Journal of open psychology data

Turi, Z, et al. 2018 Data from 'Placebo Enhances Reward Learning in Healthy Individuals'. *Journal of Open Psychology Data,* 6: 2, DOI: https://doi.org/10.5334/jopd.34

DATA PAPER

Data from 'Placebo Enhances Reward Learning in Healthy Individuals'

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This dataset contains three repeated measures of a standard reward-based reinforcement-learning task from 29 healthy male individuals who participated in three experimental sessions exploring cognitive placebo effects on reward learning. The dataset includes behavioural data (accuracy, reaction times) during learning and transfer, estimates of model-free computational analysis, self-reported arousal values, and expectations about the interventions' efficacy. The data were collected in 2014 at the Department of Clinical Neurophysiology, University Medical Center Goettingen, Germany. The data collection and formal analysis used a triple-blind study design as participants, operator and analyst were unaware of conditions. A github repository contains data and analyses for the paper "Placebo Intervention Enhances Reward Learning in Healthy Individuals". The dataset can be used for further analysis, reference, validation studies, teaching purposes, and collaborative research.

Keywords: placebo effect; cognitive placebo effect; non-invasive brain stimulation; transcranial direct current stimulation; transcranial near infrared laser stimulation; reward learning; model-free reinforcement learning

Funding statement: This study was supported by the DFG (PA 419/15-1) awarded to WP. The preparation of this manuscript was supported by the "Research program, University Medical Center, University of Goettingen" awarded to Z.T.

Overview

Context

Collection Date(s)

2014

Background

The aim of the study was to investigate potential cognitive placebo effects in healthy individuals, which is a phenomenon that describes enhanced cognitive performance following the application of a placebo intervention [1]. More specifically, the study investigated reinforcement learning performance in a standard probabilistic instrumental learning task [2, 3]. We present a dataset of 29 male healthy individuals, who received active sham protocols of non-invasive brain stimulation (NIBS) techniques in conjunction with two uncertainty-based placebo-inducing written instructions in a randomized, counterbalanced, triple-blind, repeated-measures study design. In addition, volunteers participated in a baseline session serving as a control condition, where no intervention was applied. In the purportedly low-uncertainty condition, NIBS was introduced as a well-established intervention, which would improve their cognitive performance proven by former experiments. In the purportedly high-uncertainty condition, participants were informed that they would receive NIBS, whose effect has yet to be experimentally proven. Participants' performance was monitored by using a probabilistic monetary reward-based instrumental learning task with independent sets of stimuli. The behavioural impacts of the cognitive placebo effect were characterized by assessing the amount of monetary earnings and reaction times, and by estimating model-free reinforcement-learning parameters. In the purportedly high-uncertainty condition, participants increased their monetary earnings, responded faster and had higher learning rate from rewards when compared to the baseline and purportedly low-uncertainty conditions. These findings suggest that NIBS techniques combined with uncertainty-based placebo-inducing written instructions can enhance reward learning in healthy individuals.

Methods

Sample

Thirty male healthy volunteers were recruited for the study by using online advertisement. Due to the drop-out of one participant following the baseline session, 29 participants completed the study. All participants were

financially compensated at the end of the last session, by receiving 7 EUR per every started hour. Mean age (± standard deviation) of the final sample was 23.3 ± 2.95 yrs and mean years of education was 15.8 ± 2.35 yrs. Before participation, all participants underwent a neurological screening procedure performed by a neurologist -who was blinded to the purpose of the study- at the Department of Clinical Neurology, University Medical Center Goettingen. Exclusion criteria included a history of current medical, neurological or psychiatric illnesses (e.g., epilepsy), drug and/or alcohol dependence, and the presence of metal implants in the head, neck and chest. Due to the nature of stimuli applied in the behavioural paradigm, participants with no prior experience with Chinese or Japanese language were recruited. All participants were native German speakers or were at effective operational proficiency level corresponding to C1 according to the Common European Framework of Reference for Languages classification system.

Materials

Participants performed a standard monetary reward-based instrumental learning task with three independent sets of stimuli randomly selected for the baseline and for the two active placebo sessions. In each session, participants were presented with three pairs of Chinese symbols (different ones for the three sessions) by using probabilistic reward contingencies with three difficulty levels for each symbol pair (80/20%, 70/30% and 60/40%). Reward contingencies were kept constant between the experimental sessions. The task of the participants was to select the stimulus from a pair with maximum reward probability. The task consisted of six blocks with 60 stimuli in each block. The instructions used for inducing uncertainty about the stimulation efficacy are available in the linked respository under the directory "experimental materials". In the same location, we also share the stimuli used in this experiment under a CC0 license.

