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## Using a virtual store as a research tool to investigate consumer in-store behavior. --Manuscript Draft--

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| Abstract:                                     | <p>People's responses to products and/or choice environments are crucial to understanding in-store consumer behaviors. Currently, there are various approaches (e.g. survey or laboratory setting) to study in-store behaviors, but the external validity of these is limited by their poor capability to resemble realistic choice environments. In addition, building a real store to meet experimental conditions while controlling for undesirable effects is costly and highly elusive. A virtual store developed by virtual reality techniques potentially transcends these limitations because this offers the simulation of a 3D virtual store environment in a realistic, flexible and cost-efficient way. In particular, a virtual store interactively allows consumers (participants) to experience and interact with objects in a tightly controlled, yet realistic setting. Hence, this paper presents the key elements of using a desktop virtual store to study in-store consumer behavior. Descriptions of the protocol steps to i) build the experimental store, ii) prepare the data management program, iii) run the virtual store experiment, and iv) organize and export data from the data management program, are presented. The virtual store enables participants to navigate through the store, pick a product from alternatives, and select or return the products. Moreover, consumer related shopping behaviors (e.g., shopping time, walking speed, number and type of products examined and of products bought) can also be collected. The protocol is illustrated by example of a store layout experiment showing that shelf length and shelf orientation influence shopping and movement related behaviors. This demonstrates that the use of a virtual store facilitates the study of consumer responses. The virtual store can be especially helpful when examining factors that are costly or difficult to change in real life (e.g., overall store layout), products that are not presently available in the market, and routinized behaviors in familiar environments.</p> |
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| Question   | Response |
|--|----------|
| If this article needs to be "in-press" by a certain date, please indicate the date below and explain in your cover letter. |          |

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February 20, 2017

Dear Dr. Dsouza,

Thank you for the opportunity to further revise our manuscript entitled “Using a virtual supermarket as a research tool to investigate consumer in-store behavior”, JoVE55719.

We have amended the manuscript based on your suggestion. The following revision has been made:

1. The protocol has been improved by combining the short protocol steps to make longer protocol steps with 2-3 actions per step..
2. The numbering and format of our revised protocol have also been adjusted to match JoVE’s instructions for authors.
3. The highlighted protocol has been modified to enable filming.
4. The numerical values of results have been added and the format of these quantitative results has been presented in the text.
5. The blank column in the tables has been removed to avoid confusion.
6. The instruction of the main test has been added as Supplementary 3 and Supplementary 4 to provide an example of the possible task with the virtual store experiment.

In addition to all improvement made according to your suggestion, we have made a separated protocol that can be used to make the video. This suggested protocol rearranges some protocol steps to make a logical flow of the video because some protocol steps in the main test were written in less details than similar steps in the practice test.

We would like to take this opportunity to express our sincere thanks to you and the editorial team for your help and guidance. We hope that the revised manuscript complies with the format of JoVE and the highlighted protocol facilitates the filming plan.

Sincerely yours,

Kunalai Ploydanai, MSc

**TITLE:**

Using a virtual store as a research tool to investigate consumer in-store behavior.

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**KEYWORDS:**

Virtual reality, virtual store, supermarket, consumer, in-store behavior, product choice

**SHORT ABSTRACT:**

This paper describes the use of a desktop virtual store to create virtual shopping environments to investigate in-store consumer behavior. A description of the protocol to build and run experiments, example results from an experiment concerning store layout, and important considerations when conducting virtual store experiments are presented.

## **LONG ABSTRACT:**

People's responses to products and/or choice environments are crucial to understanding in-store consumer behaviors. Currently, there are various approaches (*e.g.*, surveys or laboratory settings) to study in-store behaviors, but the external validity of these is limited by their poor capability to resemble realistic choice environments. In addition, building a real store to meet experimental conditions while controlling for undesirable effects is costly and highly difficult. A virtual store developed by virtual reality techniques potentially transcends these limitations by offering the simulation of a 3D virtual store environment in a realistic, flexible, and cost-efficient way. In particular, a virtual store interactively allows consumers (participants) to experience and interact with objects in a tightly controlled yet realistic setting. This paper presents the key elements of using a desktop virtual store to study in-store consumer behavior. Descriptions of the protocol steps to: 1) build the experimental store, 2) prepare the data management program, 3) run the virtual store experiment, and 4) organize and export data from the data management program are presented. The virtual store enables participants to navigate through the store, choose a product from alternatives, and select or return products. Moreover, consumer-related shopping behaviors (*e.g.*, shopping time, walking speed, and number and type of products examined and bought) can also be collected. The protocol is illustrated with an example of a store layout experiment showing that shelf length and shelf orientation influence shopping- and movement-related behaviors. This demonstrates that the use of a virtual store facilitates the study of consumer responses. The virtual store can be especially helpful when examining factors that are costly or difficult to change in real life (*e.g.*, overall store layout), products that are not presently available in the market, and routinized behaviors in familiar environments.

## **INTRODUCTION:**

It is undeniable that understanding consumers' in-store behavior is of critical importance to achieve effective retail marketing. To aid in this understanding, advanced virtual reality technology, known as the virtual store, can enable studies of consumer behavior using computationally created virtual environments. The virtual-store approach uses a virtual reality system to generate realistic and immersive three-dimensional virtual store environments in which people can interact with the objects in the store. In such virtual store environments, people experience artificially created sensory experiences. Virtual store environments can be either realistic representations of store environments that exist in reality, or imaginary store environments. In addition, the virtual store can be seen as an intermediate tool between traditional consumer research (*i.e.*, text-based surveys, focus groups, or lab experiments), controlled field experiments (*i.e.*, in mock store environments), and field studies (*i.e.*, video captures, personal observations, or tests of product sales promotion)<sup>1</sup>.

Virtual reality applications have considerable research history. As early as 1965, Sutherland<sup>2</sup> described his "ultimate display" concept, which includes a virtual world that provides sound and tactile feedback. Originally, attention was mainly focused on the technological hardware, but as this does not provide insights into the effects of virtual reality systems, attention has shifted to the human experience<sup>3-4</sup>. The sense of "presence," of being in the computer-generated world,

has consequently become a key to virtual-reality experiences<sup>5-6</sup>. Presence has been defined as the “subjective experience of being in an environment, even when one is physically situated in another.”<sup>7</sup> From this point of view, “sense of presence” can be retrieved from a participant and refers to the extent to which a person perceives him/herself to be in an environment. Alternatively, Slater<sup>8</sup> has distinguished between the concepts of presence and immersion, called “place illusion” (PI) and “plausibility illusion” (Psi). PI relates to having a sensation of being in a real place. It is assessed by a set of valid actions or responses that participants can perform to change their perceptions or the environment (*e.g.*, moving the head and eye to change the gaze direction or grasping some object to move it). PI is high when a similar set of responses to change perceptions are required in the virtual reality system compared to the response expected in an equivalent physical environment. Psi accounts for what is perceived in the virtual reality, referring to the illusion that it is actually occurring. A vital component that can lead to Psi is for the virtual reality to provide the illusion that events in the virtual environment over which a participant does not have direct control refer directly to him/herself. Psi can be measured by tracing any actions or responses that people manifest in response to changes in the virtual reality that originated from outside. For example, if people’s heart rates increase when they see an avatar in the virtual environment, this can represent a similar reaction to the real world. Thus, this virtual reality system provides high Psi.

The virtual store technology has been introduced in business and academics to serve several purposes. It can be used as a managerial aid, for instance to assist category managers of companies in developing a shelf plan for their products. Virtual stores also have their use in clinical settings, to measure emotional responses to food for patients with an eating disorder<sup>1</sup> or as a screening tool for mild cognitive impairment<sup>9</sup>. A more common use of virtual stores in research, however, is to assess consumer in-store behavior and consumer responses to changes in the store environment, such as price changes<sup>10-12</sup>, different setups of point-of-sale displays<sup>13</sup>, different packaging options<sup>14</sup>, different nutritional labels on the backsides of product packages<sup>15</sup>, and stock levels<sup>16</sup>. In addition, the virtual store is currently used to help create and test public health interventions to stimulate healthier food choices among children<sup>17</sup>. Due to various benefits stated previously, virtual store technology and hardware are in rapid development. Therefore, this paper will focus on the human experience and describe the essential elements of studies using virtual reality in general. All essential information obtained from the current virtual store system will be demonstrated.

Currently available virtual store systems can be briefly categorized as: 1) non-immersive (*e.g.*, desktop), 2) semi-immersive (*e.g.*, projection, CAVE-systems), and 3) fully-immersive (*e.g.*, head-mounted displays). Each system likely brings different levels of immersion, presence, PI, and Psi depending upon the support system. However, because the measures of immersion, presence, PI, and Psi are bound to the specific sensorimotor contingencies that each system supports, a comparison of these indicators across different systems has been deemed impossible<sup>8</sup>. In recent years, desktop virtual stores have received more attention and have been used increasingly in research. Even though the virtual store has been regarded as a promising tool for in-store consumer behavior research, expertise on how to use such a virtual store is required to ensure the timely and correct preparation and implementation of experiments. However, up to now,

reported studies that comprehensively describe the procedure to conduct virtual store experiments are very scarce. Therefore, this work aims to describe a protocol for conducting consumer research with the desktop virtual store, which is of vital importance.

Generally, research with a virtual store requires: 1) equipment to display the virtual environment, 2) an editor program to enable researchers to build the virtual environment, 3) a virtual representation of the studied object (*e.g.*, several elements of a store and products), 4) a consumer interface to navigate the virtual environment and make choices, 5) procedures for running the data collection itself, and 6) a data management system that facilitates data storage and analysis. Most of these will likely be managed by a virtual shop company and a programmer. Researchers should know: 1) how to create a retail store for an experiment in an editor program, 2) how to run data collection with the consumer interface, and 3) how to organize all outputs in the data management program and export outputs to be put into a statistical program. The current paper will address this information by giving detailed protocol steps for conducting experiments with the desktop virtual store. Additionally, advantages and limitations of using the virtual store in consumer research will be discussed. The detailed protocol described in this paper can be used to help researchers start and conduct virtual store research.

The desktop virtual store used in this paper requires hardware (*i.e.*, personal computers (PC), liquid-crystal display (LCD) screens, a three-dimensional (3D) space navigator, a mouse, and a keyboard) and software (*i.e.*, to design a shop and to shop like a consumer in a 3D virtual store). This particular system has been used in prior studies<sup>14, 18</sup>.

## **PROTOCOL:**

The protocol adheres to the “Generic Protocol Food Choice Simulator,” which complies with the Netherlands Code of Conduct for Scientific Practice and has been approved by the Social Sciences Ethics Committee of Wageningen University.

### **1. Setting up the virtual store equipment.**

1.1. Prepare a sufficiently spacious location for the virtual store display. Prepare all equipment for both the virtual store and the data management program.

**Note:** The equipment includes two computers (PCs; 1 virtual store PC with a high-capacity memory card for displaying the virtual store, and 1 PC for the data management programs), three 42-in LCD screens, a computer screen for displaying the data management programs, connecting cables, electronic sockets, a 3D space navigator, 2 mice, and 2 keyboards.

1.2. Connect all the equipment together, as demonstrated in **Figure 1**.

1.2.1. Connect one PC to a computer screen, a keyboard, and a mouse to use the data management program.

1.2.2. Place 3 LCD screens next to each other and adjust the left and right screens to give a 180° field-of-view of the virtual store that appears on the screens.

1.2.3. Connect the virtual store PC with the 3 LCD screens, the 3D space navigator, a mouse, and a keyboard. Connect the virtual store PC with the data management PC.

1.2.4. Turn both PCs on and adjust the screen resolution of the virtual store PC to “extend multiple display.” Set the left screen to be the main display.

[ Place Figure 1 here]

## **2. Building virtual stores for experiments.**

2.1. Open the virtual store builder interface (called the editor) by double-clicking on the “VirtualShop\_Editor.exe” icon on the desktop.

2.2. Open a store template that is suitable for the study by clicking “File” and clicking “open.” Select the desired store template, “Name.ShopConfig” (e.g., Supermarket001.ShopConfig).

2.3. Modify the store regarding the experimental conditions.

**Note:** Before modifying the store, a plan of the virtual store should be made based on the research questions and objectives of the study. This includes the type, placement, and number of shelves; the location of product categories on these shelves; and the type and location of products within the product categories.

2.3.1. Replace existing products with products of interest, where needed.

2.3.1.1. Use the “up” and “down” arrow keys on the keyboard to zoom in and out from the products, respectively.

2.3.1.2. Click on the icons on the left menu bar to change the view of the virtual store (*i.e.*, left yellow face = front view, top yellow face = top view, right yellow face = side view, and all lateral yellow faces = home view (looking from the top-left of the store)).

