

Supplementary Material on Ego Depletion to Accompany

“Correspondence of Maximum and Typical Performance Measures of Cognitive Processing”

Daniel B. Charek, Gregory J. Meyer, Joni L. Mihura, and Emily T. O’Gorman

University of Toledo

The present study built on the findings of Charek, Meyer, and Mihura (2016), with modifications made to enhance the impact of ego depletion, better pinpoint the Rorschach Performance Assessment System (R-PAS; Meyer, Viglione, Mihura, Erard, & Erdberg, 2011) variables most susceptible to the effect of ego depletion, and evaluate the impact of depletion on maximum performance measures of neuropsychological functioning. However, we found no causal relationship between depletion of cognitive resources and subsequent performance. As such, the article that this supplement accompanies (Charek, Meyer, Mihura, & O’Gorman, 2018) focuses on the interrelationship of cognitive processing variables in the control group, and this supplement presents our hypotheses and findings related to the ego depletion manipulation.

The ego depletion paradigm (Baumeister, Vohs, & Tice, 2007) has been used extensively to manipulate the self-control system and observe its impact on cognitive processing tasks. Experiments using the paradigm ask participants to complete a cognitive task that involves overriding an impulse in order to respond in a regulated manner that is consistent with pre-set rules. They then complete another task that requires cognitive resources; presumably, because they now have fewer cognitive resources available, performance on that task will be impaired.

At the time this study was developed, there appeared to be substantial empirical support for the ego depletion paradigm. In a meta-analysis of 83 studies, Hagger, Wood, Stiff, and Chatzisarantis (2010) found moderate to large effect sizes across a variety of depletion tasks and

multiple criteria. However, recent research has challenged these findings. Carter and McCullough (2014) re-analyzed Hagger et al.'s data, applying corrections for small-study bias (e.g., publication bias), and found substantially smaller effects. In a subsequent meta-analysis that included Hagger et al.'s data as well as data from unpublished studies, findings again failed to support the paradigm and suggested that the effect was near zero after accounting for publication bias (Carter, Kofler, Forster, & McCullough, 2015). These, along with other studies questioning the effect of ego depletion (e.g., Tuk, Zhang, & Sweldens, 2015) prompted Hagger et al.'s (2016) multi-site preregistered replication study, which used data from 23 laboratories ($N = 2,141$) and found an effect size near zero ($d = .04$, 95% CI $[-.07, .15]$). Recent findings have even documented a reverse depletion effect, such that, under certain conditions, regulatory self-control enhances subsequent task performance (Savani & Job, 2017).

Nonetheless, given our previous findings (Charek et al., 2016) and the existing research at the time we designed this study, we anticipated that ego depletion would have a detrimental effect on the organization and sophistication of cognitive processes that would be observable in performance on subsequent cognitive tasks.

An additional goal was to assess whether the effect of ego depletion varied across maximum versus typical performance measures. To examine this, we administered three measures of visual perceptual processing that differ in their degree of maximum versus typical performance: the Rorschach inkblot task, Design Fluency from the Delis-Kaplan Executive Functioning System (D-KEFS; Delis et al., 2007), and the Judgment of Line Orientation test (JOLO; Benton, Sivan, Hamsher, Varney, & Spreen, 1994). As discussed in Charek et al. (2018), the Rorschach is a measure of typical performance, as it gives examinees considerable latitude in establishing the task parameters. The JOLO is a maximum performance measure, as it provides

clear guidelines about what constitutes successful performance and fixed, multiple choice response options. Design Fluency falls between the two, though closer to JOLO, as it provides specific instructions for what constitutes successful performance. However, it does not provide fixed response options or guidance on how to monitor for rule violations.

Whereas the high structure of maximum performance measures provide clear instruction concerning where an examinee should direct his or her effort and motivation, typical performance measures offer more latitude. On a typical performance task, examinees are better able to mentally “coast” and recharge cognitive resources. Based on this reasoning, we anticipated ego depletion would affect maximum performance measures less than typical performance measures. Specifically, we hypothesized that Rorschach measures of cognitive processing and sophistication would be most sensitive to the impact of ego depletion, Design Fluency moderately affected, and the JOLO least affected by the manipulation.

Method

Participants

Participants were 135 undergraduates in introductory psychology courses. The control group had 66 participants (M Age = 19.40; 62% male) after four were excluded due to incomplete Rorschach protocols. The experimental group had 69 participants (M Age = 19.36; 24 male, 45 female) after seven were excluded due to incomplete Rorschach protocols.

