**Controlling, Confounding, and Construct Clarity: A Response to Criticisms of ‘Revisiting
the Marshmallow Test’**

Tyler W. Watts¹ and Greg J. Duncan²

Manuscript in press at *Psychological Science*

1. *Corresponding author:* Teachers College, Columbia University, 462 Grace Dodge Hall, New York, NY, 10027 (e-mail: tww2108@tc.columbia.edu).
2. School of Education, University of California, Irvine, 3200 Education Drive, Irvine, CA 92697-5000

Abstract

Longitudinal studies of development often rely on correlational methods to examine linkages between early-life constructs and later-life outcomes. As highlighted by responses to our article, “Revisiting the Marshmallow Test: A Conceptual Replication Investigating Links Between Delay of Gratification and Later Outcomes,” interpretations of these linkages can be difficult. In this commentary, we address criticisms that our approach “over-controlled” for key factors related to a child’s ability to delay gratification, allay concerns over multicollinearity, and discuss how multivariate regression techniques can help clarify the interpretation of observed predictive relations.

Many studies of human development use correlations to gauge the extent to which early life phenomena predict later life outcomes, while at the same time warning that their correlations should not be accorded a causation interpretation. However, discussions of results from predictive models often cross the line by using them to infer latent causal processes and to draw implications for policy and practice (e.g., Reinhart et al. 2013). In developmental psychology, the temptation to assign causal interpretations grows stronger when longitudinal data provide temporal ordering and when researchers believe that an observed “effect” might be caused by a malleable early-life factor.

These kinds of interpretation issues were at the heart of our recent article, “Revisiting the Marshmallow Test: A Conceptual Replication Investigating Links Between Early Delay of Gratification and Later Outcomes,” in which we re-examined well-known longitudinal correlations between early gratification delay and later indicators of cognitive and behavioral functioning (Watts, Duncan, & Quan, 2018). Our study had two primary goals: i) to estimate the correlations reported by Shoda, Mischel and Peake (1990) using a larger and more diverse sample of children; and ii) to explore possible interpretations of the links between gratification delay and later outcomes by estimating regression-based models not previously considered by Shoda et al.

In pursuit of our first goal, we estimated bivariate correlations between performance on the Marshmallow Test and later measures of adolescent functioning. Correlations with adolescent academic achievement were smaller in magnitude than what was reported by Shoda et al. (1990), but still positive and statistically significant, indicating at least partial replication of their achievement correlations. In contrast to Shoda et al. (1990), however, we found null correlations with behavioral outcomes.

We titled our paper a “conceptual replication” because of measurement and sample composition differences when compared with Shoda et al. (1990). But our main goal was to probe possible interpretations of the original findings with a novel set of multivariate regression models.

The commentaries of Doebel, Michaelson, and Munakata (2019) and Falk, Kosse and Pinger (2019) criticize our regression models for “over-controlling” for variables inextricably tied to a child’s ability to delay gratification and thereby obscuring the predictive association of interest. In this response, we motivate our modeling approach and argue that it illuminates possible interpretations of the correlation between gratification delay and later outcomes. In the final section of the article, we comment briefly on the measurement concerns raised by Falk et al.

Why use control variables?

Matching the approach employed by Shoda et al. (1990), our analysis began with a simple bivariate model of the unadjusted association between later achievement and early gratification delay:

$$1. \text{Achievement}_i = a_1 + \beta_{11} \text{DoG}_i + e_i$$

where Achievement_i represents the age-15 achievement of the i th child, and DoG_i represents child i ’s waiting time on the Marshmallow Test at age 54 months. Here, β_{11} corresponds to a bivariate correlation. Viewed another way, β_{11} represents the combined effect on later achievement of increases in gratification delay, plus all other environmental and personal characteristics that are correlated with both gratification delay and later achievement [for a clear discussion of omitted variables bias, see page 76 of Angrist & Pischke (2013)]. For simplicity’s sake, we refer to β_{11} as the “effect of gratification delay.” But it should be noted that both our models and the

correlations in Shoda et al. are limited by the ability of the Marshmallow Test to capture the underlying construct of interest.

Which, if any, control variables should be added to this model depends on the research question at hand. For example, one might be interested in the degree to which delay of gratification *uniquely* predicts later outcomes. Securing an estimate of this unique predictive power is confounded by the fact that children who persist on the Marshmallow Test tend to be advantaged in other early-life domains known to affect later achievement (e.g., socioeconomic status, cognitive ability, and parenting). We approached this task with the thought-experiment of imagining the long-run outcomes of a hypothetical intervention that targeted delay of gratification very narrowly. An example of such an intervention might be a series of sessions that provided children with strategies that helped them exert self-control, but changed no other child capacities nor characteristics of the home environment. Random assignment to such an intervention would be expected to produce treatment and control groups that were balanced across all observed and unobserved characteristics, with the two groups differing only in processes affected by the intervention. From this perspective, a “confound” would be considered any process unaffected by the hypothetical intervention (e.g., socioeconomic status) that has a causal impact on both early gratification and later achievement.