2.3.1.3. Double-click on a shelf or product and click on the icons on the left menu bar to change the view of this shelf or product.

2.3.1.4. Double-click on a shelf of interest and click on the “yellow spot” in the left menu bar to select the isolation mode.

**Note:** The isolation mode enables the researcher to isolate a shelf with products and to filter out other objects from the screen. This is helpful when filling the shelves.



2.3.1.5. Double-click on an existing product and subsequently press the “Delete” button on the keyboard to delete this product.

2.3.1.6. Click on the “back arrow” in the menu bar to open the product library (see **Figure 2**). Afterwards, click “Product Category” and then select the product category of interest (*e.g.*, fruit).

[ Place Figure 2 here]

2.3.1.7. Drag a selected product (*e.g.*, a tray of apples) by holding the left mouse button and place the product on the desired shelf.

2.3.1.8. Add or replace all the products to match the research interests by repeating the steps from 3.1.1-3.1.4.

2.3.2. Relocate entire shelves.

2.3.2.1. Double-click a shelf that needs to be relocated. Move the shelf to the desired location by left-clicking the entire shelf and dragging the shelf to a new location.

2.3.2.2. Rotate the shelf (if necessary) by holding down the “Ctrl” key and left-clicking the shelf. Turn or move the shelf to the desired angle by moving the mouse.

2.3.2.3. Relocate all necessary shelves to match research interests by repeating steps 2.3.2.1 and 2.3.2.2.

2.4. Save the completed store configuration by using a file name that is non-descriptive of the research condition. Click “File” → “save as” → “Name.ShopConfig” → “save.”

**Note:** It is also possible to build a store from an empty store template. Start by selecting and adding shelves and products from the product library to the empty store. The same procedure from steps 3.1 and 3.2 can be applied.

2.5. Build a separate store for a practice session and build more stores according to the experimental conditions, such as supermarkets with different store layouts, following steps from 2.1-2.4.

**Note:** The example study uses a pharmacy as a practice store.

2.6. Ask the program creator (see the Table of Materials/Reagents for contact details) to create new walking paths and decision points for participants if the store layouts are different than the existing store templates.

**Note:** Shopping paths and decision points are available for the existing store templates. It is also possible to allow participants to walk freely in the store, without predetermined shopping paths.

### **3. Preparing the data management program to record data.**

3.1. Double-click on the data management program icon on the desktop to start the program.

3.2. Open the “Virtual Shop Exp\_StartUp” project to create a new project. Select “Open” on the pop up window → “Virtual Shop Exp\_StartUp” → “Virtual Shop Exp\_StartUp.vop.”

3.3. Click on “Set up project” and select “Live Observation” as an observation source. Select “Continuous Sampling” as an observation method and select “Open ended observation” as an observation duration.

3.4. Add input variables that represent the experimental conditions (*e.g.*, the store layout and shopping motivation), if desired.

3.4.1. Click on “Set up” in the top menu bar and then click on “Independent Variable.” Click on “Add variable” to add more user-defined variables.

3.4.2. Fill in necessary details, such as variable name, variable type, predefined value, and so on.

3.5 Save the project by clicking on “File” → “Save as.” Name the project, “Name of project.vop” and click “Save.”

### **4. Participant selection criteria.**

4.1. Recruit participants without eye disorders, such as color blindness.

### **5. Preparation for the experiment.**

5.1. Prepare all the documents needed to carry out the experiments.

5.2. Invite a participant to the experiment room. Provide a consent form and request that the participant reads and signs the form prior to the study.

5.3. Provide experimental instructions that the participant must follow. See Supplements 1 and 2.

**Note:** Participants should be informed that visiting a virtual store can lead to virtual reality sickness<sup>19</sup>, and they should be urged to report it to the study coordinator when they start experiencing symptoms. If a participant expresses that he/she is experiencing virtual reality sickness, participation in the experiment should be stopped.

5.4. Seat the participant in front of the middle LCD screen, at a short distance from the middle screen (~60 cm). Adjust the chair until the participant's eye level matches the position of the screens.

## **6. Running a practice test.**

6.1. Inform the participant that he/she will be trained in a practice session to control and get familiar with the virtual store. Encourage the participant to ask questions when he/she does not fully understand the instructions.

6.2. Open the virtual store for a practice session.

6.2.1. Start the virtual shop program by double-clicking on the VirtualShop\_Uviewer icon on the desktop. Click "Begin" to enter the store.

6.2.2. Press the "`" key on the top-left of the keyboard to open the menu bar of the virtual shop program.

6.2.3. Select "SpaceNav" in an "Input" box to choose the type of walking behavior that allows the participants to look and to decide their walking direction freely.

**Note:** "SpaceNav" allows participants to look freely through the virtual environment, in any direction, using the 3D mouse. It also enables participants to decide their own walking direction. Nevertheless, it restricts participants to following predetermined walking lines.

6.2.4. Select the "Name of a practice Store" in the ShopConfig box and type the "Name of environment" to specify the store environment, such as the Practice Store [e.g., Pharmacy 001].

6.2.5. Click on "Reload shop" to open the practice store, and a "Begin" box will subsequently appear.

6.3. Provide the mouse, 3D navigator, and keyboard to the participant. Ensure that the front side of the 3D navigator faces the participant to enable the correct navigation direction.

6.4. Provide instructions on how to maneuver in the virtual store and instructions for the practice session to the participant. The instruction assigns two practice tasks that request that the participant searches for specific products and selects and/or returns some products.

**Note:** Examples of instructions on how to maneuver in the virtual store and instructions for the practice session are shown in **Supplementary Files 1** and **2**, respectively. A practice session should include all tasks that a participant may need to perform during the main test.

6.5. Allow the participant to freely practice until he/she feels familiar with the virtual store. Ensure that the participant understands clearly how to maneuver in the virtual store before starting the main study. Correct or clarify if the participant has made any mistakes.

6.6. Remind the participant to check the shopping cart (by pressing “F1”) before ending the task. Eventually, remind the participant to end the shopping task by pressing “Esc” and then clicking on “Restart.”

**Note:** It is not necessary to close the virtual shop program because it is faster to load the shop for the main test via an opened interface.

## **7. Running the main test.**

7.1. Move the participant to another area while the virtual store is prepared for the main test. Inform the participant of the tasks that will follow.

**Note:** Depending on the research objectives, this can include a task to manipulate an independent factor outside the virtual store (in the extensive example, this is a memory task to manipulate shopping motivation), a shopping task (in the virtual store), and a shopping evaluation task (questionnaire).

7.2. Administer a task to manipulate an independent variable outside the virtual store when relevant to the study objectives. For example, ask participants to describe in detail a recent shopping situation in which they had either hedonic or utilitarian shopping motivations (see **Supplementary File 3**).

### **7.3. Prepare the virtual store for the main study.**

7.3.1. Click on “Begin” to enter the store and press the “ ` ” button on the top-left of the keyboard to open the menu bar of the virtual shop program.

7.3.2. Load the virtual store and select the virtual environment (walking path), according to the experimental conditions.

7.3.3. Keep “SpaceNav” at the box of the Input to obtain the same type of walking behavior as in the practice session.

7.3.4. Select the “Name of store condition” in the ShopConfig box and type the “Name of store environment” in the environment box, such as “Supermarket001 [Supermarket001].”

7.3.5. Click on “Reload shop” to open the store for the main test; the “Begin” box will appear.

7.4. Open the data management program on another computer (in which the data management program is installed). Record the data by double-clicking on the data management program icon on the desktop.

7.5. Open the project by double-clicking on the “Name of project.vop” that the researcher has previously saved when preparing the data management program.

7.6. Create a new observation by clicking on “Observe” in the top menu bar and then clicking on “Observation” and “New.” Name the observation (e.g., observation 1) and click “OK.”

7.7. Start recording by pressing the red circle button and fill in user-defined variables, such as an experimental condition (e.g., store layout = 1 and shopping motivation = 1 (utilitarian motivation)). Click “OK”.

**Note:** The recording button will change from a circle shape (record) to a square shape (stop).

7.8. Ensure that the program starts recording data.

7.8.1. Ensure that the “Status data plugin” and “Status event plugin” windows show green checkmarks.

7.8.2. Ensure that “time” is elapsing.

7.8.3. Ensure that the number of “sample” column in the “Status data plugin” window is growing (shown in **Figure 3**).

[ Place Figure 3 here]

7.9. Move the participant from the area in which they have been provided with instructions and (optional) a task to manipulate an out-of-store variable, such as shopping motivation, back to the virtual store after he/she finishes the manipulation task.

7.9.1. Seat the participant in front of the middle LCD screen and at a short distance from the middle screen (~60 cm). Adjust the chair until the participant’s eye level matches the position of the screens.

7.10. Provide the mouse, 3D navigator and keyboard to the participant. Ensure that the front side of the 3D navigator faces the participant to enable the correct navigation direction.

7.11. Provide instructions on how to maneuver in the virtual store (see **Supplement 1**), shopping task instructions, and a shopping list for the main study (see **Supplement 4**).

7.12. Instruct the participant to press “begin” to start visiting the store. Subsequently, leave the participant alone to shop without interruption.

7.13. Check the data management program on another computer and ensure that the data is recording by checking the “Status data plugin” and the “Status event plugin;” these windows should show an increasing number of samples and events.

7.14. Wait until the participant finishes shopping in the virtual store. Remind the participant to check the shopping cart (by pressing “F1”) and to press “Esc” to complete the shopping task.

Note: It is very important to press “Esc” to mark the end of the shopping trip and to obtain a correct measurement of the shopping duration.

7.15. Press the “stop” button of the data management program on the other computer to stop recording (the square button will change back to a circle ).

**Note:** Two small windows— “Please wait for receiving Event data to finish” and “Please wait for receiving external data to finish”—will pop up during the termination. These windows will close automatically after 2-3 s.

7.16. Ask the participant to move to another area and ask him/her to fill out a questionnaire measuring, for example, the participant’s shopping experiences, perceptions about the store, and willingness to revisit the store.

7.17. Return to the data management program and click on the “Visualize” button to check the recorded data; the graph and data of bought products should be shown, and examples of visualized data are shown in **Figure 4**.

[Place Figure 4 here]

7.18. Debrief and give a reward (*e.g.*, a snack product or monetary payment) after the participant finishes.

7.19. Reload a practice store for a new participant by following steps 5.2.3-5.2.4.

7.20. Press F9 to close the virtual store after the last participant has finished.

7.21. Save the data as frequently as possible to avoid data loss.

## **8. Export the data.**

8.1. Export the data of shopping-related behavior.

8.1.1. Set up a filter to select the data of shopping-related behavior.

8.1.1.1. Click “Data Profile” under the “Analyses” folder on the left menu column; the window will show the data components and the main diagram of the data profile filter.

8.1.1.2. Select the “Nest over Behaviors” box under the “Select Intervals” heading; the box of Nested Behaviors will appear.

8.1.1.3. Select all the behaviors of interest (*e.g.*, shopping duration, products picked up, products bought, and products returned) and click “OK.”

8.1.1.4. Drag the “Nested Behaviors” box and drop it between the “Start” and “Results” boxes.

8.1.1.5. Ensure that all boxes are connected with arrows (see **Figure 5**) and that the “Results” box shows the correct number of observations.

**Note:** If the boxes are not automatically connected, a researcher can connect them by clicking the mouse on one box, holding, and making a line to the next box.

[ Place Figure 5 here]

8.1.2. Click on “Behavior Analyses” under the “Analyses” folder and then click “New Behavior Analysis” to open the table of behavior-related results.

8.1.3. Click on “Calculate” on the top left of the menu bar to extract the results. Ensure that the shopping behaviors per participant are shown in separate rows.

**Note:** A researcher can change the format of the presented results via a “Setting display.”

8.1.4. Click the “Export” button to export the data. Name the exported file “Name.xlsx.”

**Note:** This file will be saved in the “Export” folder of the data management program folder.

8.2. Export the movement-related data.

8.2.1. Set up a filter to select the movement-related data.

8.2.1.1. Click “Data Profile” under the “Analyses” folder on the left menu column. Select the “Nest over Speed” box under the “Select Intervals with External Data” heading; the “Nested Speed” box will appear.

8.2.1.2. Set the Interval criteria to “Limitation” → “Higher than” → “0.100 meter per second (m/sec)” and then click “OK.”

**Note:** This filter will export only the data (*e.g.*, walking speed and time) that occurs when the participant moves in the store.

8.2.1.3. Drag the “Nested Speed” box and drop it between the “Nested behaviors” and “Results” boxes.

8.2.1.4. Ensure that all boxes are connected (*i.e.*, “Start” box → “Nested behaviors” box → “Nested Speed” box → “Results” box (shown in **Figure 6**) and that the “Results” box shows the correct number of observations.