A Priori Power Analyses and Anticipated Effect Sizes

A priori power analyses determined that 128 participants (64 per group) were needed to have 80% power for significant group differences with an average effect size of $d = 0.50$ ($\alpha = .05$, 2-tailed). We anticipated slightly larger effect sizes than Charek et al. (2016; $d = 0.40$ and above) because we made small methodological changes designed to enhance the effect of

depletion. Hagger et al. (2010) indicated that effect sizes for complex versus simplistic criterion measures differed ($d = 0.65$ and $d = 0.35$ respectively). Thus, in the experimental group, we anticipated a difference of two to three tenths of a standard deviation between the JOLO and Rorschach variables – a Cohen’s f statistic of .15. An a priori analysis indicated 73 participants were required in the experimental group to detect an effect of this size (power = .80, alpha = .05, 1 group, 3 measures, r among dependent measures = .5). Given the final sample sizes, obtained power was .82 for the group comparison of ego depletion effects, and .78 for the within group test of maximal vs. typical performance (with other parameters as indicated above).

Measures

Rorschach Performance Assessment System (R-PAS). Five R-PAS variables (i.e., Synthetic Whole [W-Sy], Space Integration [SI], Vista [V], Human Movement [M], and Complexity) were hypothesized to be related to cognitive sophistication, and three (i.e., Space Reversal [SR] without SI, Popular [P], and Sum of Human Content [SumH]) were hypothesized to be unrelated to cognitive sophistication. Ego depletion was expected to differentially affect these variables, impacting W-Sy, SI, V, M, and Complexity but not SR without SI, P, or SumH.

A final target variable was Weighted Sum of Color (WSumC), which reflects the number of responses in a protocol that reference the chromatic color features of the inkblot. It was originally hypothesized that WSumC would be higher in the depleted group than in the control group, as had been found by Charek et al. (2016). WSumC is interpreted as indicating a reactive, rather than regulated, approach to the task (Meyer et al., 2011), and an increase in WSumC would indicate increased reactivity to stimulating features of the environment, as opposed to indicating decreased organization or sophistication of thought processes.

Delis-Kaplan Executive Functioning System (D-KEFS) Design Fluency. The D-KEFS

Design Fluency test contains three trials of increasing difficulty, with the final trial requiring inhibitory control and set shifting. Filled Dots provides a series of 35 boxes, each containing a fixed array of five solid black dots. Participants generate unique designs by drawing four lines connecting the dots. Lines have to connect to dots on either side, and each line has to connect to a dot that connects to another dot. Empty Dots provides 35 boxes containing a fixed array of five solid and five open black dots. Participants generate unique designs by drawing four lines connecting only open dots. Switching provides the same 35 boxes as Empty Dots, but participants generate unique designs by drawing four lines alternating between empty and filled dots. A Contrast score subtracts Switching from the other two trials, and a Total score sums all three. Standard record forms were used for administration, and instructions were given orally supplemented by PowerPoints.

Judgment of Line Orientation (JOLO). The JOLO (Benton et al., 1994) is a measure of visuospatial perception using two line fragments at particular angles, below which is a fanned array of 11 lines at 18-degree intervals. Participants select two lines from the array to match the fragments above. To conserve time, we used the short form (15 odd-numbered items from Form V), which is comparable to the full test (Mount, Hogg, & Johnstone, 2002). It was administered via computer, retaining the size and placement of stimuli as in the printed booklet.

International Personality Item Pool (IPIP). Two facets of conscientiousness from the International Personality Item Pool (IPIP; <http://ipip.ori.org/>; Goldberg et al., 2006) were completed. The first, Self-efficacy, assesses the extent to which one is confident in his or her abilities. The second, Achievement-striving, assesses the extent to which one is motivated to pursue and to attain goals. Each contains 10 items rated on a 5-point scale (1 = *very inaccurate*; 5 = *very accurate*). This measure was used because Charek et al. (2016) found that the IPIP

Achievement-striving scale moderated the effect of ego depletion on Rorschach color variables, with high achievement striving associated with lower color reactivity prior to the ego depletion task, but increased color reactivity after the task.

Procedure

The Rorschach, JOLO, and D-KEFS Design Fluency were administered in a group setting, with efforts made to follow standard administration guidelines as closely as possible, as described in Charek et al. (2018). Participants completed the letter cancelation task using pencil and paper prior to each of the four study blocks.

