

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

Background

ATOM ("A theory of magnitude") is a theory proposed by Walsh(2003) about relations of "cortical metrics of time, space and quantity". This might also have implications on experimental research investigating stimulus-response tendencies comprising different numerical, temporal or spatial properties.

Many studies have investigated different aspects and proposals of this theory. For example Dehaene et al.(1990) found compatibility effects between numerical size and horizontal response location, which Dehaene et al.(1993) later coined as "Spatial-Numerical Association of Response Codes" (SNARC) effect, which is interpreted as a spatial mapping of numbers to horizontal locations.

In 2013, Ren et al. have furthermore analogously investigated the relationship between physical stimulus size and horizontal response location. Their results show similar compatibility effects of stimulus size and horizontal response location, but only for right hand responses. In 2018, Wühr and Seegelke attempted a conceptual replication and extension of this study. They claim that their results indicate the existence of a general magnitude code, as proposed in ATOM in that we might intrinsically associate small objects with the left side and large objects with the right. We will here aim to assess these findings via a conceptual replication of the first experiment from Wühr and Seegelke(2018).

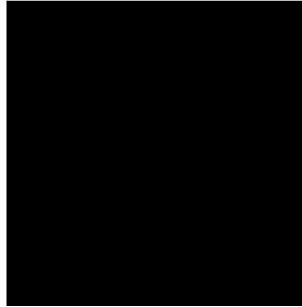
In the experiment, subjects are presented with "small" or "large" stimulus objects and are required to judge their size as "small" or "large". The keys for subjects to communicate these judgements are mapped to either left- or right-handed responses and these mappings are switched once within the experiment. Wühr and Seegelke(2018) found, that participants 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 right hand). For small stimulus objects, they found that reaction times were numerically faster for left-hand responses than for right-hand responses.

For each the two stimulus types ("small" vs. "large") used in the experiment, example stimulus objects are shown below.

(a)



(b)



Physical stimulus size - spatial response location - compatibility: - Is this object small or large?

For participants to judge whether the stimulus is a small or large object, ATOM would propose that subjects need to mentally activate an internal representation of size and the corresponding spatial response mapping in order to generate an action as response according to their judgement about stimulus size, and that these representations are linked. Ren et al. (2011), and Wühr and Seegelke (2018) showed that stimulus size and horizontal response location indeed exhibit compatibility effects, which can be regarded as evidence for this sub-aspect of ATOM. They found that the horizontal response mapping (key press with either left or right hand) to judgements about stimuli of different size influences response behavior and matters for success and swiftness of judgements of 'small' or 'large' stimulus objects.

Hypotheses

We are here concerned with some specific predictions from previous experimental research by Wühr and Seegelke(2018), namely that small stimuli are associated with left responses, whereas large stimuli are associated with right responses in right-handed people. This stimulus size - response location compatibility effect is claimed to extend proposals of ATOM. In particular, we are going to address the following **research hypotheses**, which we will separately test for right- and, in extension of the original experiment, left-handed people:

1. Response times for right-hand responses are faster to the larger stimulus than to the smaller stimulus.
2. 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.

Design

Participants. Participants are recruited via [whatever media we will use to spread the link to the experiment]. 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.]

Materials. We will use information about the stimulus objects (i.e. information about how they are to be displayed concerning their form, size and position on the display) as provided by Wühr and Seegelke. In each trial, a visual stimulus object is presented in the center of the screen with gray background. A stimulus object is a simple black square, which is either small (2*2 cm) or large (4*4 cm). The 2 different types of stimulus objects are used for training trials and main trials. Pictures of the stimulus objects are shown above.

Procedure. The experiment consists of four parts:

- (i) introduction & instructions for the first stimulus-response(S-R) mapping
- (ii) training trial phase for first S-R mapping (10 trials)
- (iii) main experimental trial phase for first S-R mapping (2 stimuli × 30 repetitions = 60 trials)
- (iv) instructions for the second S-R mapping
- (v) training trial phase for second S-R mapping (20 trials)
- (vi) main experimental trial phase for second S-R mapping (2 stimuli × 30 repetitions = 60 trials)
- (vii) post-experiment questionnaire

First, participants are welcomed to the experiment and shown written instructions about the task. Instructions include a description of the task, i.e. information about the sequence of events in a trial (fixation - stimulus presentation - key press given an S-R mapping) and the estimated duration of the experiment (15 minutes according to Wühr and Seegelke(2018)). Instructions emphasize that participants should strive to optimize speed and accuracy (this is not mentioned in the original paper but seems appropriate in this context, since a time-out occurs and an error message will be presented when participants' RT exceeds a period of 2000 ms).