[ Place Figure 6 here]

8.2.2. Export the walking time.

8.2.2.1. Click “Behavior Analyses” under the “Analyses” folder and then click “New Behavior Analysis” to open the table of behavior-related results.

8.2.2.2. Click “Calculate” on the top left of the menu bar to extract the results. Ensure that the shopping behaviors per individual are shown in separate rows.

**Note:** The results should show a lower shopping duration compared to step 1.4 because the shopping duration in this part accounts for the time that a participant has walked in the store. These results exclude the time for product examination and for picking up products.

8.2.2.3. Click the “Export” button to export the data. Name the exported file, “Name.xlsx,” with a name that differs from the first exported shopping-related data; this file will also be saved in the “Export” folder of the data management program folder.

8.2.3. Export the walking speed.

8.2.3.1. Click “Numerical Analyses” under the Analyses folder and then click “New Numerical Analysis” to open the table of movement-related results.

8.2.3.2. Click “Calculate” on the top left of the menu bar to extract the results. Ensure that the movement-related results, such as speed per participant, are shown in separate rows.

8.2.3.3. Click the “Export” button to export the data. Name the exported file “Name.xlsx;” this file will be saved in the “Export” folder of the data management program folder.

### **REPRESENTATIVE RESULTS:**

The virtual store displayed using a PC with three 42-in LCD screens has been applied to examine the effects of supermarket layout on consumer shopping behavior (*e.g.*, total shopping time, movement duration and speed, total number of products examined, and total number of products purchased) and perceived shopping experience. The virtual store enables the researcher to flexibly modify the attributes of store shelves (*i.e.*, shelf length and shelf orientation) and to examine these effects in a laboratory setting.



As an example, results from the store layout study are provided. In the study, supermarket stores were built using 4 different layouts, in which shelf length (short versus long shelves) and shelf orientation (paralleled arrangement versus unparallelled arrangement) were varied. These stores are depicted in **Figure 7**.

[ Place Figure 7 here]

The study was performed in accordance with the “Generic Protocol Food Choice Simulator” and approved by the Social Sciences Ethics Committee of Wageningen University. All participants signed an informed consent form prior to participating in the experiments. In the present example, participants (n = 241, 71% female) were divided into four groups; each group visited one of four store layouts. Participants were trained on how to use the virtual store in a practice session. Next, they completed a shopping motivation manipulation task that asked them to recall shopping trips with either hedonic or utilitarian shopping motivations. Subsequently, the participants started the main test, in which they were requested to shop for a dinner using a shopping list. Participants were asked to imagine that they were shopping with either hedonic or utilitarian motivation (the same motivation as in the previous recall task was assigned). The shopping list consisted of fixed-choice (8 pre-determined types of products) and free-choice products (undetermined products from the fruit and vegetable category). The free-choice products were used to test the effects of store layout on the number of products purchased. Once the participants finished shopping, they filled in a computer-based questionnaire to evaluate their shopping experiences, perceptions about the store, and willingness to revisit the store.

The data management program recorded shopping behavior (*e.g.*, total shopping time, moving speed, and total number of products purchased). Afterwards, variables were exported from the data management program to 3 separated tables: **Table 1**, **Table 2**, and **Table 3**. **Table 1** presents the total shopping time, the total number of products examined, and the total number of products purchased by each participant. **Table 2** presents the total movement duration (*i.e.*, shopping time) that was selected from a filter of speeds higher than 0.001 m/s. **Table 3** presents the moving speed that can subsequently be used to calculate the walking distance (walking distance (m) = average moving speed (m/s) x total moving time (s)).

[ Place Table 1 here]

[ Place Table 2 here]

[ Place Table 3 here]

Once the data was exported, univariate ANOVA was applied to analyze the effects of shelf length and shelf orientation on in-store shopping behavior. The effects of store layout can be presented in various forms, such as bar charts and tables.

**Figure 8** displays the total number of products examined and the total number of products purchased in the supermarkets with different store layouts. The results from the virtual store confirmed that store layout attributes, specifically the interaction of shelf length and shelf orientation, influenced the number of products examined ( $F(1,237) = 4.66, p < .05, \eta_p^2 = .02$ ) and the number of products purchased ( $F(1,237) = 3.47, p = .06, \eta_p^2 = .01$ ). The findings showed that when shelves were placed in parallel, the length of the shelves did not affect the number of products examined ( $M_{\text{short}} \pm SD_{\text{short}} = 16.12 \pm 5.37, M_{\text{long}} \pm SD_{\text{long}} = 17.12 \pm 5.99, F(1,237) = 0.81, p = .37, \eta_p^2 = .00$ ), nor the number of products purchased ( $M_{\text{short}} \pm SD_{\text{short}} = 12.00 \pm 2.77, M_{\text{long}} \pm SD_{\text{long}} = 12.22 \pm 2.37, F(1,237) = 0.24, p = .63, \eta_p^2 = .00$ ). In contrast, when the orientation of the shelves was unparallel, shorter shelf lengths stimulated a higher number of products examined ( $M_{\text{short}} \pm SD_{\text{short}} = 17.62 \pm 6.48, M_{\text{long}} \pm SD_{\text{long}} = 15.23 \pm 6.45, F(1,237) = 4.65, p < .05, \eta_p^2 = .02$ ) and purchased than longer shelf lengths ( $M_{\text{short}} \pm SD_{\text{short}} = 12.30 \pm 2.15, M_{\text{long}} \pm SD_{\text{long}} = 11.35 \pm 2.37, F(1,237) = 4.61, p < .05, \eta_p^2 = .02$ ).

[ Place Figure 8 here]

In addition to product choice behaviors, the virtual store can also record time and movement-related behaviors, such as, the shopping time and the walking distance. **Figure 9** and **Figure 10** show the effects of shelf attributes on the shopping time and walking distance of participants, respectively.

[Place Figure 9 and Figure 10 here]

In addition to the effects of shelf attributes, the current research also focuses on shopping motivations to understand their influence on in-store shopping behavior. The results reveal significant main effects of shopping motivations on all in-store behavioral variables. Consumers with a hedonic motivation searched for (*i.e.*, clicked on) ( $M_{\text{hedonic}} \pm SD_{\text{hedonic}} = 17.97 \pm 6.93$ ) and purchased more products ( $M_{\text{hedonic}} \pm SD_{\text{hedonic}} = 12.25 \pm 2.42$ ) than consumers with a utilitarian motivation (products examined:  $M_{\text{utilitarian}} \pm SD_{\text{utilitarian}} = 15.10 \pm 4.82$ , products purchased:  $M_{\text{utilitarian}} \pm SD_{\text{utilitarian}} = 11.69 \pm 2.43$ ). They also spent more time ( $M_{\text{hedonic}} \pm SD_{\text{hedonic}} = 607.18 \pm 205.07$  s,  $M_{\text{utilitarian}} \pm SD_{\text{utilitarian}} = 480.94 \pm 134.25$  s) and walked longer distances ( $M_{\text{hedonic}} \pm SD_{\text{hedonic}} = 89.87 \pm 31.15$  m,  $M_{\text{utilitarian}} \pm SD_{\text{utilitarian}} = 80.73 \pm 34.08$  m). The interaction effect of shopping motivation and store shelf attributes was not significant.

#### FIGURE AND TABLE LEGENDS:

**Figure 1: The virtual store setup.** The virtual store uses one PC equipped with three 42-in LCD screens that render 180° visibility. A separate PC is added to accommodate the data management program. This PC enables a research coordinator to monitor the progress and to start new virtual environments without interrupting participants.

**Figure 2: The virtual shop editor and examples of products in the product library.** The editor has a drag-and-drop interface to allow researchers to easily select products from the library and

directly place them on the shelves. In addition, a pop-up window can be used to either add or edit a product by clicking on a product in the library.

**Figure 3: An example of the observation window that signals the recording of data.** When the data management program is recording data, the “Status data plugin” window and the “Status event plugin” show a green mark. Also, time should be elapsing and the number of samples should be growing.

**Figure 4: The visualization window displayed in the data management program.** The orange bar represents the entire shopping time, since the participant entered the store until he/she pressed “Esc” to indicate the end of the shopping trip. The green bar denotes the time spent on the examined products. These outputs can be converted into tables that are easy to use in combination with SPSS or other statistical programs.

**Figure 5: Data profile filter scheme for exporting shopping-related behavior.** The data profile filter allows researchers to select and export the data of interest. For example, this scheme opts for shopping-related behaviors (*e.g.*, shopping duration, number of products examined, number of product purchased, and number of products returned).

**Figure 6: Data profile filter scheme for exporting movement-related behavior.** This scheme filters the movement-related behaviors (*e.g.*, moving speed and moving time) that occur when participants move in the store (speed > 0.100 m/s). The behaviors and times when participants stand still are filtered out.

**Figure 7: Pictures of four store layouts in the store layout experiment.** The layouts differ in shelf length and shelf orientation: 1) store with long and parallel shelves, 2) store with short and parallel shelves, 3) store with long and non-parallel shelves, and 4) store with short and non-parallel shelves.

**Figure 8: The total number of products examined (left) and the total number of products purchased (right) in a supermarket with different store layouts (short versus long shelves placed in a paralleled or in an unparalleled orientation).** The total number of products examined (packages or items) increased every time the participants clicked on a product. This number differs from the total number of products purchased (packages or items), by which the number of products in the purchase basket was recorded. Participants were allowed to return any selected products.  $p < .10^+$ ,  $p < .05^*$ ,  $p < .01^{**}$ ,  $p < .001^{***}$

**Figure 9: Total shopping time (s) participants spent in the supermarket with different shelf lengths and shelf orientations.** The total shopping time accounts for the time participants spent between entering the store and leaving the store. The data management program also allows researchers to filter out the time that participants spent in a specific area.  $p < .10^+$ ,  $p < .05^*$ ,  $p < .01^{**}$ ,  $p < .001^{***}$

**Figure 10: The walking distance of participants in the supermarket with different shelf lengths**

**and shelf orientations.** The walking distance was determined by multiplying the moving time (s) with the average shopping speed (m/s). The duration of the moving time used to calculate walking distance differs from the total shopping time because the moving time is exclusively recorded during participant movement. In contrast, the total shopping time accounts for the movement time and the time spent viewing and selecting products. Thus, the total moving time can be attained by only selecting the time during which participants move faster than 0.100 m/s.  $p < .10^+$ ,  $p < .05^*$ ,  $p < .01^{**}$ ,  $p < .001^{***}$

**Figure 11: An example of a product in a 3D model (left) and a 2D model (right).** When participants click on a product, the 3D model can be rotated on-screen to illustrate all sides of the product, whereas the 2D model illustrates only the front side of the product and cannot be rotated.

**Table 1: Examples of shopping-related behavioral data from each participant (i.e., total shopping time, total number of products examined, total number of products purchased, and total number of products returned), exported from the data management program.** All shopping-related behavioral data from each participant should be organized in one row before transferring it to SPSS or other statistical programs. This exported data will be stored to the file called “Behavioral data” in the export folder of the data management program.

**Table 2: Examples of movement-related data (i.e., the moving speed and the walking position of each participant), exported from the data management program.** The movement-related data is selected when participants moved with speeds higher than 0.100 m/s. This selection filters out all data that occurred when participants stood still. All movement-related data from each participant should be organized in one row before being transferred to SPSS or other statistical programs. This exported data will be stored to a file called “Numerical data” in the export folder of the data management program.

**Table 3: Examples of movement duration (indicated in the shopping duration column), exported from the data management program.** The movement duration is retrieved from the behavioral data table that filters out the time during which participants did not move (speed < 0.100 m/s). This duration is shorter than the total shopping duration. The exported data will be stored to a file called “Behavioral data” in the export folder of the data management program.