Letter cancelation task. Participants in the experimental condition received four pages of text from a journal article on fibromyalgia, with this topic selected because repeated references to fatigue might have a priming effect that would heighten depletion. Participants in the control group received four pages of text from a statistics article. Scripts for the control and experimental conditions were identical, with two exceptions. First, the instructions for the experimental group emphasized the cognitive effort that would be required for letter cancelation and implied that performance on subsequent tasks would be significantly impaired. The instructions for the control group described the cancelation task as a relatively easy one that was unlikely to impact subsequent performance. This difference was based on research suggesting ego depletion is effective if individuals believe it will affect their willpower and ability to self-regulate (Job, Dweck, & Walton, 2010). The second difference was in the task itself. In the experimental condition, the experimenter read aloud the following instructions to participants:

The task is to work as quickly as you can to cross all the letter “e”s on a page. However, you also have to follow a set of specific rules. There are 4 rules. First, if the e is located next to another vowel, don’t cross it out. Second, if the e is one extra letter away from another vowel,

don't cross it out. Third, cross out every letter "E" that is a capital letter, regardless of where other vowels are located. Fourth, cross out every letter "e" that ends a sentence, regardless of where other vowels are located. For this task, only consider the letters A, E, I, O, and U as vowels. Also, we ask that you disregard spaces, numbers, punctuation, and symbols in the letter sequences. The examiner then showed participants PowerPoint slides depicting several examples of when a cancellation would or would not occur. The instructions and examples remained on the screen during the task. Participants in the control condition simply crossed out all of the letter "e"s, with no additional rules imposed.

These procedures were very similar to those used by Charek et al. (2016). The only difference concerned the third and fourth rules for the experimental group, which were added to increase a mental set for crossing out "e's" that had to be overridden by self-control.

Results

Charek et al. (2016) unexpectedly found between group differences in the total number of Rorschach responses (R) and thus used percentage scores for all analyses. An independent samples *t*-test revealed that the control and depleted groups did not differ significantly on R, $t(133) = 1.04, p = 0.30$. As such, all results used raw frequencies.

Independent samples *t*-tests assessing ego depletion revealed no significant differences between groups for any of the variables. Post hoc analyses examined just the measures administered after the first experimental manipulation in case the effect dissipated, but yielded no significant results (see Charek, 2016). There also were no effects evident when examining just the first five Rorschach responses. Given the null depletion effects, there was no need to contrast maximum versus typical performance measures or test moderation by achievement striving.

Discussion

This study is a follow up to Charek et al. (2016), with primary differences being the addition of traditional neuropsychological measures as targets for depletion and modifications to the letter cancellation task to enhance its impact on ego depletion. Particularly given these modifications, it was surprising that the ego depletion differences observed by Charek et al. were not replicated. At least seven considerations may have contributed to the null effects.

First, some research (e.g., Xiao, Dang, Mao, & Liljedahl, 2014) suggests that participants adapt to performance requirements by increasing effort when completing multiple cognitive tasks. If so, the effects of depletion would be less perceptible for measures administered later. However, exploratory analyses for order effects failed to show evidence the effect dissipated.

Second, a more likely contributor is that people can conserve cognitive resources when they anticipate engaging in further volitional action (Muraven, Shmueli, & Burkley, 2006). In this study, participants did not know how many tasks they would complete, but they knew the study lasted for two hours. They also received the all materials they would use over the course of the experiment at the beginning of the session, and instructions implied that certain tasks had multiple parts (e.g., four pages of text for four rounds of letter cancellation). This may have allowed participants to pace themselves to avoid depleting cognitive resources early on.

Third, Charek et al. (2015) required participants to fast for three hours before the study. Although evidence suggests blood glucose levels do not account for ego depletion (Kurzban, 2010), removing this requirement may have differentially influenced the type of participants recruited. In the previous study, participants almost uniformly reported they fasted as instructed, suggesting they were conscientious, motivated, and willing to endure the demands of ego depletion. We may have obtained less conscientious and motivated participants this time.

A fourth consideration is the pace of the experiment, which was more urgent than Charek

et al. (2016) because several more tasks needed to be completed within the allotted time. Some participants may have given briefer Rorschach responses, where they would have elaborated more if they had perceived fewer time constraints. It is also possible that the timing imposed constraints on participants that simulated more maximum performance conditions during this task, which could have offset the impact of the ego depletion task. When we explored this using the three variables that overlapped between the previous project and this project, we found only small differences. If this effect was present, it was not evident in these variables.

A fifth factor may relate to use of Design Fluency as a criterion measure. It is arguably as depleting as the experimental letter cancellation task. As such, it may have introduced an unintended depletion effect for the control group that reduced effect sizes.

Sixth, according to the strength model of self-regulatory control, ego resources are depleted in proportion to the self-regulatory resources exerted (Baumeister et al., 2007) and may not be evident if insufficient time were spent on the depleting task. This explanation, however, is unlikely for at least two reasons. First, the timing of cancellation tasks was the same as that used by Charek et al. (2016). Second, Hagger et al. (2010) investigated task duration as a moderator of the depletion effect and found it to be just a small contributor to outcome ($\beta = .11, z = 1.79$).