Participants then perform a training block (10 trials) and an experimental block with the first S-R mapping(2 stimuli × 30 repetitions) followed by a training block (20 trials) and an experimental block with the second S-R mapping(2 stimuli × 30 repetitions). With the start of a new block, participants are given information about which keys to press for "small" or "large" stimuli (corresponding to the respective S-R mapping) and information on whether the next block belongs to training or main experimental phase.

The order of S-R mapping conditions for the first and second training and main trial phases (first = compatible – second = incompatible or first = incompatible – second = compatible) is determined experiment initially, uniformly at random once for each participant.

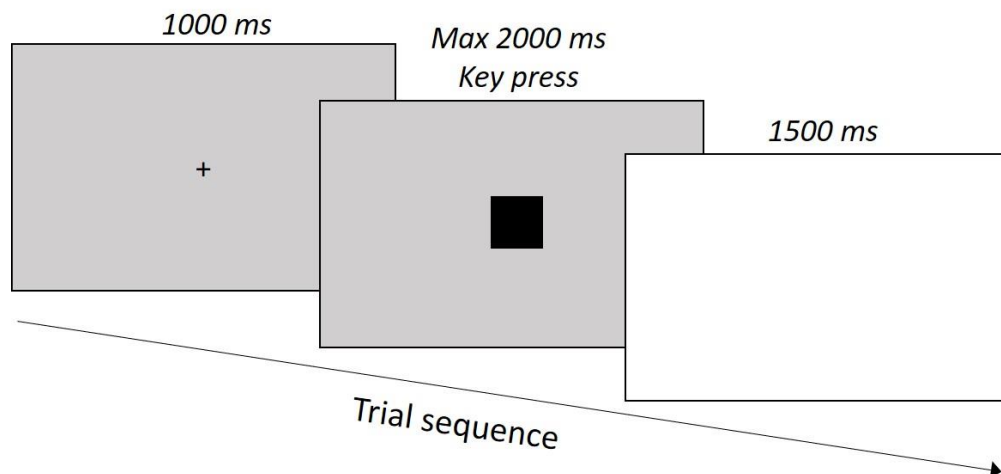
During the training phases participants will get accustomed to the task, specifically to the respective S-R mapping, by completing the given amount of practice trials (2 stimuli \times 5 repetitions = 10 trials for the first S-R mapping, 2 stimuli \times 10 repetitions = 20 trials for the second S-R mapping).

Each main experimental block contains 60 trials in random order (2 stimuli \times 30 repetitions). The order in which individual trials are presented in the training and experimental phases is determined uniformly at random and on the fly for each participant.

Participants can take a rest between blocks and start the next block at leisure.

Experimental trials within the training and main (test) phases are structured as follows (see also picture below):

- Each trial starts with the presentation of a fixation point (a small plus sign in Courier font, font size 18) for 1000 ms in the center of the screen.
- Afterwards, one of the two stimulus objects is displayed until a keypress occurs. Participants respond by pressing the left “q” key or the right “p” key on their keyboard. We do not take the original experiment’s mapping here, because we thought that, on a standard keyboard, these keys (“q” and “p”) would be more convenient to use and are positioned in the same horizontal line of keys, whereas this is not true for tab and backspace key. In the compatible mapping condition, the small stimulus required a response with the left (“q”) key, whereas the large stimulus required a response with the right (“p”) key. The mapping is reversed in the incompatible mapping condition.
Participants should operate the left key with the index finger of their left hand and the right key with the index finger of their right hand.
- A correct response with an RT below 2000 ms is followed by a blank screen for 1500 ms. If a wrong key or no key is pressed within the maximum response period of 2000 ms, a corresponding error message is shown for 1500 ms in black color (Courier font, font size 24).



Finally, the experiment terminates with a post-experiment survey asking participants for their preferred hand (left or right) and to optionally supply socio-demographic information and comments.

Alternative suggestions for the experiment's procedure (sequence of parts). In the above description, we tried to construct a design resembling the original experiment as closely as possible. However, we find the sequence of trials or experimental box questionable, as there are no obvious reasons stated why the experiment is divided into two big blocks and why the number of training trials is different for the first and second S-R mapping condition. Therefore, we have some alternative design suggestions listed below, which we thought might address these problems and thereby increase the validity of this conceptual replication compared to the original experiment. Since we found no consent on which design we should finally employ, we would be happy to get some feedback on these options, or criteria which could guide our decision.