## **DISCUSSION:**

The virtual store is one of the more advanced computer technologies that have been developed to create virtual environments in which people can experience and react to close-to-reality objects. Generally, the desktop virtual store consists of user-friendly interfaces that require a short time to understand. However, a number of critical points need to be accounted for. First, clear research objectives are needed beforehand to specify the starting points when building the virtual store. This includes a plan about the products; the type, placement, and number of shelves; the location of product categories on these shelves; the type and location of products within the product categories; and other elements (e.g., poster, signage, and special displays). Moreover, it is important to decide which model (2D or 3D) of a digital representation of objects

will be used (see **Figure 11**). The 3D models are virtual representations, with height, width, and depth, in which all sides are represented in detail. In contrast, the 2D model gives the illusion of a 3D representation by presenting an object in a cube frame (3D shape), with realistic visuals of the front of the object. The other sides of the 2D models are roughly shown without detail. Different forms of representations give rise to different user experiences and different senses of immersion. The 3D model that shows all details of an object may give a higher sense of presence and immersion (PI and Psi) than the 2D model. However, the 2D model is flexible and easy for a researcher to use, and the size of the cube frame can be easily adjusted. Thus, the choice of the virtual representation depends upon the research aims. Second, after all stores are built, the researcher should run and test all versions of the virtual store by visiting each store and picking up, selecting, and returning products to verify that the data is stored correctly. Third, because the study consists of several steps, clear instructions and detailed virtual store manuals are extremely important. The instructions should indicate what participants should and should not do in each step. Fourth, the practice session is vital to familiarizing participants with the virtual store and minimizing biases generated from different computer skills. Last, researchers should be cautioned to save data as frequently as possible to avoid any potential data loss.

The use of virtual stores in consumer research has advantages over more traditional research methods. A virtual store is a tightly controlled yet realistic environment<sup>17,19</sup>, thereby providing the internal validity of a controlled experiment while maintaining a high degree of external validity as well. It thus combines the advantages of both field and laboratory approaches<sup>20</sup>. This implies that consumer behavior can be observed and measured in a realistic context, with less concern for socially desirable answers than in other research methods, such as surveys and focus groups<sup>21</sup>. A recent study has indicated that, compared to a method of using photographs to display a store shelf, the use of virtual reality results in consumer in-store behavior that more closely resembles the behavior demonstrated in a physical store, based on several parameters (*i.e.* feelings of presence, type of brands selected, and responses to the location of products in the display)<sup>18</sup>. An additional advantage of using virtual reality is that changes in the store environment can be made without having to rely on complex implementation processes in real-life settings<sup>22-23</sup>. This provides flexibility for the researcher. As a result, the use of a virtual store has clear benefits when the objective of a study is to examine consumer responses to products that are not yet available in the market (*e.g.*, in early stages of new product development), to examine consumer responses to factors that are costly or difficult to change in real life (*e.g.*, overall store layout), and/or to examine routinized behaviors in familiar environments.

Despite the stated advantages of the virtual store, several limitations need to be carefully considered. The major limitations, at this stage of development, relate to: 1) the time and space needed per participant, 2) the potential skill-related bias, 3) the costs involved in adapting new environments, and 4) real behavior and incentives. Currently, the virtual store can be used by only one person at a time. In particular, a number of participants are sampled in a virtual laboratory or an experimental area in order to run simulations. This limitation of time and physical space for the virtual store experiment restricts sample size and types of target groups. In addition, the restriction on the types of target groups is also caused by the skills required for participants to use the computer. Gamers or younger participants are likely to be able to handle

the program more efficiently than the elderly or persons with low computer skills. Another limitation of the virtual store is that the adaptation of the store and the product library is in the development stage. If one wants to use a complex store design or store elements or products that are different from the available templates (*e.g.*, enlarging the store size or including new store elements, such as display tables), the program needs to be adjusted. Thus, cost and time are incurred for the preparation of data collection. Lastly, even though previous studies have shown that the virtual store reflects behavior in the physical store more closely than does an experiment using pictorial stimuli, participants tend to buy more products in the laboratory setup than they do in actual stores. Thus, although the use of a virtual store increases realism compared to the use of pictures, several differences from real-life behavior remain<sup>18</sup>. To be cautious, this must be considered when interpreting results from a study using the virtual store.

There is a vast range of different technological features and systems for virtual reality applications. These systems mainly vary on aspects of equipment mobility, user interfaces, and development costs. The costs for equipment and licenses vary and are subject to drastic changes due to technological developments. In general, the costs per participant are higher when more behavior data is needed with higher-level 3D simulations. The use of a different system or interface may counteract some of the mentioned limitations, but at a cost in terms of money or flexibility. Specifically, the first limitation, on the time and space needed per participant, can be counteracted by using smartphone technologies. Smartphones, in combination with a designated headset, can render a full, immersive, 360° environment. Limitations on space are as low as possible, since it does not cost more space than what one would normally use. Due to the widespread use of smartphones and the low cost of designated headsets, multiple people can use it at the same time. The downside of this technology is that smartphones have a lower computing power and thus can only handle less-difficult environments. The second limitation is the potential skill-related bias, a limitation that any system must deal with. Some systems, such as the Cave system, simulate natural movements<sup>24</sup>, which potentially could reduce this bias. The Cave system uses projector screens and head tracking, which allows participants to physically move through a limited space and to orient their head arbitrarily. Such a system, however, is not or is hardly mobile and requires much more developmental and hardware costs. The third limitation, the costs that are involved with adapting the store products and environment, are dependent upon the degree of simulation. It is possible to simulate a stationary environment based on a picture, but as soon as more detail, such as a 3D world or 3D products, are needed, one is dependent upon the availability of these objects in 3D. The last limitation, the simulation of real behavior and incentives, are likely dependent on the aforementioned factors of mobility, skill bias, and, in general, the degree of immersion. Mobile units can be used in a relevant context (*e.g.*, in the actual supermarket), thereby making the incentive and the purpose of the visit real (*e.g.*, buying a product virtually results in actually buying the product in real life). Furthermore, it can be expected that, when the user interface closely resembles natural movement, it will better resemble real-life behavior. Lastly, the level of immersion achieved by the current virtual store is between those of a regular desktop and a semi-immersive virtual reality projection<sup>8</sup>. Since other virtual store systems are in the early stages of development, studies describing and comparing different virtual store systems are scarce. A comparison of shopping behavior under different levels of immersion is yet to be conducted.

As virtual reality has become a widely used technology, outside the scope of computer games, virtual reality technology is likely to enter the market of home users (*e.g.*, by television, internet or mobile application). This will potentially enable researchers to do virtual reality testing outside the laboratory. Moreover, this development opens up ample opportunities to measure, research, and understand the behavior of people on a broader scale in terms of groups and areas (*e.g.*, in developing countries or rural areas with limited accessibility to technology). The external validity of the research will consequently be enhanced. With the advancement of this technology on the consumer market, virtual reality research could further develop from supporting simulations to the direct measurement and tracking of real behavior. Just like people surfing on the web or consumers choosing in a web shop are already intensely tracked to predict or influence behavior, the same type of behavioral measures exist (and will come to exist) for simulated virtual worlds. Another potential development is foreseen in the area of generating personalized environments. Several websites are already automatically adjusted to the individual who visits them. Examples of such websites are online retailers that give suggestions based upon aspects such as location, previous purchases, and Facebook (*i.e.*, a social media and networking platform), which personalizes not only the advertisements, but also other content to fit personal preferences. The same could happen for virtual worlds. In practice, people could, for example, select personalized supermarkets, design or choose the manner in which they would prefer to be guided (*e.g.*, “guide me towards sustainable product choices”), or even limit the choices they can make (*e.g.*, only products for people with a specific disease).

In summary, unravelling the mysteries of consumer behavior cannot be achieved by any stand-alone research method. Thus, to compare or combine insights, various data collection tools must be used. The virtual reality developments have taken great steps in the last few years. Now, it is the time to link these methods to traditional methods so that new insights can emerge. There are multiple options of the virtual store, all with their respective advantages and disadvantages. The virtual store described here is unique in that there is an easy editor to build a virtual store that includes a range of options in order to collect behavioral data. An example of research with the virtual store presented here lays the groundwork as a universal way of measuring consumer behavior in virtual-reality research.

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#### **DISCLOSURES:**

The authors have nothing to disclose.

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Figure 1: The virtual store setup.

[Click here to download Figure 1 The virtual store setup.psd](#)



[Click here to download Figure 2 Editor and product library.psd](#) 



Figure 3: An example of the observation window that signals the recording of data.

[Click here to download Figure 3 Observation window.psd](#)

Observation 7 - Event log

Playback Control

Time Behavior Modifier Comment

|       |       |  |  |
|-------|-------|--|--|
| 0,00  | Start |  |  |
| 12,55 |       |  |  |

Status data plugin

|                     |          |           |  |
|---------------------|----------|-----------|--|
| Source name         | Sampl... | Connected | Status                                 |
| General Data Source | 492      | ✓         | Initialized to recognise 4 channels... |

Status event plugin

|                     |        |           |  |
|---------------------|--------|-----------|--|
| Source name         | Events | Connected | Status                                 |
| Virtual Shop Events | 0      | ✓         | Initialized to recognise 4 behavior... |



Figure 4: The visualization window displayed in the data management program. [Click here to download Figure 4 Visualization window.psd](#)

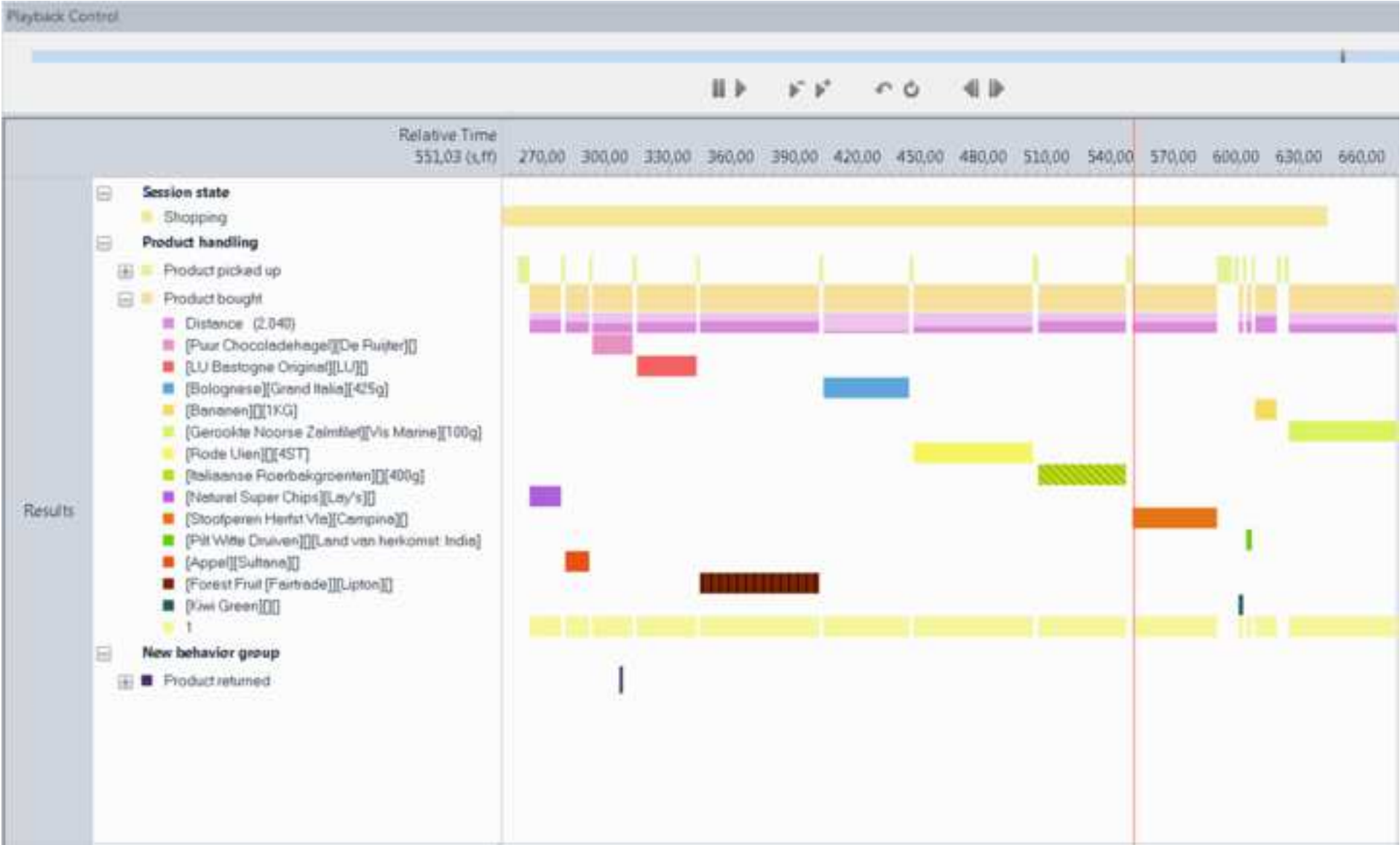
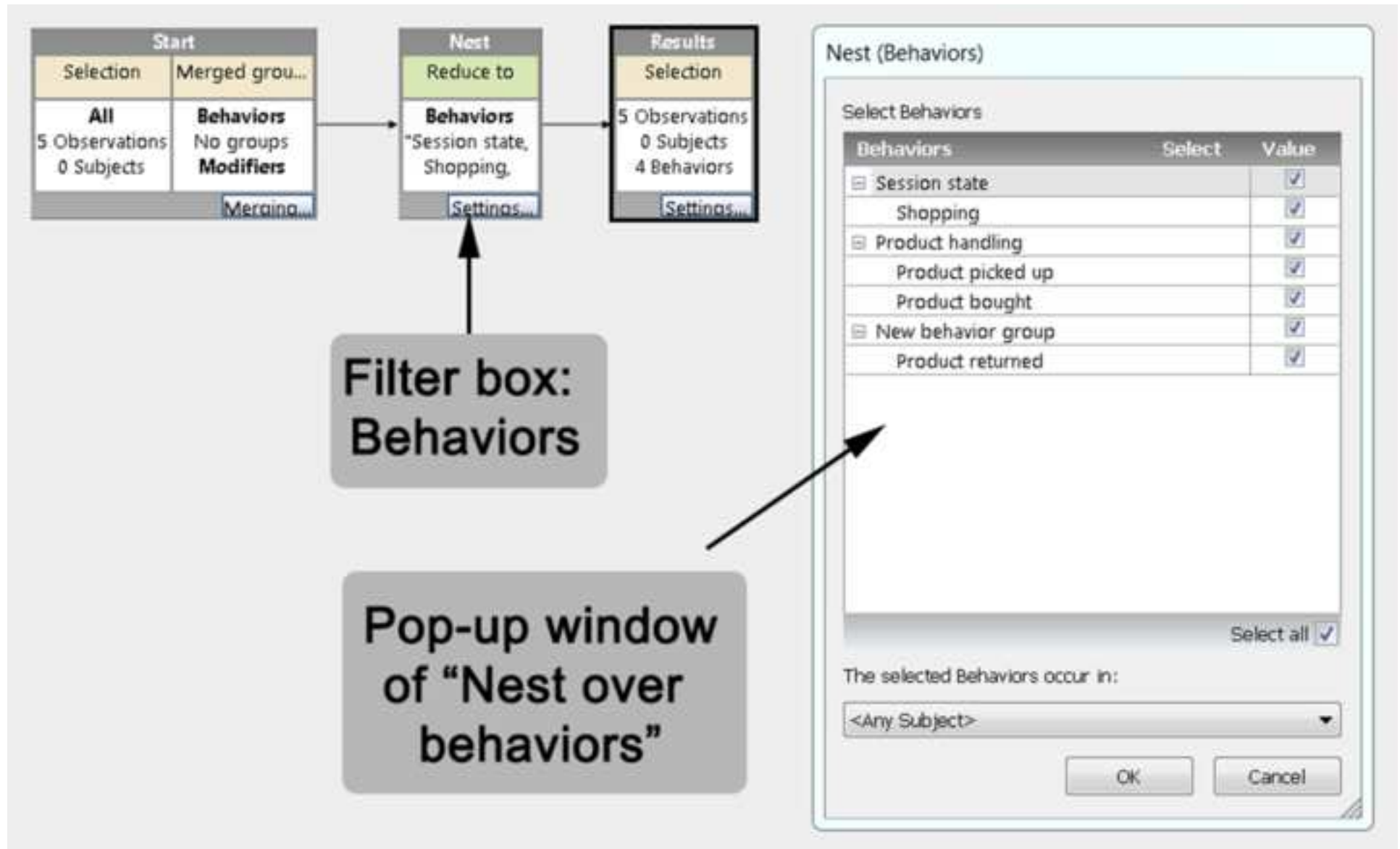


