Study Information

Title

Is there a compatibility effect between physical stimulus size and spatial left-right handed responses?

Authors

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Description

The processing of cognitive tasks based on somatosensory inputs and motor-sensory outputs is a deeply investigated field of study in the cognitive sciences. Former research proposes “A theory of magnitude” (ATOM, Walsh, 2003, 2015). The theory assumes that the brain uses a generalized magnitude-processing system where the perception of space, time and quantity overlap and interact on an intermediate level of processing antecedent to the response-selection stage. This means that specific properties of the three branches space, time and quantity share a certain representational system. ATOM is therefore regarded as a *shared-representations account*.
For example, it is well accepted that numbers can be represented spatially from left to right (see “SNARC” effect; Dehaene, Dupoux and Mehler, 1990, Dehaene et al. 1993).

In this study we replicate the original paper “Compatibility between Physical Stimulus Size and Left-right Responses: Small is Left and Large is Right” by Wühr and Seegelke (2018). Since in the past the focus of research regarding the ATOM framework lay on interactions of number and size and number and space (see above) but not on the relation between size and space, we here look at how differences in reaction times could support the idea of a horizontal response location representation of stimulus size. Our task at hand is a classic stimulus – response compatibility task where the participant responds to a single stimulus in each trial, the compatible mapping condition being a left handed response for small stimuli and a right handed response for large stimuli; *vice versa* being the incompatible mapping condition. We then investigate whether the stimulus size – response location compatibility effect only occurs for right-hand or also for left-hand responses, as previous research, for example Ren et al. (2011) and Wühr and Seegelke (2018) already found a larger compatibility effect for right-hand responses than for left-hand responses. The study’s results can then be of further assistance for neuroscientific studies, expanding the theory of a shared-representation account, like ATOM.

Hypotheses

To check whether the theory of a compatibility effect in reaction times is profound, the study addresses two hypotheses.
First of all, there is a direct compatibility effect on reaction times, which will be faster in the compatible mapping condition than in the incompatible mapping condition. Secondly, the stimulus size - response location compatibility effect is more pronounced for the right-hand than for the left-hand responses. This means that the difference in reaction times between compatible and incompatible mapping conditions is larger for right-hand responses than for left-hand responses.
To investigate both hypotheses, the below mentioned statistical ANOVA model uses the null hypothesis of no difference between the compared groups - the groups being compatible and incompatible mapping conditions for the first hypothesis and the differences in reaction times between both mapping conditions for right- as well as left-hand responses for the second hypothesis. The null hypothesis will then be rejected if a significant main effect (p-value < 0.05) can be found and we consequently accept the alternative hypothesis.

Design Plan

Study type

Experiment - A researcher randomly assigns treatments to study subjects, this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

Blinding

No blinding is involved in this study.

Study design

The study is a 2x2 factorial within-subjects design. The independent variables at hand are the compatibility mapping, being either compatible or incompatible and the response, being either made with the left or right hand. The measured variable will be the reaction time.
To control for order effects, the compatibility mapping condition is counterbalanced across participants.

Conduction and stimuli. The experiment will be implemented via the _magpie (“Minimal Architecture for the Generation of Portable Interactive Experiments”, Illieva, Xiang, Rautenstrauch, Franke) framework and executed solely online. That consequently means that the recording of reaction times might slightly differ because of participants’ differing hardware properties. Antecedent to the main study, there will be a pilot study including about 3-5 participants. The main study will then try to at least reach the original paper’s number of participants (24 participants), but the goal will be to gather as much data from as many participants as possible. Only right-handed people can take part in the study. We will only use

the data from the main study for our analyses, as the pilot study only serves to further improve the experiment's implementation and to figure out the exact analysis methods to use for the main study.

A small black colored "X" sign as a fixation point, a small and a large black colored square will serve as stimuli. While the small one is supposed to be 2x2cm and the big one 4x4cm, in practice we focus on the proportion of these two, as the experiment is conducted as an online experiment, which may cause the squares to differ in actual size on the participant's screen. All stimuli are presented at screen center appearing on a white background and the participants respond by pressing either the left "f" key or the right "j" key. The participant's task is then in each trial to respond with the corresponding key when the stimulus appears. This means that the participant has to press the left "f" key for a small stimulus and the right "j" key for a large stimulus in each trial in the compatible mapping condition and *vice versa* in the incompatible mapping condition.

