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Replication of "Object Persistence Enhances Spatial Navigation" by Liverence & Scholl (2015, *Psychological Science*)

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Introduction

In their paper "Object Persistence Enhances Spatial Navigation", Liverence & Scholl test their theory that persistent object representation could "serve as underlying units of longer-term memory and active spatial navigation". Liverence & Scholl used a "novel paradigm inspired by the visual interfaces common to many smartphones". In the experiment, the participants used "key presses to navigate through simple visual environment consisting of grids of icons". Liverence & Scholl limited the view of the grid to one object at a time via a static window. The researchers found that participants "found target icons faster when navigation involved persistence cues (via *sliding* animations) than when persistence was disrupted (e.g., via temporally matched *fading* animations)". In addition, the researchers found that the difference between the two transition methods "occurred even after explicit memorization of the relevant information, which demonstrates that object persistence enhances spatial navigation in an automatic and irresistible fashion."

More specifically, three different pairs of animation types were tested to attempt to isolate the specific effects of object persistence and motion. The pairs of animations used by the researchers in the experiments were a) slide vs. fade, b) slide vs. wipe and c). fade then slide vs. slide then fade. A fourth experiment, which tested grid memory, was performed to probe the effects of explicit memory as the experiment went on. This was done as the experimenters found that the participants had essentially memorized the grid by the end of each block of experiments. For the purposes of replication, just the first three experiments will be replicated.

Methods

Planned Sample

The sample size for each of the experiments was 18 individuals. Mean age for participants was just over 19 years old, and performed 50 trials per block. For replication purposes, I intend to decrease the number of trials per block (which partially eliminates the need for the aforementioned fourth experiment).

Materials

Per Liverence and Scholl, "Stimuli were presented (on a CRT monitor subtending 44.6° × 36.3°) using custom software written with MATLAB and the PsychToolbox libraries (Brainard, 1997; Pelli, 1997). Participants sat approximately 50 cm from the display. (All sizes reported are

based on this distance.) Responses were made using the keyboard and mouse."

In contrast to the original experiment, this particular replication will use custom software written in Javascript and HTML. There will not be a standard monitor type or size, and inputs will still be done via keyboard and mouse.

Procedure

Per Liverence & Scholl, the following is the procedure for the first experiment. "The icons were 64 photos of real-world objects (Brady, Konkle, Alvarez, & Oliva, 2008). Sixteen unique icons were used for each of four blocks. Each icon subtended roughly 3.99° (though each had a unique shape) and was presented at the center of the display inside a white square window (presented on a black background) that measured 9.96° on each side and was surrounded by a thin (0.16°) visible border. Participants pressed four keys (for "up," "down," "left," and "right") to navigate through each 4 × 4 virtual environment (Fig. 1a). Upon each key press, the current icon was replaced inside the static window with the new corresponding icon (via a 400-ms animation during which no other key presses were possible). The grid was functionally bounded (e.g., so that a "right" key press had no effect if the current icon was from the right-most virtual column). On slide-transition trials, outgoing and incoming icons moved smoothly in the direction opposite the key press at a rate of 24.57° per second; because successive pages were separated by a center-to-center distance of 9.96°, this entire animation lasted 400 ms. On fade-transition trials, the current icon faded gradually to white over 167 ms; a blank white window was then displayed for 66 ms, and then the new icon gradually faded in from white over 167 ms (for a total of 400 ms). On each trial, four target icons were displayed beneath the window (Fig. 1b), and participants had to locate and click on them in the order in which they were displayed (from left to right). The order and identity of the target icons for each trial were randomly generated once and stored offline, and these trials were then presented in a uniquely randomized order for each participant. After a correct click, a green border (0.24°) appeared around the image of the target icon. Out-of-order (i.e., incorrect) clicks were not registered."

For the second, "This experiment was identical to Experiment 1 except as noted here. Eighteen new participants were tested (4 female; mean age = 19.2 years). The distances between icons in the virtual grid were 13.91°, and icons moved at 33.91° per second during slide-transition animations. During wipe-transition animations (depicted in the left column of Fig. 2b), the outgoing object gradually disappeared (and the incoming object gradually appeared) from one side to the other, as during slide-transition animations (so that moment-by-moment visibility was equated), but without actually moving. For example, a "right" key press caused the outgoing object to disappear as if it were gradually occluded by an invisible wall moving left to right—and after that object disappeared, the incoming object appeared as if it were gradually disoccluded from behind an invisible wall moving left to right."

For the third, "This experiment was identical to Experiment 1 except as noted here. Eighteen new participants were tested (7 female; mean age = 19.4 years). The same 64 photos were reshuffled into four new 4 × 4 grids. Transition animations now lasted 667 ms each. During fade-then-slide animations, an initial delay of 300 ms was followed by a 50-ms phase during which the outgoing icon gradually faded to white, then another 50-ms phase during which the outgoing icon gradually faded back in from white, and finally a 267-ms phase during which the

outgoing icon was replaced by the incoming icon as in the slide-transition animations of Experiments 1 and 2. Slide-then-fade animations began with a 267-ms phase during which the outgoing icon was replaced by itself as in the slide-transition animation of Experiments 1 and 2; following a 300-ms delay, two 50-ms fading animations were presented, this time with the outgoing icon fading away and the incoming icon fading in. To account for the cumulative effect of longer transition times, we reduced the number of trials per block to 40 (for a total of 160 trials)."

Note that differences from the above descriptions include population ages and demographics; in addition some of the measurements (i.e. distances between icons in the grid, speed of icon transition) may be changed in the implementation.

Analysis Plan

The data collected and analyzed during this experiment (at least for the first three experiments) simply involve the participants response times for the task given (traverse the grid in order of the icons given to them). Per Liverence and Scholl, "The initial two trials of each block were not analyzed, as pilot testing suggested that participants typically made an especially large number of key presses during those initial trials (a pattern consistent with subjective reports of a period of free exploration). In addition, trials with response times (RTs) longer than 30 s (0.56% of the remaining trials) were excluded."

Differences from Original Study

There should not be major differences between the original and replicated study. While most of the differences have been mentioned previously, they are restated below.

- **Experiment:** The fourth experiment will no longer be replicated.
- **Sample:** I intend to use a larger number of individuals per trial (ideally 25 or so per experiment as opposed to 18), and a lower number of trials per block (perhaps somewhere near 15 as opposed to 50 in the original experiment).
- **Materials:** As opposed to the Liverence & Scholl experiment, where the actual hardware is standardized, each participant may have slightly different hardware setups. In addition, the testing application will be written in JavaScript and HTML, as opposed to Matlab.
- **Procedure:** Slight differences in several measurements for the display (i.e. distance between icons, etc) may exist in the replicated implementation of the software. Of course, the experiments will also no longer be done in person, but instead via mechanical turk.
- **Analysis:** No changes from original experiment planned.

I do not forsee any differences in results between the original experiment and the replicated experiment. None of the changes have a clear connection with any of the conditions that caused the effects observed by the experimenters.