Figure 5: Data profile filter scheme for exporting shopping related behaviors.

[Click here to download Figure 5 Data profile filter\\_shopping related behav.psd](#)



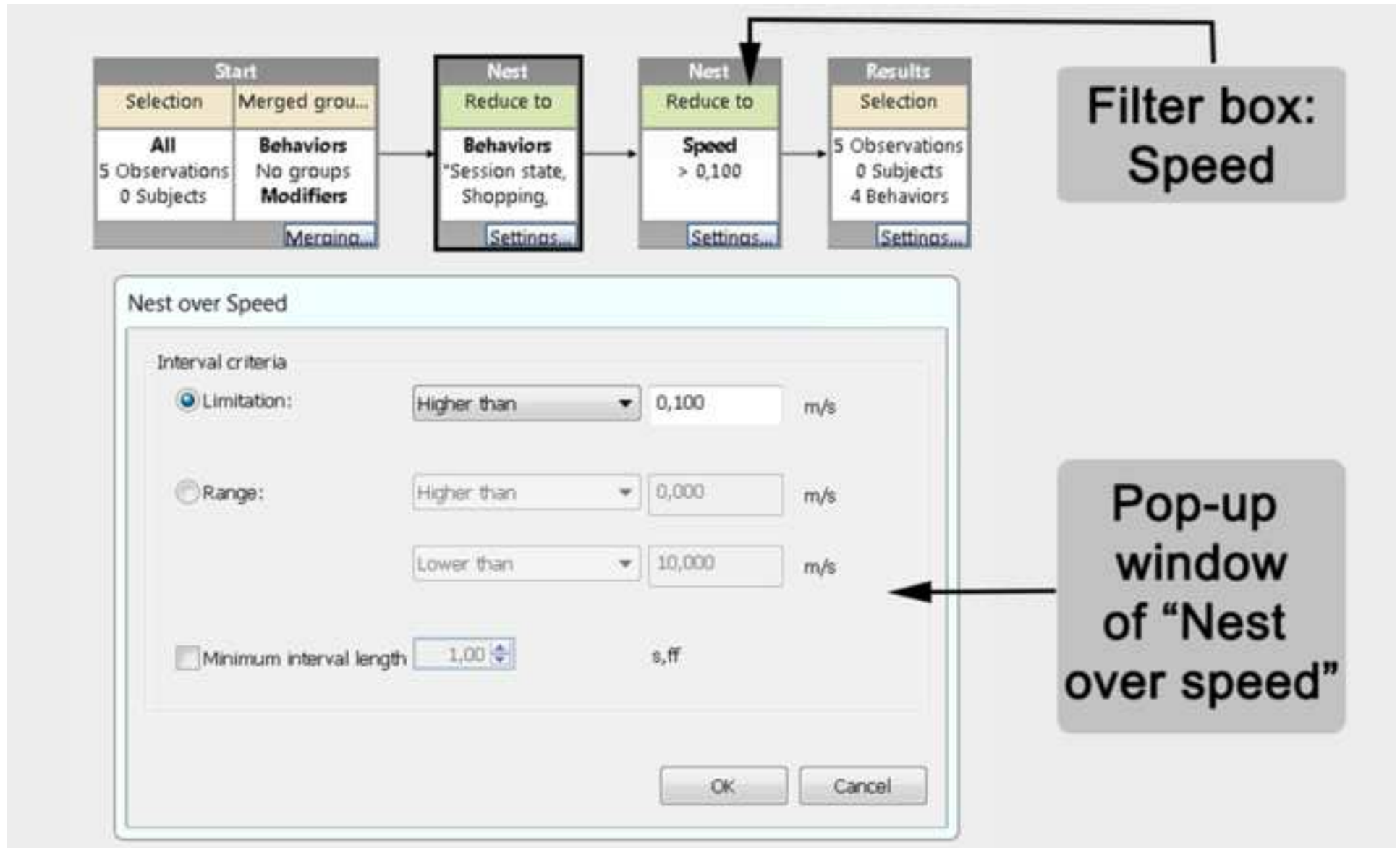


Figure 7: Pictures of four store layouts in the store layout experiment.

[Click here to download Figure 7 Store layouts in an experiment.psd](#)





Figure 8: The total number of products examined (left) and the total number of products purchased (right) in a supermarket with different store layouts (short vs. long shelves

[Click here to download Figure 8 Product examined and product purchased.psd](#)

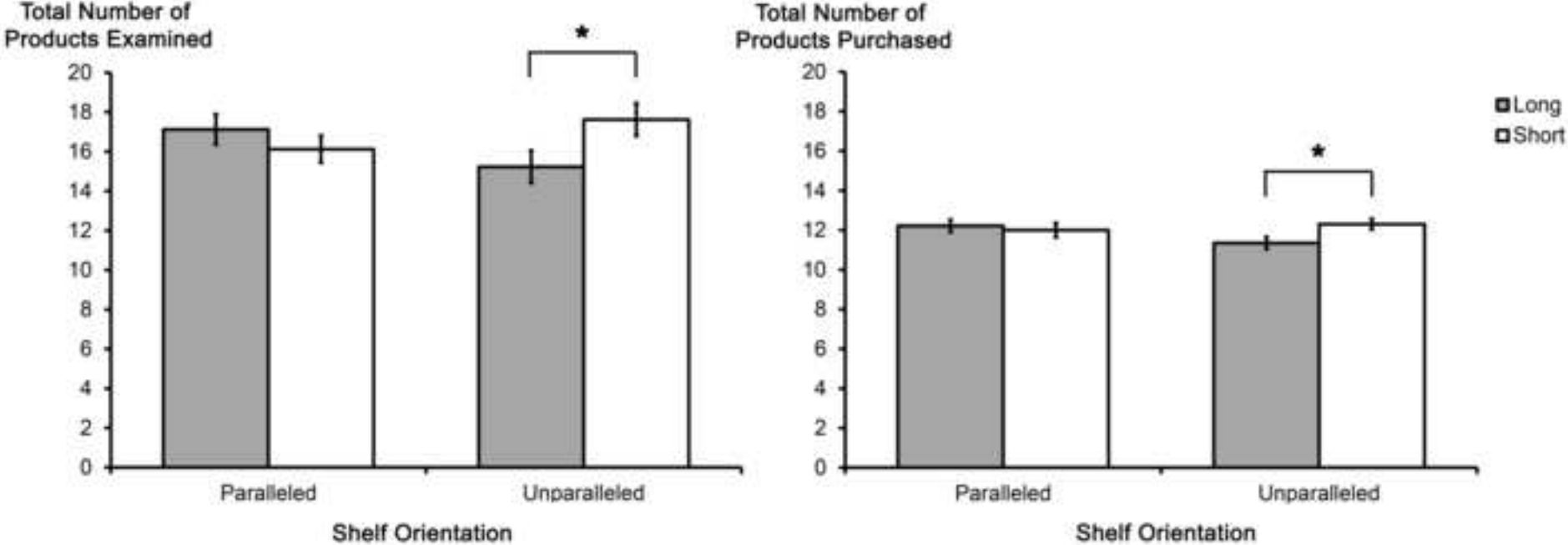


Figure 9: Total shopping time (sec) participants spent in the supermarket with different shelf lengths and shelf orientations.

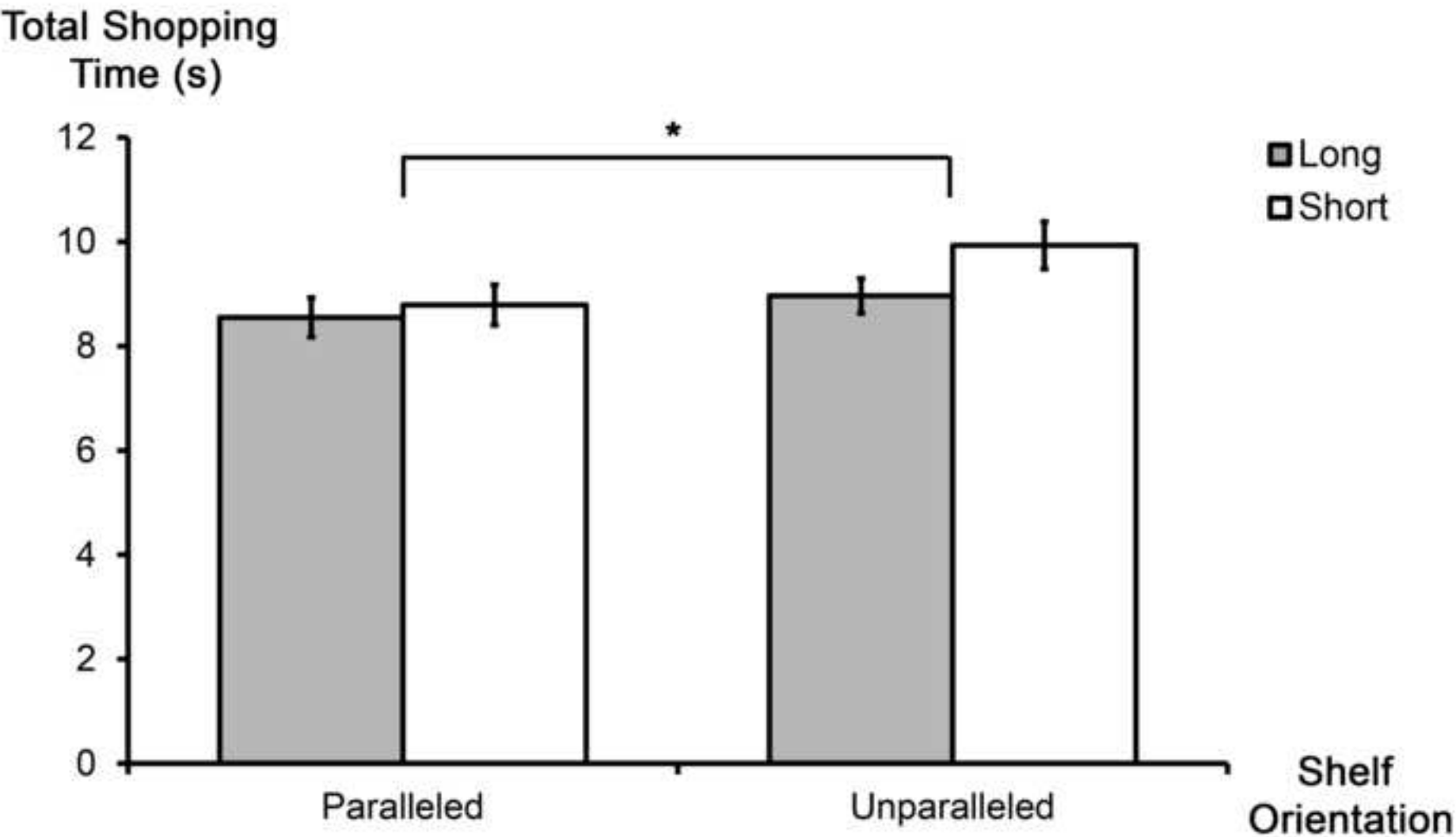


Figure 10: The walking distance of participants in the supermarket with different shelf lengths and shelf orientations.