Procedures

Participants first took part in a baseline session, where they performed the behavioural task and no intervention was applied. The baseline session was followed by the two randomly ordered and counterbalanced active placebo sessions (i.e., purportedly low- and high-uncertainty sessions). Each placebo session started with filling in questionnaires. This was followed by the preparation procedure of the NIBS intervention. Due to the repeated-measures study design, we implemented different treatment characteristics for the two placebo sessions. In the low-uncertainty session, participants were informed that they would receive a combined stimulation of both transcranial direct current stimulation (tDCS) and transcranial near infrared laser stimulation (tNILS) that is a standard and effective intervention to improve cognition. In the high-uncertainty session, participants were given the information that they would receive a tDCS intervention whose effect has yet to be experimentally proven. By using the international 10/20 EEG system, the anodal electrode of tDCS was placed over the F3 location, whereas the cathode over the F4 location, which approximately corresponds to the left and right dorsolateral prefrontal cortex, respectively. The stimulation current intensity was set to 1 mA and it was applied in a fade in (15s), short stimulation (30s) and fade out (15s) fashion. Unknown to the participants and the data collector, four laser needles used for the tNILS in the low-uncertainty session were inactive. The inactive laser needles were focused over the anode tDCS electrode, and were fixed using a metal crown during the intervention period. The operator was required to wear goggles as protection from the "laser beam", while the participants were asked to close their eyes during the stimulation. In reality, in both placebo sessions only active sham protocol of tDCS was used, therefore, the stimulation-induced cutaneous sensations were physically equivalent in the two sessions.

Quality Control

All participants received detailed written instructions about the task. Before participation, our volunteers were asked to perform a practice session to make them familiar with the task and to ensure that they can operate comfortably with the response box. Participants had the chance to repeat the practice session when they did not feel confident with certain aspects of the task. Before the start of the task, participants were required to fill out a questionnaire to ensure that the participants correctly understood the task. This questionnaire assessed whether i) the participants understood the meaning of the three feedback types (win, no win, late answer) and ii) the nature of the feedback (i.e., that they were not guaranteed to receive a positive feedback even though they had chosen the correct stimulus).

Ethical issues

The study was approved by the local ethic committee of the University Medical Center Goettingen (approval number 12/4/12) and was performed according to the guidelines of the Declaration of Helsinki. All participants read and signed the informed consent form before participation in the study. A letter- and digit-based code was used to pseudo-anonymize participants' identity. All data were collected by using pseudo-anonymized codes.

Dataset description

Object name

Directory "data". This directory contains the following items:

- the raw data as outputted by the experimental software is located under "data/raw/learning" and "data/raw/transer" (.csv files, one per participant and condition)
- pre-processed data is located in "data/export" and is available in two formats, .csv and .RData; The R-script that produced these files is available under "src/export_data.R"

Data type

Contains both raw and preprocessed (combined, missing values replaced by NA, irrelevant variables dropped) data along with analysis scripts.

Format names and versions

The data are available .csv format which can be easily imported into any spreadsheet software (e.g., Excel) and .RData for use with R/RStudio. The .RData file is called "data/export/placebo_tdcs_study.RData" and contains the following 4 data-structures (tables):