Finally, it is possible that the ego depletion effect either does not exist, as suggested by some recent research (e.g., Carter et al., 2015; Hagger et al., 2016) or that it is more inconsistent and complex than initially hypothesized (e.g., Muraven et al., 2006; Savani & Job, 2017). The contrast of findings between the very similar studies by Charek et al. (2016) and Charek et al. (2018) are more consistent with the latter than the former.

References

- Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*, 1252-1265. doi: 10.1037/0022-3514.74.5.1252
- Benton, A. L., Sivan, A. B., Hamsher, K., Varney, N., & Spreen, O. (1994). *Contributions to neuropsychological assessment: A clinical manual* (2nd ed.). New York, NY: Oxford University Press.
- Carter, E. C., Kofler, L. M., Forster, D. E., & McCullough, M. E. (2015). A series of meta-analytic tests of the depletion effect: Self-control does not seem to rely on a limited resource. *Journal of Experimental Psychology: General, 144*, 796-815.
doi:10.1037/xge0000083
- Carter, E. C., & McCullough, M. E. (2014). Publication bias and the limited strength model of self-control: Has the evidence for ego depletion been overestimated? *Frontiers in Psychology, 5*, Article ID 823.
- Charek, D. B. (2016). *Differentiating maximal and typical performance measures: The impact of ego depletion on measures of maximal and typical cognition* (Unpublished dissertation). University of Toledo, Toledo, OH.
- Charek, D. B., Meyer, G. J., & Mihura, J. L., (2016). The impact of an ego depletion manipulation on performance-based and self-report assessment measures. *Assessment, 23*, 637-649. doi: 10.1177/1073191115586580
- Charek, D. B., Mihura, J. L., O’Gorman, E. T., & Meyer, G. J. (2018) *Correspondence of maximum and typical performance measures of cognitive ability in the context of an ego depletion study*. Manuscript submitted for publication.

Delis, D. C., Kaplan, E., Kramer, J. H., Buysch, H. O., Noens, I., & Berckelaer-Onnes, I. (2007).

D-KEFS: Delis-Kaplan executive function system: Design Fluency Test. Amsterdam, Netherlands: Harcourt Test Publishers.

Donnellan, M. B., Oswald, F. L., Baird, B. M., Lucas, R. E. (2006). The Mini-IPIP Scales: Tiny-yet-effective measures of the Big Five Factors of Personality. *Psychological Assessment*, *18*, 192-203. doi:10.1037/1040-3590.18.2.192

Goldberg, L. R., Johnson, J. A., Eber, H. W., Hogan, R., Ashton, M. C., Cloninger, C. R., & Gough, H. C. (2006). The International Personality Item Pool and the future of public-domain personality measures. *Journal of Research in Personality*, *40*, 84-96.

Hagger, M. S., Chatzisarantis, N. D., Alberts, H., Anggono, C. O., Batailler, C., Birt, A., ... Zwieneberg, M. (2016). A multi-lab pre-registered replication of the ego depletion effect. *Perspectives on Psychological Science*, *11*, 546-573.
doi:10.1177/1745691616652873

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*, 495-525.
doi:10.1037/a0019486.

Job, V., Dweck, C.S., & Walton, G. M. (2010). Ego depletion-is it all in your head? Implicit theories about willpower affect self-regulation. *Psychological Science*, *21*, 1686-1693.
doi: 10.1177/0956797610384745.

Meyer, G. J., Viglione, D. J., Mihura, J. L., Erard, R. E., & Erdberg, P. (2011). *Rorschach Performance Assessment System: Administration, coding, interpretation, and technical manual*. Toledo, OH: Rorschach Performance Assessment System, LLC.

Mount, D. L., Hogg, J., & Johnstone, B. (2002). Applicability of the 15-item versions of the

Judgement of Line Orientation Test for individuals with traumatic brain injury. *Brain Injury*, 16, 1051-1055. doi:10.1080/02699050210154259

Muraven, M., Shmueli, D., & Burkley, E. (2006). Conserving self-control strength. *Journal of Personality and Social Psychology*, 91, 524–537. doi:10.1037/0022-3514.91.3.52

Savani, K., & Job, V. (2017). Reverse ego-depletion: Acts of self-control can improve subsequent performance in Indian cultural contexts. *Journal of Personality and Social Psychology*, 113, 589-607. doi:10.1037/pspi0000099

Tuk, M. A., Zhang, K., & Sweldens, S. (2015). The propagation of self-control: Self-control in one domain simultaneously improves self-control in other domains. *Journal of Experimental Psychology*, 144, 639-654. doi:10.1037/xge0000065

Xiao, S., Dang, J., Mao, L., & Liljedahl, S. (2014). When more depletion offsets the ego depletion effect. *Social Psychology*, 45, 421-425. doi:10.1027/1864-9335/a000197