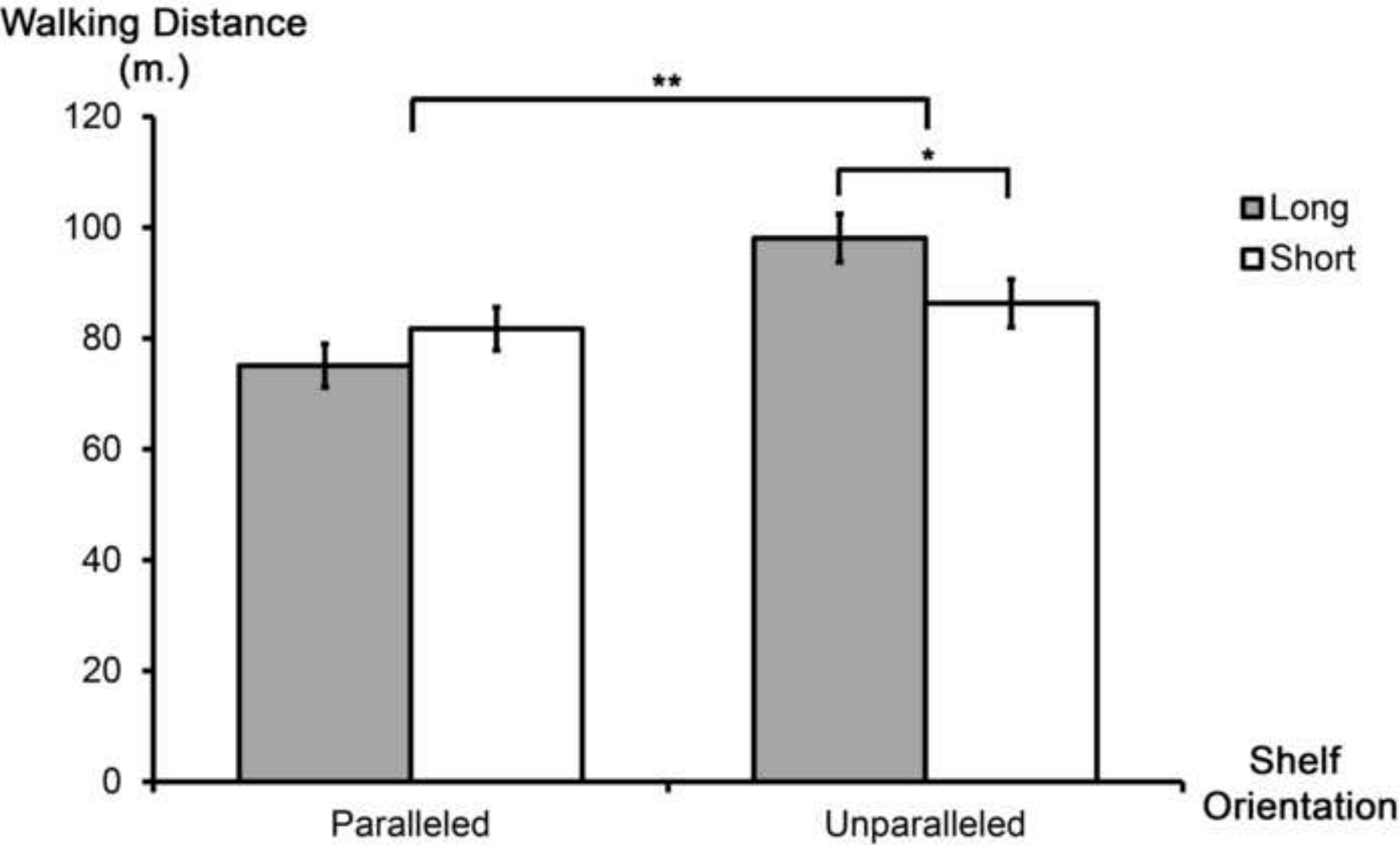


Figure 11: An example of a product in 3D model (left) and 2D model (right).

[Click here to download Figure 11 3D and 2D models.psd](#)



Table 1: Examples of shopping related behavioral data of each participant (total shopping time, total number of products

[Click here to download Table 1 Shopping related behavior.xlsx](#)

| Result Containers | Observations  | Behaviors         | Mean    | Total duration | Rate per minute (observation duration) | Total number |
|-------------------|---------------|-------------------|---------|----------------|--|--------------|
| Results           | Observation 1 | Shopping          | 578.632 | 578.632        | 0.0590102                              | 1            |
| Results           | Observation 1 | Product picked up | 3.55356 | 113.714        | 1.88833                                | 32           |
| Results           | Observation 1 | Product bought    | 28.1741 | 366.264        | 0.767132                               | 13           |
| Results           | Observation 2 | Shopping          | 400.5   | 400.5          | 0.0887163                              | 1            |
| Results           | Observation 2 | Product picked up | 2.50967 | 37.645         | 1.33074                                | 15           |
| Results           | Observation 2 | Product bought    | 29.0326 | 377.423        | 1.15331                                | 13           |
| Results           | Observation 2 | Product returned  | -       | -              | 0.0887163                              | 1            |
| Results           | Observation 3 | Shopping          | 182.537 | 730.148        | 0.235446                               | 4            |
| Results           | Observation 3 | Product picked up | 5.32313 | 79.847         | 0.882924                               | 15           |
| Results           | Observation 3 | Product bought    | 71.0311 | 710.311        | 0.588616                               | 10           |
| Results           | Observation 3 | Product returned  | -       | -              | 0.0588616                              | 1            |
| Results           | Observation 4 | Shopping          | 570.07  | 570.07         | 0.0656902                              | 1            |
| Results           | Observation 4 | Product picked up | 4.32891 | 99.565         | 1.51088                                | 23           |
| Results           | Observation 4 | Product bought    | 21.8755 | 306.257        | 0.919663                               | 14           |
| Results           | Observation 4 | Product returned  | -       | -              | 0.13138                                | 2            |
| Results           | Observation 5 | Shopping          | 400.547 | 400.547        | 0.129493                               | 1            |
| Results           | Observation 5 | Product picked up | 2.29655 | 50.524         | 2.84884                                | 22           |
| Results           | Observation 5 | Product bought    | 19.8386 | 277.74         | 1.8129                                 | 14           |

| Observations  | Motivation | Participant number | Store | Duration | Start time  | Stop time   |
|---------------|------------|--------------------|-------|----------|-------------|-------------|
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43 PM | 12:19:40 PM |
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43 PM | 12:19:40 PM |
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43 PM | 12:19:40 PM |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 1:00:08 PM  | 1:11:24 PM  |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 1:00:08 PM  | 1:11:24 PM  |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 1:00:08 PM  | 1:11:24 PM  |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 1:00:08 PM  | 1:11:24 PM  |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 1:17:25 PM  | 1:34:25 PM  |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 1:17:25 PM  | 1:34:25 PM  |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 1:17:25 PM  | 1:34:25 PM  |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 1:17:25 PM  | 1:34:25 PM  |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 1:34:56 PM  | 1:50:10 PM  |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 1:34:56 PM  | 1:50:10 PM  |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 1:34:56 PM  | 1:50:10 PM  |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 1:34:56 PM  | 1:50:10 PM  |
| Observation 5 | 1          | 5                  | 2     | 463.346  | 2:12:05 PM  | 2:19:48 PM  |
| Observation 5 | 1          | 5                  | 2     | 463.346  | 2:12:05 PM  | 2:19:48 PM  |
| Observation 5 | 1          | 5                  | 2     | 463.346  | 2:12:05 PM  | 2:19:48 PM  |

Table 2: Examples of movement related data (the moving speed and the walking position of each participant) exported from the

[Click here to download Table 2 Movement related data.xlsx](#)

| Observations  | Result Containers | Behaviors         | Modifiers | External data | Minimum | Maximum | Mean    | Total duration |
|---------------|-------------------|-------------------|-----------|---------------|---------|---------|---------|----------------|
| Observation 1 | Results           | Product picked up | Distance  | PositionX     | 0       | 0       | 0       | 0              |
| Observation 1 | Results           |                   |           | PositionY     | 0       | 0       | 0       | 0              |
| Observation 1 | Results           |                   |           | PositionZ     | 0       | 0       | 0       | 0              |
| Observation 1 | Results           |                   |           | Speed (m/s)   | 0       | 0       | 0       | 0              |
| Observation 1 | Results           |                   |           |               | 0.94    | 2.02    | 1.62333 | 0.15121        |
| Observation 1 | Results           |                   |           |               | 0.94    | 2.67    | 1.68418 | 128.295        |
| Observation 2 | Results           | Product bought    | Distance  | PositionX     | 0       | 0       | 0       | 0              |
| Observation 2 | Results           |                   |           | PositionY     | 0       | 0       | 0       | 0              |
| Observation 2 | Results           |                   |           | PositionZ     | 0       | 0       | 0       | 0              |
| Observation 2 | Results           |                   |           | Speed (m/s)   | 0       | 0       | 0       | 0              |
| Observation 2 | Results           |                   |           |               | 1.01    | 2.58    | 1.82346 | 114.3          |
| Observation 2 | Results           |                   |           |               |         |         |         |                |
| Observation 3 | Results           | Product bought    | Distance  | PositionX     | 0       | 0       | 0       | 0              |
| Observation 3 | Results           |                   |           | PositionY     | 0       | 0       | 0       | 0              |
| Observation 3 | Results           |                   |           | PositionZ     | 0       | 0       | 0       | 0              |
| Observation 3 | Results           |                   |           | Speed (m/s)   | 0       | 0       | 0       | 0              |
| Observation 3 | Results           |                   |           |               | 1.09    | 2.63    | 1.48896 | 229            |
| Observation 3 | Results           |                   |           |               |         |         |         |                |
| Observation 4 | Results           | Product picked up | Distance  | PositionX     | 0       | 0       | 0       | 0              |
| Observation 4 | Results           |                   |           | PositionY     | 0       | 0       | 0       | 0              |
| Observation 4 | Results           |                   |           | PositionZ     | 0       | 0       | 0       | 0              |
| Observation 4 | Results           |                   |           | Speed (m/s)   | 0       | 0       | 0       | 0              |
| Observation 4 | Results           |                   |           |               | 1.82    | 1.82    | 1.82    | 0.029213       |
| Observation 4 | Results           |                   |           |               | 1       | 2.5     | 1.29911 | 100.1          |
| Observation 5 | Results           | Product bought    | Distance  | PositionX     | 0       | 0       | 0       | 0              |
| Observation 5 | Results           |                   |           | PositionY     | 0       | 0       | 0       | 0              |
| Observation 5 | Results           |                   |           | PositionZ     | 0       | 0       | 0       | 0              |
| Observation 5 | Results           |                   |           | Speed (m/s)   | 0       | 0       | 0       | 0              |
| Observation 5 | Results           |                   |           |               | 1.13    | 2.37    | 1.51552 | 82.4           |
| Observation 5 | Results           |                   |           |               |         |         |         |                |