- learn: This table contains the data from all three sessions (baseline, low-uncertainty and high-uncertainty) of the learning-task. The following variables are included:
  - Participant – number of the participant (consistent across the three conditions)
  - pair – pair number (1,2,3) with (60/40, 70/30 or 80/20% reward probability)
  - condition – one of N, A, B where N is baseline, A low-uncertainty and B is high-uncertainty
  - ACC – accuracy: 1 correct, 0 incorrect, −1 no response
  - RT – reaction time in s
  - reward – 1: reward was received, 0: no reward
- transfer: This table contains the data from all three sessions (baseline, low-uncertainty and high-uncertainty) of the transfer phase of the learning-task. Participants were presented with all possible combinations of the learned stimuli and had to choose the one that would yield a higher reward probability. The following variables are included:
  - Participant – number of the participant (consistent across the three conditions and identical to the values in the "learn" table)
  - RT – reaction time in s
  - symb1, symb2 – the two presented symbols (one of A, B, C, D, E, F)
  - choice – which symbol was picked (one of A, B, C, D, E, F) or NA in case of no response
- antexp: Contains the subjectively reported anticipated/experienced changes due to the placebo stimulation. The included variables are:
  - PID – number of the participant (consistent with the other tables)
  - AAntDirection – anticipated direction of change in condition "A" (low-uncertainty) before the experiment; one of (−1, 0, 1) where
    - −1 means that subjects expected to get worse,
    - 0 means no anticipated change,
    - 1 means subjects expected to have improved performance
  - AAntAmount – anticipated amount of change in condition "A" (low-uncertainty) on a percentage scale relative to the previous performance at baseline
  - AExpDirection – experienced amount of change in condition "A" (low-uncertainty) after the experiment; one of (−1, 0, 1) where
    - −1 means that subjects experienced a decline in performance
    - 0 means no experienced change,
    - 1 means subjects experienced to have improved performance
  - AExpAmount – experienced amount of change in condition "A" (low-uncertainty) on a scale from −100 to +100
  - all those variables exist also prefixed with "B" for condition "B" (high-uncertainty)
- arousal: Subjectively reported ratings of the participants' arousal state on a scale from 1–10. The following variables are included:
  - Participant – number of the participant
  - BL_before – arousal rating in the baseline session ("N") before the experiment
  - BL_after – arousal rating in the baseline session ("N") after the experiment
  - A_before – arousal rating in the low-uncertainty session ("A") before the experiment
  - A_after – arousal rating in the low-uncertainty session ("A") after the experiment
  - B_before – arousal rating in the high-uncertainty session ("B") before the experiment
  - B_after – arousal rating in the high-uncertainty session ("B") after the experiment

These four tables are also saved in separate .csv files "placebo_tdcs_learn.csv", "placebo_tdcs_transfer.csv", "placebo_tdcs_antexp.csv" and "placebo_tdcs_arousal.csv" in the directory "data/export" for compatibility with other analysis software.

Data Collectors

The data were collected by Sophie Alexandra Schäfer as part of her medical dissertation at the University Medical Center Goettingen, Germany in the year of 2014. The data collection was supervised by Zsolt Turi, who was present during the stimulation part in both placebo sessions and had minimal verbal contact with the participants.

Language

All the instructions (written and oral) in the experiments were in German.

License

Embargo

Authors declare that the current dataset is not under embargo.

Repository location

https://github.com/ihrke/2016-placebo-tdcs-study (https://doi.org/10.5281/zenodo.818809)

Publication date

23/01/2017

Reuse potential

The dataset is potentially interesting for the field of basic neuroscience, cognitive psychology, and healthcare science or for other researchers who are interested in placebo research and in cognitive placebo effects. The data can also be used for comparing the pure placebo effects we observed with the effectiveness of real interventions

(e.g., a real tDCS stimulation or a pharmacological intervention), thus allowing for a better evaluation of their effectiveness. Furthermore, the data can be used as a basis for model-development on the bases of a carefully executed, classical reinforcement task that also allows estimating within-subject variability (due to the three repeated measures we conducted). Another area in which the data can be usefully applied is for meta-analytic purposes and, finally, it can be used for teaching purposes as it provides a multi-faceted dataset that allows exemplifying man advanced analysis and modeling techniques.

Acknowledgements

We thank Dr. Caspar Stephani for the neurological examinations of our volunteers and Christine Crozier for proof-reading our manuscript.

Competing Interests

The authors have no competing interests to declare.

Author Contribution

1. Conceptualization, methodology, project administration, software (experimental paradigm), supervision, data curation, visualization, funding acquisition, writing.
2. Data collection, writing.
3. Resources, funding acquisition, writing.
4. Supervision, project administration, writing.
5. Software (data analysis), supervision, formal analysis, visualization, data curation, writing.

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How to cite this article: Turi, Z, Schäfer, S A, Antal, A, Paulus, W and Mittner, M 2018 Data from 'Placebo Enhances Reward Learning in Healthy Individuals'. *Journal of Open Psychology Data,* 6: 2, DOI: https://doi.org/10.5334/jopd.34

Published: 20 April 2018

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