- (1) Include an intermediate block of a distracting task trials (e.g. 20 in total), which differ from the "real" experimental trials only in the participant's task, but the rest of the trial sequence remains the same (fixation cross, stimulus presentation (e.g. either a circle or a triangle is presented in the center of the screen), task (e.g. classify the presented stimulus as a circle or triangle), response (here we again have two quite different proposals on how the participant should respond, see (a) and (b), below) or timeout after 2000 ms, white screen (with error message if timeout occurred)). We would employ this after the first main block (without RT measurement), so that participants might be distracted from the original stimulus-response key mapping. Thereby, we hope to limit training effects regarding the key-mapping. This might allow for halving the number of training trials before the second main experimental block (from 20 to 10 trials), so that there are equally many training trials for the first and second mapping condition.
 - a. key press response using the same keys as in the experimental tasks (e.g. press "q" for circle and "p" for triangle)
 - b. mouse click task (click on the respective button for "circle" or "triangle" on the screen)
- (i) introduction & instructions for the first S-R mapping
- (ii) training trial phase for first S-R mapping (10 trials)
- (iii) main experimental trial phase for first S-R mapping (2 stimuli \times 30 repetitions = 60 trials)
- (iv) instructions for the intermediate distracting task
- (v) intermediate distracting trial phase (e.g. 2 stimuli \times 20 repetitions = 40 trials)
- (vi) instructions for second S-R mapping
- (vii) training trial phase for second S-R mapping (10 trials)
- (viii) main experimental trial phase for second S-R mapping (2 stimuli \times 30 repetitions = 60 trials)
- (iv) post-experiment questionnaire
- (2) Split the two big blocks (including training and main trials for the two mapping conditions) up into four blocks, where mappings are reversed between blocks. We hope that by shortening the blocks for the two different response mapping conditions, training effects might be small, thus we uniformly put 15 training trials (average number of training trials in the original experiment) before each main experimental block:
 - (i) introduction & instructions for first S-R mapping
 - (ii) training trial phase for first S-R mapping (15 trials)
 - (iii) main experimental trial phase for first S-R mapping (2 stimuli \times 15 repetitions = 30 trials)

- (iv) instructions for second S-R mapping
 - (v) training trial phase for second S-R mapping (15 trials)
 - (vi) main experimental trial phase for second S-R mapping (2 stimuli × 15 repetitions = 30 trials)
 - (vii) instructions for first S-R mapping
 - (viii) training trial phase for first stimulus-response(S-R) mapping (15 trials)
 - (iv) main experimental trial phase for first S-R mapping (2 stimuli × 15 repetitions = 30 trials)
 - (v) instructions for second S-R mapping
 - (vi) training trial phase for second S-R mapping (15 trials)
 - (vii) main experimental trial phase for second S-R mapping (2 stimuli × 15 repetitions = 30 trials)
 - (viii) post-experiment questionnaire
 - We acknowledge that this (latter alternative) might pose quite high cognitive demands on participants due to the multiple switching of key mappings, and that this might increase dropout rates.
- (3) Alteration of (2): Have 3 main blocks, complete half the trials of the first S-R mapping block, switch to second S-R mapping, complete 15 training and all 60 main trials, switch back to first S-R mapping, complete second half of trials:
- (i) introduction & instructions for first S-R mapping
 - (ii) training trial phase for first S-R mapping (15 trials)
 - (iii) main experimental trial phase for first S-R mapping (2 stimuli × 15 repetitions = 30 trials)
 - (iv) instructions for second S-R mapping
 - (v) training trial phase for second S-R mapping (15 trials)
 - (vi) main experimental trial phase for second S-R mapping (2 stimuli × 30 repetitions = 60 trials)
 - (vii) instructions for first S-R mapping
 - (viii) training trial phase for first stimulus-response(S-R) mapping (15 trials)
 - (iv) main experimental trial phase for first S-R mapping (2 stimuli × 15 repetitions = 30 trials)
 - (v) post-experiment questionnaire
 - We thought this might be better in terms of balancing fatigue effects for the first and second S-R mapping condition.

References:

- Dehaene, S., Bossini, S., & Giraux, P. (1993).** The mental representation of parity and number magnitude. *Journal of Experimental Psychology: General*, 122, 371–396. DOI: <https://doi.org/10.1037/0096-3445.122.3.371>
- Dehaene, S., Dupoux, E., & Mehler, J. (1990).** Is numerical comparison digital? Analogical and symbolic effects in two-digit number comparison. *Journal of Experimental Psychology: Human Perception and Performance*, 16, 626–641. DOI: <https://doi.org/10.1037/0096-1523.16.3.626>
- Ren, P., Nicholls, M. R., Ma, Y., & Chen, L. (2011).** Size matters: Non-numerical magnitude affects the spatial coding of response. *Plos ONE*, 6. DOI: <https://doi.org/10.1371/journal.pone.0023553>
- Walsh, V. (2003).** A theory of magnitude: Common cortical metrics of time, space and quantity. *Trends In Cognitive Sciences*, 7, 483–488. DOI: <https://doi.org/10.1016/j.tics.2003.09.002>
- Wühr, P., and 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, pp. 1–11, DOI: <https://doi.org/10.5334/joc.19>