| Observations  | Minimum | Maximum | Mean       | Number of samples | Motivation | Participant number | Store | Duration | Start time  | Stop time   |
|---------------|---------|---------|------------|-------------------|------------|--------------------|-------|----------|-------------|-------------|
| Observation 1 | -4.6    | 5       | -0.176714  | 1549              | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 0.9     | 1.4     | 1.39335    | 1549              | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | -4.5    | 4.5     | -0.0838864 | 1549              | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 0.11    | 1.45    | 0.522647   | 1549              | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 0       | 0       | 0          | 0                 | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 0       | 0       | 0          | 0                 | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 2 | -4.6    | 5       | -0.437633  | 1183              | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 2 | 0.4     | 1.4     | 1.30374    | 1183              | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 2 | -4.51   | 4.48    | -1.24505   | 1183              | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 2 | 0.11    | 1.45    | 0.713719   | 1183              | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 2 | 0       | 0       | 0          | 0                 | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 3 | -4.6    | 4.99    | -0.660736  | 2378              | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 3 | 0.4     | 1.4     | 1.32214    | 2378              | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 3 | -4.5    | 2.83    | -1.4969    | 2378              | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 3 | 0.11    | 1.52    | 0.645114   | 2378              | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 3 | 0       | 0       | 0          | 0                 | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 4 | -4.6    | 5       | -1.55204   | 1813              | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 0.4     | 1.4     | 1.28643    | 1813              | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | -4.5    | 4.5     | -0.0923607 | 1813              | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 0.11    | 1.54    | 0.579509   | 1813              | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 0       | 0       | 0          | 0                 | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 0       | 0       | 0          | 0                 | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 5 | -4.6    | 1.2     | -0.562364  | 1265              | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |
| Observation 5 | 0.4     | 1.4     | 1.19858    | 1265              | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |
| Observation 5 | -4.5    | 2.8     | -0.590324  | 1265              | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |
| Observation 5 | 0.11    | 1.51    | 0.603273   | 1265              | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |
| Observation 5 | 0       | 0       | 0          | 0                 | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |



Table 3: Examples of moving duration (indicated in the shopping duration column) exported from the data management program. [Click here to download Table 3 Moving duration.xlsx](#) 

| Result Containers | Observations  | Behaviors         | Mean      | Total duration | Rate per minute (observation duration) | Total number |
|-------------------|---------------|-------------------|-----------|----------------|--|--------------|
| Results           | Observation 1 | Shopping          | 1.16466   | 154.9          | 7.84835                                | 133          |
| Results           | Observation 1 | Product picked up | 0.0504033 | 0.15121        | 0.17703                                | 3            |
| Results           | Observation 1 | Product bought    | 1.30913   | 128.295        | 5.783                                  | 98           |
| Results           | Observation 2 | Shopping          | 1.37558   | 118.3          | 7.6296                                 | 86           |
| Results           | Observation 2 | Product bought    | 1.41111   | 114.3          | 7.18602                                | 81           |
| Results           | Observation 3 | Shopping          | 1.39882   | 237.8          | 10.0065                                | 170          |
| Results           | Observation 3 | Product bought    | 1.40491   | 229            | 9.59444                                | 163          |
| Results           | Observation 4 | Shopping          | 1.20867   | 181.3          | 9.85353                                | 150          |
| Results           | Observation 4 | Product picked up | 0.029213  | 0.029213       | 0.0656902                              | 1            |
| Results           | Observation 4 | Product bought    | 1.26709   | 100.1          | 5.18953                                | 79           |
| Results           | Observation 5 | Shopping          | 1.30412   | 126.5          | 12.5608                                | 97           |
| Results           | Observation 5 | Product bought    | 1.42069   | 82.4           | 7.51059                                | 58           |

| Observations  | Motivation | Participant number | Store | Duration | Start time  | Stop time   |
|---------------|------------|--------------------|-------|----------|-------------|-------------|
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 1 | 1          | 1                  | 1     | 1016.77  | 12:02:43.20 | 12:19:39.97 |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 2 | 1          | 2                  | 1     | 676.314  | 13:00:07.63 | 13:11:23.94 |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 3 | 2          | 3                  | 1     | 1019.34  | 13:17:25.23 | 13:34:24.57 |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 4 | 2          | 4                  | 1     | 913.378  | 13:34:56.22 | 13:50:09.60 |
| Observation 5 | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |
| Observation 5 | 1          | 5                  | 2     | 463.346  | 14:12:04.95 | 14:19:48.29 |

| Name of Material/ Equipment                    | Company                            | Catalog Number   | Comments/Description   |
|--|------------------------------------|--|--|
| Virtual Supermarket Software                   | GreenDino BV                       | <a href="http://www.greendino.nl/virtual-labs.html">http://www.greendino.nl/virtual-labs.html</a>  | This software consists of editor, product library and consumer interface.  |
| Data Management Software: Observer XT          | Noldus Information Technology      | <a href="http://www.noldus.com/human-behavior-research/products/the-observer-xt">http://www.noldus.com/human-behavior-research/products/the-observer-xt</a>                        | This software records observational data and facilitates the exportation of researcher-specified data sets using filters   |
| 3D SpaceNavigator                              | 3Dconnexion                        | <a href="http://www.3dconnexion.eu/index.php?id=26&amp;redirect2=www.3dconnexion.eu">http://www.3dconnexion.eu/index.php?id=26&amp;redirect2=www.3dconnexion.eu</a>                | A 3D SpaceNavigator allows participants to walk and make turns in the virtual store. In addition, it can be used by participants to adjust their eye-level during a shopping trip. |
| 3D modeling software (e.g. Blender or 3DS Max) | Blender Foundation / Autodesk      | <a href="https://www.blender.org/">https://www.blender.org/</a><br><a href="http://www.autodesk.nl/products/3ds-max/overview">http://www.autodesk.nl/products/3ds-max/overview</a> | In case 3D models need to be made or adjusted 3D modeling software is needed. Many objects can be found online under different licencing agreements.                               |
| Contract Reseach                               | Wageningen Univeristy and Research | <a href="http://www.wur.nl/en/Expertise-Services/Research-Institutes/Economic-Research.htm">http://www.wur.nl/en/Expertise-Services/Research-Institutes/Economic-Research.htm</a>  | The socio-economic research institute (Wageningen Economic Research) with experience in conducting the consumer research with the virtual store.                                   |



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### CORRESPONDING AUTHOR:

|                |   |                  |
|----------------|---|------------------|
| Name:          | Ploydanai, Kunalai  |                  |
| Department:    | Marketing and Consumer Behaviour Group  |                  |
| Institution:   | Wageningen University and Research  |                  |
| Article Title: | Using a virtual supermarket as a research tool to investigate consumer in-store behavior. |                  |
| Signature:     |        | Date: 16/11/2016 |

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## Response to the editor.

Following your comments (shown in italic), the manuscript has been revised as follows:

Note: The line number in this revision note represents the line number of the final manuscript without track changes.

**Comment1:** *Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammatical errors.*

**Authors' response:** The manuscript has been carefully proofread to avoid spelling and grammatical errors.

**Comment2:** *Protocol Detail:*

**Comment2.1:** *7.3: It isn't obvious what is to be done here. What would you show when this step is filmed.*

**Authors' response:** We agree that it is not necessary to include this step in the video because we will only be able to show this step by letting a participant sit in a specific area and complete the task on paper. Therefore, this step has been unhighlighted.

**Comment2.2:** *7.9: What is the experimental condition entered?*

**Authors' response:** The experimental condition depends on the research interest. We have given examples of the experimental conditions in the revised manuscript. (see step 7.7, line 400 - 402).

**Comment2.3:** *7.11: Do you mean switch the computer?*

**Authors' response:** No, we mean the same virtual store computer that has been used in the practice test. In the previous step, after completing the practice test, the participant has been moved to another area to complete the task to manipulate the specific shopping motivation. In the 7.11 steps, the participant should be moved back to the virtual store computer to start the main test.

Since the length of protocol in the video is limited, we decide to skip filming the practice test and the manipulation task. To ensure that the flow of the video is logical, we added a sentence *"Seat the participant in front of the middle LCD screen and adjust the chair until the participant's eye-level matches with the position of the screens."* We propose to include only this sentence in the video and skip the previous sentence saying *"Move the participant from another area, where they have been assigned a task to manipulate shopping motivation, back to the virtual store after he/she finishes the manipulation task."*

**Comment2.4:** *7.13: What are the instructions?*

**Authors' response:** These are the instructions of a shopping task and the way to maneuver in the virtual store. Examples of the instructions are provided in Supplements 1 and Supplements 4 as referred to in step 7.11, line 425 – 426.

**Comment2.5:** 7.16: Which computer is this on?

**Authors' response:** We apologize for the unclear step. This step refers to the computer in which the data management program has been installed and run. The sentence “*Check the data management program in another computer*” is added to clarify this step (see step 7.15 line 442 - 443).

**Comment2.6:** 7.20: What is the questionnaire about?

**Authors' response:** The questionnaire measures participant's shopping experiences, perceptions about the store, and willingness to revisit the store. This more detailed information about the questionnaire is now added to step 7.16 in step 7.16, line 449 – 451.

**Comment3:** *Protocol Numbering: Please adjust the numbering of your protocol section to follow JoVE's instructions for authors, 1. should be followed by 1.1. and then 1.1.1. if necessary and all steps should be lined up at the left margin with no indentations. There must also be a one-line space between each protocol step, and notes.*

**Authors' response:** We apologize for misunderstanding the protocol numbering format. The numbering of our revised protocol has been adjusted according to this guideline.

**Comment4:** *Protocol Highlight: After you have made all of the recommended changes to your protocol (listed above), please re-evaluate the length of your protocol section. There is a 10-page limit for the protocol text, and a 2.75- page limit for filmable content. If your protocol is longer than 3 pages, please highlight 2.75 pages or less of text (which includes headings and spaces) in yellow, to identify which steps should be visualized to tell the most cohesive story of your protocol steps. Please see JoVE's instructions for authors for more clarification. Remember that the non-highlighted protocol steps will remain in the manuscript and therefore will still be available to the reader.*

**Comment4.1:** *Notes cannot be filmed and should be excluded from highlighting.*

**Comment4.2:** *The highlighted steps should form a cohesive narrative, that is, there must be a logical flow from one highlighted step to the next.*

**Comment4.3:** *Please highlight complete sentences (not parts of sentences). Include sub-headings and spaces when calculating the final highlighted length (2.75 pages or less). Please see JoVE's instructions for authors for more information.*

**Authors' response:** We have reconsidered the protocol steps to be included in the video and highlighted them according to the requirements of JoVE.

Because the length of highlighted protocol is limited, we need to skip the practice test and the motivation manipulation task described in the protocol and focus only on the protocol step for the main test. However, since some details of the protocol used in the main test



have been described in the practice test or other steps excluded in the video, it is difficult to make a logical flow by highlighting only the protocol steps in the main test without any modification. Thus, we have rearranged and modified the steps we would like to include in the video and attach this to these revision notes. Some steps from the experimental preparation heading and the pretest heading are included in the main test to make a better flow. Please consider using the protocol we have proposed to make the video.

**Comment4.4:** *Some of your shorter protocol steps can be combined so that individual steps contain 2-3 actions and maximum of 4 sentences per step.*

**Authors' response:** Most of the shorter protocol steps have been combined according to your suggestion. However, some protocol steps that may confuse readers if they were combined, such as step 7.8 that explains the criteria to check the recording program, remain short. Similarly, the steps 7.18 – 7.21 that refer to different topics remain separated.

**Comment4.5:** *6.1 was unhighlighted as there is nothing filmable.*

**Authors' response:** We agree with you to unhighlight this step.

**Comment4.6:** *7.21 looks important and interesting, can it be highlighted?*

**Authors' response:** Yes, this step has been highlighted in the revised manuscript and also has been included in our proposed protocol to make a video attached in these revision notes.

**Comment4.7:** *A few steps that include handing instructions to participants don't have any specific filmable content, please unhighlight if appropriate.*

**Authors' response:** These steps without filmable content have been unhighlighted.

**Comment5:** *Results: Please report all numerical values of results in the text. Please specify the format of quantitative results presented, for example, was mean  $\pm$  standard deviation used?*

**Authors' response:** Numerical values have been added to the results in the request format (see line 608 - 617 and line 628 – 637).

**Comment6:** *Tables: ) Table 1: Is column 1 left blank intentionally?*

**Authors' response:** The column 1 in all tables is blank because this is an original format of the table exported from the data management program. However, to avoid confusion of the readers, we have removed the first column from the tables.