We estimated two additional models in an attempt to isolate the predictive effect of gratification delay from confounding capacities and processes. The first included controls for early-life measures of child and environmental characteristics:

$$2. \text{Achievement}_i = \alpha_1 + \beta_{21} \text{DoG}_i + \chi \text{Dem}_i + \lambda \text{EarlyChild}_i + \delta \text{Home}_i + e_i$$

where Dem_i represents a vector of child demographic characteristics (i.e., geographic location, ethnicity, gender), and EarlyChild_i represents a vector of personal child characteristics measured

at early ages (i.e., temperament measured at age 6 months and cognitive ability measured at ages 24 and 36 months). The set of controls captured by $Home_i$ included early characteristics of the home environment. In this model, β_{21} can be interpreted as the expected effect of an intervention that altered gratification delay, and perhaps other child capacities not controlled for in *Equation 2* (e.g., age-54-months cognitive functioning), but did not change the other factors included in *Equation 2*. As the results shown in Table 4 of our paper illustrate, the addition of these measures substantially diminished the association between age-54-months gratification delay and later achievement.

With *Equation 2*, the included controls would lead to “overcontrolling” if one’s interest was in estimating the upper-bound impact of a very comprehensive intervention that altered not only gratification delay but also all of the other factors included in *Equation 2* (i.e., see literature reviewed by Doebel et al., 2019, and alternative estimates presented by Falk et al., 2019). Put another way, β_{21} may be of little use if interest centers on the predictive ability of gratification delay *due to* its association with the controls included in *Equation 2*. Indeed, Falk et al. (2019) explain how the early cognitive controls in *Equation 2* might lead to an underestimate of the effect of gratification delay on later achievement if gratification delay is inextricably tied to a child’s cognitive ability. As Falk et al. (2019) note, cognitive ability and gratification delay could be empirically inseparable if both capacities develop jointly, or if one construct cannot be measured without tapping the other. Indeed, Shoda et al. (1990) wrote of the cognitive strategies apparently employed by children who persisted on the Marshmallow Test.

Yet, most research in this area is based on the premise that gratification delay and cognitive ability are separable constructs. The title of Walter Mischel’s 2014 book “The Marshmallow Test: Why Self Control is the Engine of Success” emphasizes self-control, not

correlates such as intelligence, as the main driver of the Marshmallow Test prediction. More generally, some of the most influential research on self-control has highlighted how self-control predicts later outcomes even when controlling for intelligence (e.g., Moffit et al., 2011; see review by Duckworth et al., 2019). In our view, the models that control for early cognitive ability illuminate a conceptual problem that should be a focus of future research in this area. If gratification delay (as measured by the Marshmallow Test) and cognitive ability are so closely linked that they cannot be studied independently of one another, then researchers may need to reconsider whether early gratification delay can be understood as a unique construct.

Our final set of models included even more controls, in particular age-54-months measures of child cognitive and behavioral functioning:

$$3. \text{Achievement}_i = \alpha_1 + \beta_{31} \text{DoG}_i + \chi \text{Dem}_i + \lambda \text{EarlyChild}_i + \delta \text{Home}_i + \theta \text{CogSkill54}_i + \pi \text{Behavior54}_i + e_i$$

where CogSkills54_i and Behavior54_i represent other concurrent (i.e., age 54 months) measures of cognitive ability and behavior. Here, β_{31} corresponds to the estimation of the long-run effects of a very narrowly focused intervention that boosted gratification delay, but changed neither other dimensions of concurrent cognitive or behavioral functioning nor the kinds of influences discussed in the context of *Equation 2*.

Doebel et al. (2019) raise the additional concern that the multicollinearity caused by the inclusion of control variables in *Equations 2* and *3* might lower the chances of detecting statistically significant differences. Although possible, this is not the case in our data. In fact, control variables can improve study power by increasing the explained variation in a given model, thereby reducing residual variance and decreasing standard errors as a result. The net impact of these offsetting forces can be seen in changes in standard errors before and after controls are introduced. As Tables 4 and 5 illustrate in our paper, additional controls generally

decrease standard errors on our measures of gratification delay and increase the power to detect its effects (see discussion of this issue in Bloom, 1995).

Table 4 of our paper shows that gratification delay was no longer a statistically significant predictor when all of the controls in *Equation 3* are included. As before, the utility of these estimates lies in the eye of the beholder. From our perspective, these results suggest that gratification delay does not uniquely predict later outcomes net of other important early life factors. In other words, an intervention that targeted gratification delay, but not other factors such as SES, cognitive ability, and parenting would likely fail to alter later life outcomes. To this point, it seems that we agree with both Doebel et al. (2019) and Falk et al. (2019), as both sets of authors advocate for the study of broader interventions. Indeed, as we stated in our paper, the best tests of interventions will come from RCTs with longitudinal follow-up. However, we believe these regression-controlled estimates provide better indicators for what we might expect given the dearth of long-run RCTs in developmental psychology.

