

Preregistration Report for Conceptual Replication of Experiment 1 by Wühr and Seegelke (2018)

[Study Information](#)

[Design Plan](#)

[Sampling Plan](#)

[Variables](#)

[Analysis Plan](#)

[Other](#)

Study Information

1. Title

Conceptual Replication of Experiment 1 by Wühr and Seegelke (2018)

2. Authors

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3. Description

The study is a conceptual replication of an experiment 1 from Wühr and Seegelke (2018) "Compatibility between Physical Stimulus Size and Left-right Responses: Small is Left and Large is Right". We investigate stimulus-size-horizontal-response mapping compatibility effects by means of an online experiment. For example, Wühr and Seegelke(2018) found that participants in their experiment 1 were faster to respond to a large stimulus object with a key that is on the right of the keyboard (e.g. "Backspace", pressed with the right hand), than with a key that is on the left of the keyboard (e.g. "Tabulator", pressed with the left hand). For small stimulus objects, they found that reaction times were numerically faster for left-hand responses than for right-hand responses. The background of this study is "A theory of magnitude" (ATOM), which was proposed by Walsh (2003). The theory basically claims that there exist certain relations between the cortical representations of "time, space and quantity". Many studies reported evidence for this theory in the form of compatibility effects between numerical size and horizontal response location (Dehaene et. al., 1990), size-congruity effects between numerical size and physical size (e.g., Henrik & Tzelgov, 1982) and compatibility effects of stimulus size and horizontal response location (Ren et al., 2013, in 2018 extended by Wühr and Seegelke).

4. Hypotheses

- (1) Response times for right-hand responses are faster to the larger stimulus than to the smaller stimulus.

- (2) Response times for left-hand responses are faster to the smaller stimulus than to the larger stimulus.
- (3) The stimulus size – response location compatibility effect is larger for right-hand responses than for left-hand responses. This means, the difference in response times for right-hand responses to be faster to the larger stimulus than to the smaller stimulus is larger than the difference in response times for left-hand responses to be faster to the smaller stimulus than to the larger stimulus.

Hypotheses (1)-(3) will be tested for left- and right-handed participants separately. Additionally, we will test the following hypotheses for left-handed participants, to investigate whether we can find a compatibility effect in opposite direction for left-handed people (opposing to Hypotheses (1)-(3)):

- (4) Response times for left-hand responses are faster to the larger stimulus than to the smaller stimulus.
- (5) Response times for right-hand responses are faster to the smaller stimulus than to the larger stimulus.
- (6) The stimulus size – response location compatibility effect is larger for left-hand responses than for right-hand responses. This means, the difference in response times for left-hand responses to be faster to the larger stimulus than to the smaller stimulus is larger than the difference in response times for right-hand responses to be faster to the smaller stimulus than to the larger stimulus.

Finally, we will compare the size of possible compatibility effects regarding people's handedness under the following hypothesis:

- (7) The stimulus size- response location compatibility effect is not equally large for left- and right-handed people. I.e., the absolute difference between response times in the compatible condition and response times in the incompatible condition is not similar for right-handed and left-handed people.

Design Plan

5. **Study type**

Online experiment

6. **Blinding**

(There is no explicit blinding involved in this study.) The relevant experimental manipulation of the dependent variable (i.e. the stimulus-response mapping) happens within-participants. Participants are neither informed about the purpose of their tasks in the experiment nor about the research hypotheses, but they are only presented with

relevant information containing practical instructions on their task. This implies, that participants are informed about the change of stimulus-response mapping, since this is relevant for their task. However, they are not provided with any explanation for this change. The experiment is conducted via the internet. No direct contact between experimenters and participants will take place.

7. **Is there any additional blinding in this study?**

No

8. **Study design**

The experiment uses a within-subject design with one factor: stimulus-response mapping. The factor has two levels: the compatible condition (small stimulus=left-hand response and large stimulus=right-hand response), and incompatible condition (small stimulus = right-hand response and large stimulus = left-hand response). Our study consists of two main experimental blocks and one intermediate (non-experimental/ distraction) block. In the experimental blocks, which are further divided into training trials and experimental trials, a simple black square will be presented in each trial. This black square is either small (3*3 cm) or large (6*6 cm). The participants have to decide via a keypress (either “q” or “p”) whether the square is small or large. In the compatible condition they have to press the “q” key with their left hand (index finger) when they see a small square and press the “p” key with their right hand (index finger) when they see a large square. In the incompatible condition, participants have to press the “q” key with their left hand (index finger) when they see a large square and press the “p” key with their right hand (index finger) when they see a small square. Both S-R mappings will be presented to the participants, the order, whether the compatible S-R mapping will be shown first or the incompatible mapping, will be decided randomly. The intermediate distraction task block is intended to distract participants from the initial S-R mapping and to limit training effects. The stimulus object in this block is either a simple black circle or a simple black triangle. The participants have to select with a mouse click one of two decision fields under the stimulus (decision whether they see a circle or triangle). Further information on the detailed design, materials and procedure can be found in the attached document "Design for Conceptual Replication of Experiment 1 by Wühr and Seegelke (2018)".

