Chapter: boundaryVR

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# Introduction

As we experience the world through a continuous stream of sensory input, our brains are constantly trying to predict what comes next. Prediction errors (PE) can result in “event boundaries”, which segment our memories for our experiences (add quotes). Walking into a new room is thought to trigger such a boundary, as evidenced by better temporal order memory for objects within the same room than for objects in different rooms, e.g. in a virtual environment (Horner et al., 2016). However, walking between rooms also typically results in large perceptual changes (PC). Here I report an experiment that was designed to tease apart the contributions of PE and PC to the formation of event boundaries.

I designed an “M-room” for virtual environments (add FIGURE). When traversing such a room, the viewer can only see one half of the room until they reach the middle section. This enables independent manipulation of PE and PC: PC can be induced by changing the wall colours between the two halves of the room, and PE can be induced by presenting a cue indicating the colour of the second half, which is then violated.

The first step in this study was a pilot study to verify that crossing to the second half of the room in the M-room in the absence of PC or PE does not constitute a boundary. To test this, we examined whether the superior temporal order memory for objects within the same room is similar in M-rooms and the “O-rooms” used in Horner et al. (2016). For that, participants encountered 88 objects in a series of virtual rooms.

In three experiments, I describe how I failed to replicate the boundary effect on memory (i.e. within > across) while successively removing possible confounds.

# Experiment 1

## Method

### Participant pool

In all experiments, we recruited participants from the website <https://www.prolific.co/>.

### Procedure

Participants first saw a video of another camera navigating through a series of rooms. Note that Horner et al. (2016), participants navigated through the virtual environment themselves. After watching the video, participants completed a memory task (see below for details).

### Virtual environment and stimuli

The rooms were build with SketchUp (<https://www.sketchup.com>) and then imported into unity3d (<https://unity.com/>). 88 everyday objects were downloaded (e.g. guitar, toys, household items etc.) from archive3d (<https://archive3d.net/>) and edited them either in blender (<https://www.blender.org/>) or in unity3d itself. I tried to find as many 3D versions of objects as possible that were also used in Horner et al. (2016). The object sizes were kept to be scaled realistically to the other feature of the environment.

In contrast to Horner et al., the layouts of all rooms of the same type were always identical including the positions of the tables differing only in wall colour and floor material (wood or carpet textures).

In Experiment 1, M-room and O-room alternated so that each participant saw the both types of rooms. Four videos were created where the order of the objects presented was always the same (i.e. the pencils were always presented as the first object).

Video 1 and 2 two objects were presented in the first room. The first object-object sequence was hence within-boundaries. Video 3 and 4 showed only one object in the first room. The next object was therefore presented across a spatial boundary (i.e. door). The first room in video 1 and 3 was M-shaped, while the first room in video 2 and 4 was an open plane room. The reason for this was to create four counter-balancing conditions that control for the sequences of the boundary conditions (within vs. across) and which room began the series.

Like the order of the objects, the wall colours and floor materials of the rooms were constant across the videos. The only exception to this rule was that video 3 and 4 featured 45 rooms to presented all objects. The number of wall colours (blue, brown, green, grey, orange, pink, purple, red, turquoise and yellow) and floor materials (5 different carpets and 5 different wood floors) allowed us to construct 45 unique rooms.

Both types of rooms contained three tables, however only two were used in the experiments discussed here. The first table in the room as added for future version of the experiment that I never ran. All of tables had a cardboard box placed on top of it. If the camera approached two of the tables (see labels 1 and 2 in figure above), the cardboard boxes disappeared.

While watching the video, participants in this tasks were required to judge whether an object was smaller or bigger than a reference as soon as the object appeared. In this and all subsequent versions of the Experiment the object was visible for 3 seconds. After the 3 seconds, the object disappeared and the cardboard box that was covering the object re-appeared. This controlled the time during which the object could be seen by the participant.

### Batch 1

#### Description of memory task

To asses the boundary effect, I showed participants a cue object with three images under it one of which was the target object and the other two were foils. The question the participants had to answer was “What came before this object?”.

The foils were +/- 4 positions away from the target object (see Figure). This was done to implement tighter control of the foils than it was done in Horner et al. (2016). This ensured that the two foils were always from the same room type and on the same table as the target.

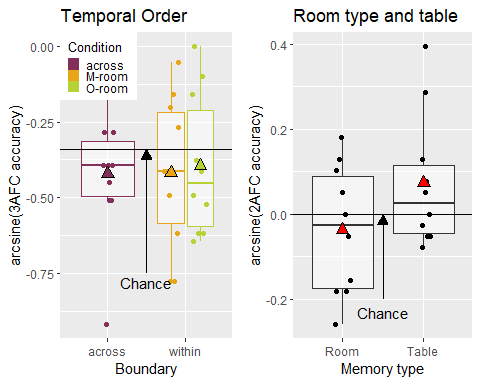
An in-lab pilot experiment has shown that participants could not identify the exact room a particular objects was in based on as still image that showed wall colour and floor texture. This memory question was therefore not used again. However, I asked participants to choose the but room type and table type in a 2AFC task.

#### Sample

In this batch, I collected data of 10 participants.

#### Statistical analysis

#### Results



There is considerable evidence that memory performance was not above chance ( = 6.75) for the temporal memory question. Furthermore, I did not find a boundary effect for M-rooms (across vs. within) for accuracy, = 3.11, and for RT, = 4.06, but I did not find an effect for O-rooms for accuracy, = 2.7, and for RT, = 1.21.

Participants also did not show above chance performance for remembering in which room type a cue object was presented in ( = 5.07). However, there was weak evidence that participants did remember on which table type a cue object was presented ( = 1.29).

#### Discussion

In contrast to my expectations, I did not find boundary effect for either room type. After consultation in a lab meeting, I considered whether the question “What came before this object?” could be interpreted in a way that participants thought that both objects that appeared before the cue object (i.e. the target as well as one of the foils) would be a valid answer.

Another notable concern was that memory performance was not above chance, which might have been another reason why I did not fnd the boundary effect.

### Batch 2

### Batch 3

# Experiment 2

# Experiment 3

# General discussion

## Potential reason for the null effect

There, the rooms were also arranged so that they formed a closed circle, in our experiment the rooms were arranged so that they all laid on a linear track. These are potential factors that could explain differences in the results.