Procedure. The experiment consists of six parts:

1. introduction & instructions
2. practice phase first mapping condition
3. main phase first mapping condition
4. practice phase second mapping condition
5. main phase second mapping condition
6. post-experiment questionnaire

At the beginning, the participants are shortly informed about the general background of the experiment and also receive written instructions about the task at hand. The instructions emphasize that the participants should strive to optimize speed and accuracy. The instructions are followed by a practice phase (10 trials) as well as the main test phase (60 trials) for the first mapping condition. Afterwards, there is a practice phase (20 trials) and main test phase (60 trials) for the second mapping condition. While in the experimental main trials correct responses are not indicated for the participant, there is a short indication of correctness in the practice trials. We only use the data of the main trials for our data analysis.

Each experimental main trial starts with the presentation of the fixation point for 1000ms, followed by the stimulus presented until a key is pressed. Correct responses are followed by a blank screen for 1500ms, for incorrect responses an error screen is shortly presented, followed by a blank screen for 1500ms. The amount of small and large stimuli appearing is balanced within each training and test block. Since the experiment is conducted with a *repeated measures design*, the order of compatibility mapping conditions is *counterbalanced* across participants to control for order effects.

At the end of the experiment, participants are presented with a survey kindly asking them to provide socio-demographic information as well as their handedness. There is also space for further remarks.

Randomization

The experiment consists of two blocks, one in the compatible mapping condition and one in the incompatible mapping condition, the order of which will be counterbalanced across participants. The first block will contain a training block with 10 trials and a test block with 60 trials, the second will contain a training block with 20 trials and a test block with 60 trials. The order of experimental trials, i.e. the stimulus size being either small or large, within every training and test block is randomized *ad hoc* for each participant. Furthermore, the number of small and large stimuli appearing in a block is balanced.

Sampling Plan

Existing data

Registration prior to creation of data: As of the date of submission of this research plan for preregistration, the data have not yet been collected, created, or realized.

Data collection procedures

Participants will be recruited through direct email contact and social media. Participation will be voluntary and participants will not be compensated in any way. There are no constraints on the recruitment of participants.

Sample size

We will try to get at least 24 participants but will recruit as many as we can.

Sample size rationale

Since the sample size in the original study we are trying to replicate was 24 we will try to get at least that amount. Since we have no means of compensating our participants we can not guarantee that we will successfully recruit 24 participants and will work with whatever amount we are able to get.

Stopping rule

Because the deadline for the submission of our experiment is on the 1st of August, we will recruit participants until the 29th of July and then stop.

Variables

Manipulated variables

The two variables manipulated in the experiment are the response location, being the left- or right handed response and the compatibility mapping condition, where the compatible mapping condition corresponds to the left handed response to a small stimulus and the right handed response to a large stimulus and *vice versa* for the incompatible mapping condition.

Measured variables

We measure the (continuous and metric) reaction time of each participant by recording the participant's response in milliseconds between the appearance of the stimulus and the corresponding key press.

Analysis Plan

Statistical models

We perform hypotheses-following confirmatory analyses, using a two-way repeated measures ANOVA with the manipulated independent factor variables S-R mapping (compatible and incompatible) and the response location (left and right) to investigate the main effect of the mapping condition. We also added the interaction between both factors to further investigate a potential mapping effect between left and right-handed responses. The predicted response variable is "RT" (reaction time). Beforehand, we also specified a two-way ANOVA model without the interaction between both independent variables, as well as a one-way ANOVA model that predicts RT based on the mapping condition only. We then compared the models' explanatory power by looking at their respective residuals and also by using "Akaike's Information Criterion" to choose the best-fitting model for our purposes - the ANOVA interaction model.
Our analysis uses the statistical programming language R and relies on the "Analysis of variance model" function for the realization of ANOVA as well as the TukeyHSD function for investigation of the direction of the main and mapping effect.
The attached "pilot_analysis.Rmd" file contains the analysis script for the pilot study.

- **pilot_analysis.Rmd**

Inference criteria

As we use a frequentist approach with the ANOVA model, p-values are the statistics of interest that give us information about the significance of a main effect (hypothesis 1) and mapping effect (hypothesis 2). Standard p-values with $p < 0.05$ will tell us whether the results are significantly different from those expected if the null hypothesis were true. Furthermore, we use “Tukey’s Honestly Significant Difference” post-hoc test to check for directions of main effect and mapping effect in hypothesis 1 and 2. The mean differences as well as the standard deviations for compatible and incompatible trials can be found in the analysis script (see above).

Data exclusion

Since in the original paper, the experiment took about 15 minutes, we exclude every participant that completes the whole experiment in less than 5 minutes. Furthermore, trials with a reaction time below 100 milliseconds or above 1500 milliseconds are discarded, just like in the original paper. Furthermore, only data contributions from right-handers are taken into account, to go along the lines of the second hypothesis.

Missing data

If there is only partial data for a participant, we will not use this data for our analysis in order to maintain effectiveness of the counterbalancing procedure.