9. **Randomization**

We will randomize the order in which each participant completes the experimental trial blocks by randomly choosing the initial S-R mapping condition for the first training and main block. The S-R Mapping-condition of the following individual experimental trial blocks is determined by the (randomly chosen) initial S-R mapping (see the attached design document.), such that each participant completes in total the same number of trials for each of the two mapping conditions (factor levels). The training and main experimental blocks each contain a fixed number of trials, in which one of the two

stimulus items (namely large or small square) is presented. Within the trials of a block, the number of instances of the two stimulus items which are shown is equal for the two stimulus types. All participants thus see the same number of instances of either of the two stimulus types within each block. The order in which these instances are presented is determined randomly and ad hoc, thus the sequence of small and large stimuli might also vary (randomly) between-participants.

Sampling Plan

10. **Existing data**

Registration prior to creation of data: The data have not yet been created, since the experiment was not yet conducted. Data from the previous study (N=24) by Wühr and Seegelke (2018) was available and guided the specification of statistical models. This data is not included in the final analysis. No data from the experiment to be preregistered here was available at the time of preregistration.

11. **Explanation of existing data**

We are aware of the effect found in the original study and have reanalyzed the data created by this study. We will use in our eyes more fitting analyses on our collected data to test for the same hypotheses as in the original paper.

12. **Data collection procedures**

Participation is voluntary and will not be compensated. Participants are advised to take part only once, however, we did not control for this. After having sent the initial invitations through social media and email, we will wait until 3rd August, 11:59 pm before closing data collection.

By following the link to the experiment, participants declared to have normal or corrected-to-normal visual acuity and should be naive with respect to the purpose of the study. Participation is voluntary and not rewarded with material things or money but the experimenters' deep gratitude.

13. **Sample size**

We are aiming to recruit as many participants as possible.

14. **Sample size rationale**

Since we have limited time for our project (project deadline) we cannot give a precise minimum number of participants to draft.

15. **Stopping rule**

We will stop collecting data on the 3rd of August at 11:59pm.

Variables

16. **Manipulated variables**

We manipulate the stimulus-response mapping: Either the response for a small stimulus is a left key (q) and the response for a large stimulus is a right key (p) or vice versa. We label the former (left=small, right=large) as the "compatible" and the latter (left=large, right=small) as the "incompatible" mapping condition.

17. **Measured variables**

The response of the participant to a given stimulus will be recorded (either left key or right key) as well as the reaction time it took them from being shown the stimulus to them pressing the key (in ms).

18. **Indices**

We are not going to use any indices.

Analysis Plan

19. **Statistical models**

We will use a Bayesian regression model to analyze the influence of the factors S-R Mapping and Response separately on the (log-)Reaction Time as well as the interaction effect of S-R Mapping and Response on (log-)Reaction Time. We additionally accounted for group level variation between participants by adding random effects, namely random intercepts and slopes for the factor Response.

We will use the R package 'brms'. Our model is defined by the formula:

$$\log RT \sim \text{Mapping} * \text{Response} + (\text{Response} || \text{Participant})$$

Every other parameter of the model remains on the default setting, namely the family is set to Gaussian and we assume flat priors. The model will run on the preprocessed data as described in section 22. data exclusion. The exact analysis can be found in the attached script.

The independent, manipulated variable is the S-R Mapping with levels compatible and incompatible, the further independent variable Response with levels left and right. These factors were encoded using the default dummy/treatment coding with the group level combination "compatible" and "left" as the reference level. The dependent variable is the (log-)Reaction Time.

20. **Transformations**

We will log-transform the Reaction Time: $\log RT = \log(RT)$.

We need to do this because Reaction Time measurements are typically assumed to be log-normally distributed and our regression model expects normally distributed data.

21. **Inference criteria**

We will use the 'hypothesis' function from the 'brms' package and test our hypotheses with the posterior samples provided by our previously defined Bayesian regression model. This yields us a Bayes factor for each hypothesis (provided by the Evidence Ratio of the function output), which we compare to the interpretation table as suggested by Harold Jeffreys. Since this is a replication study, we picked a high threshold of 25. If the Bayes factor lies below this threshold we will reject the respective hypothesis, otherwise we will fail to reject it.

22. **Data exclusion**

First, we will only use data from the experimental trials, i.e. exclude the data collected during test trials. Second, we will exclude Reaction Times faster than 100ms or slower than 1500ms.

23. **Missing data**

If less than 10 trials were recorded incorrectly for a participant, e.g due to technical issues, we will use the remaining intact data from that participant. Otherwise we will discard all data from that participant.

24. **Exploratory analysis**

We plan on also including left-handed participants in our experiment and are interested in the following questions:

1. Does the interaction effect between Mapping and Response effect left-handed participants' Reaction Time in the same manner as those of right-handed participants?

Other

25. **Other**

Wühr, P., & Seegelke, C. (2018). Compatibility between Physical Stimulus Size and Left-right Responses: Small is Left and Large is Right. *Journal of Cognition*, 1(1), 17. doi:10.5334/joc.19