Measurement Concerns

Falk et al. (2019) also raise an important point about the Marshmallow Test used in our study: study designers of our dataset elected to end the test after a child had waited for 7 minutes. We appreciate the simulations presented by Falk and colleagues, which illustrate how the measurement censoring might have affected the unadjusted correlation reported in our paper. These simulations also show the substantial confidence interval around the original correlations reported by Shoda et al. (1990), which suggests that virtually any non-zero estimate of the correlation between gratification delay and achievement would probably fall within the CI of the original estimates, regardless of censoring. However, it should be noted that we discussed this measurement limitation at length in our previous study and emphasized results from models that

used dummy variables as indicators of the child's ability to wait. This dummy variable method suggested that for the models estimated in *Equations 2 and 3* (i.e., estimates with controls), the censoring issue did not substantially affect the estimate produced by the Marshmallow Test because the return for students who waited the full 7 minutes was no different from the return for students who waited only 20 seconds [see Figure 1 and the p-values from tests of coefficient equality in Table 4 of Watts et al. (2018)]. As we stated in the limitations section of our paper, this censoring issue prevented us from directly replicating Shoda et al., but because our conceptual replication was focused on interpretations of the Marshmallow Test predictions, the censoring issue did not substantially affect our key conclusions.

Conclusion

We appreciate the dialogue and thoughtful critiques offered by Doebel et al. (2019) and Falk et al. (2019). In general, we agree that our study did not lend itself to making simplistic conclusions about the replicability of the Shoda et al. (1990) study, as we clearly observed positive and substantively important correlations between early gratification delay and later achievement. However, we believe our contribution rested in our ability to clarify how this predictive association should be interpreted.

The difficulty in interpreting predictive associations highlighted by the conversation in these commentaries should not be considered unique to the Marshmallow Test. Many other early skills and behaviors have been promoted as key sources of unique variation due to longitudinal correlations [e.g., executive function (Clark, Pritchard, & Woodward, 2010); reading achievement (Cunningham & Stanovich, 1997)]. Indeed, we ourselves have been guilty of misinterpreting longitudinal correlations between early mathematics achievement and later outcomes (e.g., Duncan et al., 2007; Watts et al., 2014), only to see those views rectified by

sobering longitudinal evidence from experimentally-evaluated interventions (see Bailey, Duncan, Watts, Clements, & Sarama, 2018).

In this case, the models that included control variables may be met with varying levels of interest depending one's specific question of interest and particular interpretation of the underlying construct(s) measured by the Marshmallow Test. As such, our paper provided a range of estimates designed to provide multiple perspectives within which to view the association between early gratification delay and later outcomes. In our view, it is precisely the complexity implied by our results that sharpens our understanding of the predictive validity the Marshmallow Test, and provides new avenues for future research.

References

- Bailey, D. H., Duncan, G. J., Watts, T. W., Clements, D. H., & Sarama, J. (2018). Risky business: Correlation and causation in longitudinal studies of skill development. *American Psychologist*, 73(1), 81.
- Clark, C. A., Pritchard, V. E., & Woodward, L. J. (2010). Preschool executive functioning abilities predict early mathematics achievement. *Developmental Psychology*, 46(5), 1176.
- Cunningham, A. E., & Stanovich, K. E. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology*, 33(6), 934.
- Doebel, S., Michaelson, L., & Munakata, Y. (2019). Good things come to those who wait: Delaying gratification likely does matter for later achievement. *Psychological Science*.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., ... & Sexton, H. (2007). School readiness and later achievement. *Developmental Psychology*, 43(6), 1428.
- Duckworth, A. L., Taxer, J. L., Eskreis-Winkler, L., Galla, B. M., & Gross, J. J. (2019). Self-control and academic achievement. *Annual Review of Psychology*, 70, 373-399.
- Falk, A., Kosse, F., & Pinger, Pia. (2019). Revisiting the Marshmallow Test: On the interpretation of replication results. *Psychological Science*.
- Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., ... & Sears, M. R. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, 108(7), 2693-2698.
- Reinhart, A. L., Haring, S. H., Levin, J. R., Patall, E. A., & Robinson, D. H. (2013). Models of not-so-good behavior: Yet another way to squeeze causality and recommendations for practice out of correlational data. *Journal of Educational Psychology*, 105(1), 241.

- Shoda, Y., Mischel, W., & Peake, P. K. (1990). Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: identifying diagnostic conditions. *Developmental Psychology*, 26(6), 978.
- Watts, T. W., Duncan, G. J., & Quan, H. (2018). Revisiting the Marshmallow Test: A conceptual replication investigating links between early delay of gratification and later outcomes. *Psychological Science*, 29(7), 1159-1177.
- Watts, T. W., Duncan, G. J., Siegler, R. S., & Davis-Kean, P. E. (2014). What's past is prologue: Relations between early mathematics knowledge and high school achievement. *Educational Researcher*, 43(7), 352-360.