89**	19.00***	-2.08*	-.09	-.12	[-.20, -.04]	96%
CCAPS – Academic Distress	-2.89**	13.61***	-2.31*	-.79	-.10	[-.17, -.03]	66%
CCAPS – Eating Concerns	-2.89**	7.97***	-2.45*	-1.45	-.08	[-.15, -.03]	41%
CCAPS – Hostility	-2.89**	9.06***	-2.65**	-1.56	-.01	[-.02, -.004]	41%
CCAPS – Family Concerns	-2.89**	12.30***	-1.70†	-.19	-.02	[-.03, -.01]	89%
SAS – Student Functioning	-2.89**	8.02***	-3.03**	-2.07	-.05	[-.01, -.002]	32%

† $p < .10$, * $p < .05$; ** $p < .01$; *** $p < .001$. *t*-test values are reported for paths tested: X-M = predictor and mediator, M(X)-Y = mediator and outcome controlling for predictor, X-Y = predictor and outcome, X(M)-Y = predictor and outcome controlling for mediator. CCAPS Social Anxiety and SAS Social Functioning subscales were excluded because the c path (relation between DD and mental health problems) were not statistically significant.