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Invited Letter Rejoinder

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The fundamental questions left unanswered: response to commentary on the 'problems with delay discounting'

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We appreciate the opportunity to continue a dialogue on these important issues. We will briefly address some specific points of Stein, MacKillop, McClure, and Bickel (2022), but will open with a few general comments. First, we recognize the seminal contributions of the authors of the commentary (Stein et al., 2022) to the understanding of intemporal choice (ITC; Dai and Busemeyer, 2014) and psychopathology. We also see great value in the research that aims to understand ITC and how such processes relate to clinical phenomena. Indeed, our group has published a number of articles utilizing essentially the same measure of discounting that we now critique as having significant limitations (Bailey, Gerst, & Finn, 2018, 2020; Bobova, Finn, Rickert, & Lucas, 2009; Finn, Gunn, & Gerst, 2015; Molloy et al., 2020). Our review (Bailey, Romeu, & Finn, 2021) is actually the culmination of asking ourselves basic questions about the construct of delay discounting and its role in real-world decision-making and subsequently, being concerned with what we observed as weaknesses in the theoretical foundation, and external validity, of the current task that is overwhelmingly used to assess how individuals discount incentives across time. Furthermore, our paper was meant to invite the field to question whether delay discounting measurement paradigms provide generalizable information about ITC patterns and psychopathology at large. We make it clear throughout our paper that discounting is reliably and modestly related to criteria of interest. However, we question whether a measure with very modest associations with criterion outcomes and limited theoretical understanding should be described as a 'core' transdiagnostic process, and subsequently should demand so central a position in substance use research.

Importantly, our review means to discuss overarching theoretical concerns with the constructs of delay discounting and ITC at large. Although we cite extensive empirical findings, we do not agree with the assertion by Stein et al. (2022) that such questions should and even could be addressed through meta-analysis. Our concerns are not about the value of specific parameters, but about the theoretical foundations of an expansive research program, an issue that a meta-analysis cannot address. Therefore, we believe readers can assess the value of our arguments and form their own conclusions.

Convergent and divergent validity

We want to make it clear what our primary concerns are in relation to the convergent and divergent validity of the current delay discounting measurement paradigm. Our concern is not with the multivariable determinants of delay discounting rates, assessed with the current paradigm, but with the decision-making processes associated with actual and clinically relevant behaviors. Delay discounting is poorly understood theoretically due to the modest or nonexistent associations between delay discounting rates (assessed with the usual tasks) and other relevant measures, *especially* clinically relevant criteria of interest (e.g. addiction severity). Therefore, Bickel, Moody, Eddy, and Franck (2017) do not address these primary concerns, but actually continue to highlight the problems we have identified. In this study, discounting rates are simply the best of several weak predictors of alcohol use disorder status (i.e. $R^2 = 0.10$ for delay discounting). This indicates, to us, that none of the tested tasks can be said to capture a core process related to AUD. Furthermore, the fact that discounting rates are uncorrelated with all other tested measures (Bickel et al., 2017), continue to contribute to an unclear picture of how discounting rates theoretically relate to other established constructs (e.g. working memory). This lack of theoretical understanding is exacerbated by the lack of divergent validity. As reviewed by Amlung, Vedelago, Acker, Balodis, and MacKillop (2017), we know that discounting rates tend to be higher in almost all clinical populations compared to controls, however, there is no clear theoretical formulation that accounts for these associations. In summary, we have hundreds of studies comparing clinical populations on delay discounting tasks, but these studies have been unable to provide theoretical clarity about the association between the signal picked up by the task and or how it relates to the variety of clinical phenomena it has been associated with.

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Lastly, we do not believe a discussion of the construct validity of impulsivity is within the scope of our paper or this commentary.

Generalizability

We are afraid Stein et al. (2022) may have missed our primary argument related to generalizability. Odum et al. (2020) reviewed 97 studies that examined the correlation between monetary discounting rates and discounting of another commodity (e.g. food, drugs) and reported a correlation of $M = 0.35$. This suggests, consistent with our review, that 'a single discounting rate provides only modest information about performance on *very* similar tasks' (Bailey et al., 2021, pg. 1802). Our concern is that discounting rates account for a modest amount of variance in other decision-making paradigms and in clinical symptoms (Amlung et al., 2017). Therefore, discounting rates cannot be said to capture a process that is highly informative about an individual's ITC patterns broadly or their clinical presentation. Consequently, in our estimation, discounting rates should not be described as reflecting a 'core' transdiagnostic process, as a behavioral 'marker', or used as a summary measure of ITC patterns given the limited generalizability of the measure. It is here we may simply have a difference of perspective with Stein et al. (2022). We believe that the unfocused, limited nature of the relationships is cause for concern and a principal reason to motivate research into better measures. However, Stein et al. (2022) presumably place more value in the *reliability* of these modest observed relationships than we do.

Conclusions

We believe there is a plethora of specific issues with the current approach to measuring discounting rates that could be discussed. However, our original manuscript was meant to ask researchers to take a step back and ask the most basic questions: (1) Do we theoretically understand the signal being picked up in discounting tasks? (2) Does the empirical evidence support the centrality and importance of delay discounting tasks in understanding decision making and clinical symptoms? We believe the field has been overly focused on smaller issues in the measurement of discounting rates (e.g. exponential *v.* hyperbolic analytic models), while missing the much larger theoretical concerns. We hope these conversations are continued both through formal and informal mechanisms in clinical science.

As a final illustrative example, consider the transdiagnostic construct of rumination. Rumination, defined as '(a) repetitive thoughts that are (b) passive and/or relatively uncontrolled, and (c) focused on negative content' (McLaughlin & Nolen-Hoeksema, 2011) is an important process for understanding both depressive and anxiety disorders. Measures of rumination are strongly related to both measures of anxiety and depression, and have a clear theoretical relationship with both disorders (McEvoy, Watson, Watkins, & Nathan, 2013; McLaughlin & Nolen-Hoeksema, 2011). In fact, rumination was demonstrated to be a full mediator of anxiety and depression symptoms in adolescents and a partial mediator in adults (McLaughlin & Nolen-Hoeksema, 2011). This stands in stark contrast to the theoretical understanding and empirical backing of delay discounting as a core transdiagnostic process, which we see as being primarily driven by face-valid hypotheses about its relationship to disorders. We argue that having reliable, modest associations with multiple disorders indicates delay discounting tasks tap into *some* transdiagnostic process. However, this is not compelling evidence to suggest the centrality of these tasks in understanding the etiology or treatment of complex clinical phenomena. We believe the field should focus on developing new approaches to measuring generalizable ITC processes and lessen its focus on a single measurement paradigm.

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