<CT>**Is ego depletion too incredible? Evidence for the overestimation of the depletion effect**

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<C-AB>**Abstract:** The depletion effect, a decreased capacity for self-control following previous acts of self-control, is thought to result from a lack of necessary physical or psychological resources (i.e., "ego depletion"). Kurzban et al. present an alternative explanation for depletion; but based on statistical techniques that evaluate and adjust for publication bias, we question whether depletion is a real phenomenon in need of explanation.

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Much of Kurzban et al.'s discussion centers on the so-called depletion effect (i.e., the reduction of task performance between self-control tasks; Baumeister et al. 1998). For example, in the target article the authors argue that currently popular theoretical accounts of the depletion effect (i.e., that it is due to the depletion of some necessary resource) are inadequate (sect. 3.2) and that an opportunity cost model is more appropriate (sect. 3.1).

If one assumes the depletion effect is a real phenomenon, we believe the authors' account is indeed preferable to other explanations that have been proffered. However, based on the meta-analytic methods that Hagger et al. (2010) used to evaluate the depletion effect, we believe there is license for doubting that depletion really occurs. If one wishes to believe it is real (which may also be licensed), then it could be meaningfully weaker than Hagger et al. concluded.

Hagger et al. estimated that the overall size of the depletion effect was d=0.62 (95% confidence interval [0.57,0.67]). However, a meta-analytic estimate of an overall effect size is biased to the extent that the sample of experiments used to derive that estimate misrepresents the population of experiments that have been conducted on the effect. Samples of experiments can easily become unrepresentative if the probability that an experiment is included in a meta-analytic sample is influenced by the results of the experiment, a phenomenon known as *publication bias* (e.g., when findings confirming a particular idea are more easily published and consequently more easily identified and included in the meta-analysis than are contradictory findings). Importantly, Hagger et al.'s meta-analytic estimate resulted from a sample of experiments that was drawn exclusively from the published literature. Their neglect of the relevant unpublished results leaves open the possibility that the estimate is, therefore, inflated. Here we summarize some results from our work that was prompted by this possibility (Carter & McCullough 2013).

Based on Ioannidis and Trikalinos (2007), Schimmack (2012) proposed the

"incredibility-index" (IC-index) as an estimate of the probability that a set of studies

contains fewer statistically nonsignificant findings than would be credible under unbiased

sampling – that is, that the number of significant findings is incredible. The IC-index,

which takes values from 0 to 1 (where higher values suggest greater incredibility), is

calculated through a binomial test on the observed number of significant results (151 of

the 198 experiments analyzed by Hagger et al. were significant), given the probability

that a single experiment will be significant (estimated as the average statistical power of

the set of experiments). Based on post-hoc power calculations for each experiment in the

Hagger et al. dataset, in which we assumed the true effect size was d=0.62, we estimated

average power to be 0.55, which resulted in an IC-index greater than 0.999 (for the

binomial test, p=3.72E-10). Therefore, it is extremely likely that more nonsignificant

findings exist than are included in Hagger et al.'s meta-analysis, because the probability

of drawing a set of 198 experiments in which only 47 or fewer were nonsignificant is

roughly 3.7 in 1,000,000,000.

Hagger et al. addressed the possibility of publication bias in their dataset by

calculating the fail-safe N (Rosenberg 2005), but this method for assessing the robustness

of a meta-analytic conclusion to publication bias is considered far from adequate (Sutton

2009). Alternatively, regression-based methods can both assess and correct for

publication bias in a sample of experiments (Stanley 2008). In a weighted least squares

regression model in which effect sizes are regressed on the standard errors (SEs) of those

effect sizes, effect size and SE should be unrelated. However, if publication bias exists,

SEs will be negatively associated with effect size (Egger et al. 1997). Additionally, one can think of the intercept in this model as an estimate of the effect size of a hypothetical infinitely large study (i.e., one with zero sampling error variance; Moreno et al. 2011; Stanley 2008). Simulation studies suggest that such regression-based extrapolation yields accurate estimates of true effect sizes in the face of publication bias (Moreno et al. 2009; Stanley 2008).

We applied two regression models to Hagger et al.'s dataset: One in which the predictor was SE, and an alternative model in which the predictor was SE-squared (SE^2; Moreno et al., 2009). In both models the regression coefficient for the predictor was significant (t_{SE}=11.87; t_{SE^2}=11.99; ps<.001), which is consistent with the presence of publication bias. The model-based estimates of the true underlying effect differed, however. Using SE-squared, the corrected effect size was d=0.25 (95% CI [0.18, 0.32]). Using SE as the predictor, the corrected effect size was a nonsignificant d=−0.10 (95% CI [-0.23, 0.02]). Based on these methods, then, ego depletion could be a small effect – less than half the size of that estimated by Hagger et al. – but it also could be a nonexistent effect in which belief has been kept alive through the neglect of null findings. If the true effect size is close to d=0.25, then the set of experiments Hagger et al. analyzed was extremely underpowered (mean power=0.15, 95th percentile=0.24). And even these less skeptical results counsel caution: Assuming the mean effect size is d=0.25, researchers hoping to study depletion by comparing two means with 80% power should be prepared to collect a sample with N>460, not N=84 (as implied by Hagger et al.'s estimate of d=0.62).

The great pity here is that editorial vigilance could have obviated these concerns: Editors and reviewers of meta-analyses should insist on rigorous efforts to track down the hard-to-find (i.e., unpublished) results. As things stand, we believe that the highest priority for research on the depletion effect should not be arriving at a better theoretical account but rather, determining with greater certainty whether an effect to be explained exists at all.

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<RFT>**References** [Evan C. Carter and Michael E. McCullough][ECC]

<refs>

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* 74:1252–65. [ECC]

Carter, E. C. & McCullough, M. E. (2013) Publication bias and the limited strength model of self-control: Has the evidence for ego depletion been overestimated? Unpublished manuscript. [ECC]

Egger, M., Davey Smith, G., Scheider, M. & Minder, C. (1997) Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal* 316:629–34. [ECC]

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

Ioannidis, J. P. A. & Trikalinos, T. A. (2007) An exploratory test for an excess of significant findings. *Clinical Trials* 4:245–53. [ECC]

Moreno, S. G., Sutton, A. J., Ades, A. E., Stanley, T. D., Abrams, K. R., Peters, J. L. & Cooper, N. J. (2009) Assessment of regression-based methods to adjust for publication bias through a comprehensive simulation study. *BMC Medical Research Methodology* 9:1–17. [ECC]

Moreno, S. G., Sutton, A. J., Thompson, J. R., Ades, A. E., Abrams, K. R. & Cooper, N. J. (2011) A generalized weighting regression-derived meta-analysis estimator robust to small-study effects and heterogeneity. *Statistics in Medicine* 31:1407–17. [ECC]

Rosenberg, M. S. (2005) The file-drawer problem revisited: A general weighted method for calculating fail-safe numbers in meta-analysis. *Evolution* 59:464–68. [ECC]

Schimmack, U. (2012). The ironic effect of significant results on the credibility of multiple study articles. *Psychological Methods*, 17: 551–66 [ECC]

Stanley, T. D. (2008) Meta-regression methods for detecting and estimating empirical effects in the presence of publication selection. *Oxford Bulletin of Economics and Statistics* 70:103–27. [ECC]

Sutton, A. J. (2009) Publication bias. In: *The handbook of research synthesis and meta-analysis,* ed. H. Cooper, L. Hedges & J. Valentine, pp. 435–52. Russell Sage Foundation. [ECC]