Drift diffusion modeling of ego-depletion effects on Stroop task

Previous research has shown that performance on tasks involving speed-accuracy tradeoffs can be described by parameters (e.g., drift rate, threshold) in the drift diffusion model (Wagenmakers et al., 2007; Ratcliff et al., 2016). For example, faster drift rates reflect faster information accumulation rates, while larger thresholds reflect greater cautiousness, in that more information has to be accumulated before one makes a decision. Here, we will investigate whether ego depletion leads to changes in two key parameters of the diffusion model: drift rate (i.e., processing efficiency or the amount of evidence accumulated per unit time) and reduced threshold (response caution or the amount of evidence required before response is made). Exploratory analyses in existing data suggest that depletion leads to reduced drift rate (reduced information accumulation rates) and threshold (reduced cautiousness), and the present study aims to replicate and confirm these effects.

Experimental conditions and design

There are two conditions: control and depletion. After completing the control task (watching a 5-minute video) or depleting task (15 minutes), participants will complete questions that assess subjective experience (i.e., boredom, effort, frustration, fatigue, mental demand). Then, to measure ego-depletion effects, participants will complete a modified Stroop task (dependent variable).

We will use a **within-subjects design**, which will give us greater statistical power. Each participant will complete both the depleting and control tasks in our laboratory, but on two separate days space exactly a week apart (i.e., same day of the week and same hour of the day). Participants will be pseudo-randomly assigned to either the control or depleting condition on the first day based on their allocated participant number (i.e., odd-numbered participants will be assigned to the control condition; even-numbered participants will be assigned to the depleting condition).

Sample and power

We will recruit 130 participants. Based on effect sizes from our exploratory analyses (drift rate effect size: $r \approx 0.13–0.15$), a sensitivity analysis indicates that we will have about 80% statistical power to detect these effect sizes or larger (sensitivity analysis done using Jakefall's PANGEA, https://jakewestfall.shinyapps.io/pangea/).

Control task: video

Participants will watch a wildlife video that lasts approximately 5 minutes (https://www.youtube.com/watch?v=Q52ZXTZK_dc&t=1s). We have opted to use this 5-minute video as the control task to avoid inducing boredom (easy cognitive tasks often induce boredom), which might also impair cognitive performance in a similar fashion to depletion.

Titrated depletion task: Modified symbol counter task (15 minutes)

To induce depletion, we will use the symbol counter task, which has been shown to differentially activate brain regions associated with working memory as a function of trial difficulty (for task details see Garavan, Ross, Li, & Stein, 2000). This task requires participants to count the number of small and big squares presented on each trial, and

requires mainly two components of executive function (i.e, updating, shifting). We will use a modified version of this task that adjusts its difficulty on a trial-by-trial basis via three parameters:

1. Number of squares presented (11 to 17)
2. Switch frequency (i.e., how frequently it switches from big to small or small to big square; there are four levels of difficulty)
3. Display duration of each square (starts at 800 ms)

The first actual trial presents 12 squares at switch frequency difficulty level 2. If participants get this trial correct, the next trial will have 13 squares and the display duration will decrease by 20 ms (from 800 ms to 780 ms). That is, the number of squares increases by 1 and display duration decreases by 20 ms each time participants respond correctly. Whenever they make a mistake, the number of squares presented will decrease by 1 and display duration will increase by 20 ms. If they are at 17 squares at switch frequency 2, the next trial will present 11 squares at switch frequency difficulty level 3 (if they get the current trial correct).

On each trial, a square is presented and is preceded by a fixation cross (300 ms). The task begins with two practice trials with feedback indicating whether participants have counted the correct number of squares correctly. After which, the actual task begins and no feedback will be provided. Participants will perform the task for 15 minutes.

Dependent measure: Stroop

Participants will complete a Stroop task (3 colours: red, blue, yellow; adapted from Stroop, 1935). They will complete 180 trials (120 congruent, 60 incongruent), presented in two blocks (90 trials each), with no break between blocks. On each trial, the stimulus will remain on screen until the participant responds or until a maximum of 2000 ms. If participants fail to respond on 3 consecutive trials, a message will be shown to remind them to respond faster and more accurately.

Exploratory dependent measure: Food ratings

After completing the Stroop task, participants will indicate how hungry they are currently. They will then rate 20 food images (10 tasty but unhealthy foods [e.g., chips, smarties]; 10 healthy but not tasty foods [e.g., asparagus, cauliflower]); they will indicate how much they want to eat each food and how much they like this food. Participants will also indicate whether they are trying to eat healthy in general.

Exclusion criteria

Titrated depletion task: Modified symbol counter task

- Participants whose overall accuracy is less than 25%

Dependent measure: Stroop task

- Trials with reaction time < 250 ms
- Trials with reaction time > 3 median absolute deviations (MAD) from individual's overall reaction time across both experimental conditions
- Participants whose total number of errors on congruent trials > 3 MADs from the overall median across both experimental conditions

Demographic measures

- Age, gender, ethnicity, perceived socio-economic status

Primary hypotheses

1. Depletion (vs. control) condition will be associated with *reduced drift rate*, after controlling for congruency effects.
2. Depletion (vs. control) condition will be associated with *reduced threshold*, after controlling for congruency effects.

Bayes factors for primary hypotheses

We will also supplement the two effects above with Bayes factors, computed using JASP with a Gaussian prior (mean = 0.28, SD = 0.14) truncated at 0 to allow only positive effect sizes (a similar prior have used analyse recent ego-depletion effects; see https://www.bayesianspectacles.org/redefine-statistical-significance-xiii-the-case-of-ego-depletion/). Dienes (2014) also suggested to use SD = mean/2 for a Gaussian distribution.

Other predictions based on pilot data (unrelated to depletion)

We have also observed other findings in our pilot data and expect to replicate them. While we are predicting to replicate these effects, they are not tests of ego depletion effects.

1. Incongruent (vs. congruent) trials will be associated with lower drift rates.
2. Incongruent (vs. congruent) trials will be associated with lower thresholds.

Exploratory analyses

- We will explore whether depletion leads to changes in how much participants want to consume and like different foods. For example, when depleted, participants might like and want to consume tasty but unhealthy foods (e.g., chips) more than when they are not depleted. Conversely, they might be less likely to want to and consume foods that are not tasty but healthy (e.g., asparagus).

References

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