Ploydanai, Kunalai  
kunalai.ploydanai@wur.nl

January 31, 2017

Dear Dr. Dsouza,

Thank you for the opportunity to revise our manuscript, entitled "Using a virtual supermarket as a research tool to investigate consumer in-store behavior", JoVE55719.

We appreciate the careful review and insightful suggestions from you and reviewer team. We carefully considered your comments as well as those offered by the four reviewers.

Herein, we summarize how we revised the paper based on the review team's collective input. The following revision has been made:

1. The paper has been proofread to minimize spelling and grammatical errors, to minimize the use of the pronoun "we" and the use of commercial language.
2. The objective of the paper in a short abstract, an extended abstract and the introduction are improved. The objective is now clearer and more specific to the virtual supermarket that we present.
3. The introduction has been strengthened by including other theories on presence and immersion and by moving information about the advantages of using a virtual store to the discussion section.
4. The protocol has been improved by providing detailed steps of protocol in imperative tense. The numbering and format of our revised protocol have also been adjusted to match JoVE's instructions for authors.
5. The experimental conditions are explained in detail and depicted to improve the representative results. Additionally, the effect of shopping motivation is clearly stated.
6. Information about other virtual store systems as well as their limitations is provided in a discussion. In addition, practical information is briefly discussed.
7. The protocol and representative results that should be included in the video have been highlighted based on JoVE's instructions for authors.
8. The quality of the figures has been improved.
9. Separate tables are provided in excel files.
10. References have been revised to match the JoVE format for reference.

It is our belief that the manuscript is substantially improved after making the suggested revisions. Following this letter are the reviewer comments with our responses, including how and where the text was modified. The revision has been developed in consultation with all co-authors, and each author has given approval to the final form of this revision.

Sincerely,

Kunalai Ploydanai, MSc

## Response to the editor.

Following the editor's comments (shown in italic), the manuscript has been revised as follows:

**Comment1:** *Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammatical errors.*

**Authors' response:** The manuscript has been carefully checked to avoid spelling and grammatical errors.

**Comment2:** *Please minimize use of the pronoun "we" throughout the manuscript.*

**Authors' response:** The use of "we" has been reduced in the revised version.

**Comment3:** *Please include an ethics statement before your numbered protocol steps indicating that the protocol follows the guidelines of your institutions human research ethics committee.*

**Authors' response:** We have accordingly included the ethics statement in the beginning of the protocol steps (line 151 - 153).

**Comment4: Abstracts:** *Please re-word the Short Abstract to more clearly state the goal of the protocol. For example, "This protocol/manuscript describes..."*

**Authors' response:** The short abstract has been improved in a clearer way as shown below:

This paper describes the use of a desktop virtual store to create virtual shopping environments and investigate in-store consumer behavior. A description of the protocol to build and run experiments, example results from an experiment concerning store layout and important considerations when conducting virtual store experiments are presented.

**Comment5: Protocol Language:** *Please ensure that all text in the protocol section is written in the imperative tense as if you are telling someone how to do the technique (i.e. "Do this", "Measure that" etc.) Any text that cannot be written in the imperative tense may be added as a "Note", however, notes should be used sparingly and actions should be described in the imperative tense wherever possible.*

*1) The protocol section should be made up almost entirely of discrete steps, without large paragraphs of text between sections. Please break up the paragraphs into simple steps (with 2-3 actions per step) as much as possible throughout the protocol. Alternatively, please consider moving long paragraph style text (Lines 115 to 178 and 313 to 332) to the introduction or Discussion.*

**Authors' response:** The revised protocol is written in discrete and simple steps and written in the imperative tense. Following changes are made:

- Lines 115 to 134 have been rewritten and moved to the introduction (line 133 - 145)
- Lines 135 – 178 have been shortened and moved to discussion (line 608 - 623)
- Other parts of the protocol have been removed or rewritten, such as lines 313 to 332 have been removed.

**Comment6:** 2) Lines 183-184, 223-227: These should be “notes”

**Authors’ response:** To improve the revised protocol, we have changed the text in these lines as follows:

- ☐ Lines 183 – 184 have been removed.
- ☐ Lines 223 – 227 have been rewritten and included in the protocol (line 158 - 161).

**Comment8: Protocol Detail:** Please add more details to the ALL protocol steps. There should be enough detail in each step to supplement the actions seen in the video so that viewers can easily replicate the protocol. Please ensure that all additional details in the protocol section are written in the imperative tense, as if you are telling someone how to do the technique (i.e. “Do this”, “Measure that” etc.).

1) ALL steps: What would you show each step was filmed? Please provide details of menu selections and button clicks to perform each software action. These pieces of information are necessary for proper scripting and filming for a successfully reproducible protocol. Think about a possible demo example and use that to rewrite ALL your protocol steps.

**Authors’ response:** The comprehensive details of menu selection and button clicks are provided in the revised protocol in imperative tense. These details should enable readers to replicate the protocol and facilitate film makers to make a script.

**Comment7: Protocol Numbering:** Please adjust the numbering of your protocol section to follow JoVE’s instructions for authors, 1. should be followed by 1.1. and then 1.1.1. if necessary and all steps should be lined up at the left margin with no indentations. There must also be a one-line space between each protocol step.

**Authors’ response:** The numbering and format of our revised protocol have been adjusted to match JoVE’s instructions for authors.

**Comment8: Protocol Highlight:** After you have made all of the recommended changes to your protocol (listed above), please re-evaluate the length of your protocol section. There is a 10-page limit for the protocol text, and a 3- page limit for filmable content. If your protocol is longer than 3 pages, please highlight 2.75 pages or less of text (which includes headings and spaces) in yellow, to identify which steps should be visualized to tell the most cohesive story of your protocol steps. Please see JoVE’s instructions for authors for more clarification. Remember that the non-highlighted protocol steps will remain in the manuscript and therefore will still be available to the reader.

1) The highlighting must include all relevant details that are required to perform the step. For example, if step 2.5 is highlighted for filming and the details of how to perform the step are given in steps 2.5.1 and 2.5.2, then the sub-steps where the details are provided must be included in the highlighting.

- 2) Please ensure that the highlighted part of the step includes at least one action that is written in imperative tense.
- 3) The highlighted steps should form a cohesive narrative, that is, there must be a logical flow from one highlighted step to the next.
- 4) Please highlight complete sentences (not parts of sentences). Include sub-headings and spaces when calculating the final highlighted length (2.75 pages or less). Please see JoVE's instructions for authors for more information.
- 5) Notes cannot be filmed and should be excluded from highlighting.
- 6) Please remember that software steps without a graphical user interface cannot be filmed.

**Authors' response:** We have reconsidered the protocol steps to be included in the video and highlight them according to the requirements of JoVE (see page 4 - 11). The highlighted steps are 2.75 pages long and filmable.

**Comment9: Discussion:** JoVE articles are focused on the methods and the protocol, thus the discussion should be similarly focused. Please ensure that the discussion covers the following in detail and in paragraph form: 1) modifications and troubleshooting, 2) limitations of the technique, 3) significance with respect to existing methods, 4) future applications and 5) critical steps within the protocol.

**Authors' response:** The revised discussion now covers all requirements. The first paragraph (line 606 - 630) indicates the critical steps within the protocol. The second paragraph presents significance with respect to existing methods (line 631 - 647). The third paragraph (line 648 - 667) and fourth paragraph (line 669 - 700) discusses the limitations of the technique, and modifications and troubleshooting, respectively. The fifth paragraph (line 702 - 721) presents future applications of the virtual store.

**Comment10:** editor's comments about format of the table, the reference, the Commercial Languages and the abbreviation used in the paper.

**Authors' response:** We would like to apologize for using the wrong formats for those parts. The following changes have been made:

1. Individual excel files of each table have been uploaded.
2. The reference format has now been corrected by using the JoVE EndNote style file.
3. All the commercial language has been replaced by the generic term.
4. We have ensured that all abbreviations and symbols are defined at the first use. They are written in the standard format. Single space is used between the numerical value and the unit.

**Comment11:** If your figures and tables are original and not published previously or you have already obtained figure permissions, please ignore this comment. If you are re-using figures from a previous publication, you must obtain explicit permission to re-use the figure from the previous publisher (this can be in the form of a letter from an editor or a link to the editorial policies that allows you to re-publish the figure). Please upload the text of the re-print permission (may be copied and pasted from an email/website) as a Word document to the Editorial Manager site in the "Supplemental files (as requested by JoVE)" section. Please also

*cite the figure appropriately in the figure legend, i.e. "This figure has been modified from [citation]."*

**Authors' response:** The figures used in this manuscript are original, therefore permission is not needed.

## Response to the comments of Reviewer 1.

We would first like to thank you for your constructive suggestions which have helped us to improve the quality of the manuscript. We reply to all of your comments (repeated in italics), in the risen order.

**Comment1:** *This is an interesting paper and clearly about a new and promising way of carrying out in-store experiments. I am convinced it has great potentials as a research tool.*

**Authors' response:** We appreciate your positive feedback.

**Comment2:** *But the structure needs to be improved. For instance Line 72 to 114 is a making a good case of the promise of the technology already before the start of the paper is getting started.*

*\*It would fit better in the discussion with pros and cons listed - strengths and weaknesses. A table might help do the trick. But discussion rather than intro.*

*\*My main concern is that the paper is mainly attempting to make case - that is demonstrating the promise of the VR technology to study consumer behaviour.*

**Authors' response:** In response to the reviewer's comments, we accordingly moved the discussion of the benefits of VS to the discussion section of the paper (line 631 - 647) in revised manuscript).

**Comment3:** *In that sense the paper is primarily descriptive in the way that it goes through the different steps in an experiment. I consider it more a "recipe" book and users manual - a very good one though - than a proof of the reach of the technology.*

**Authors' response:** We have taken this comments into account by focusing on one specific procedure (as can be seen in the revised protocol and description of example experiment). This example shows how researchers can apply the desktop virtual supermarket in consumer research.

**Comment4:** *The weakness is that the paper in its present form is a sort of - with all due respect - "lets tell everything that we know about the thing". The lack of a clear paper structure becomes clear in the introduction that fails to state a clear purpose of the paper. Why is this paper needed - besides describing an interesting and novel technology.*

**Authors' response:** Thank you for pointing out this weakness. We have strengthened our paper by explicitly stating the importance of our paper in line 126 - 132 as shown below:

Even though the virtual store has been regarded as a promising tool for in-store consumers' behavior research, expertise in how to use such a virtual store is required to ensure timely and correct preparation and implementation of experiments. Yet, up to now, reported studies that comprehensively describe the procedure to conduct virtual store experiments are very scarce. Therefore, our work aims to describe a protocol for conducting consumer research with the desktop virtual store, which is of vital importance.

**Comment5:** *The paper could be improved by giving an example on how the tool can be used to understand and maybe even to test a virtual intervention. A fair attempt is given in line 336 and on but it is not completely clear what new insight that this experiment showed*

**Authors' response:** We apologize for the unclear experimental description. More details of the experimental conditions, store pictures in each condition, the procedure, and a summary of findings have been added to the paper (line 443 - 473). This additional information is expected to clarify the new insights gained from VS experiments. Basically, the representative results support that in-store consumer behavior research (e.g., effects of shelf arrangements), which may not be convenient to do in the real store, can flexibly be conducted in the virtual store.

**Comment6:** *Needless to say writing papers in this field is difficult since the technology needs to be "sensed" in real life rather than in a paper. But I think the authors could do more to "walk the reader through". References are done in parenthesis but could be made more active by using phrasing such a "as can be seen in the first picture .....".*

**Authors' response:** Thank you for your understanding and suggestions. The references of figures throughout the revised paper have been changed according to your suggestion.



## Response to the comments of Reviewer 2.

We would like to thank the reviewer for the time and feedback to improve our paper. We will respond to the comments (repeated in italics), in the order in which these are risen.

**Comment1:** *This is an interesting article and it is a great idea to publish the virtual supermarket method as a video! Overall, the manuscript is well written,*

**Authors' response:** Thank you for your encouraging words.

**Comment2:** *however, it reads more like a normal paper rather than an outline that could directly be used to produce a video.*

**Authors' response:** We agree with your comment that the paper should be used as an outline to run an experiment and to produce a video. This video should enable researchers to replicate our protocol. Accordingly, the protocol has thus been rewritten in more specific steps that can be used to produce a video (in page 4 - 12). Some more general suggestions from the previous version of the protocol have been moved to the discussion section (see line 608 - 630).

**Comment3:** *The highlights in the protocol section are useful, but it is unclear which sections of the example results or the discussions would be included. The format of the video is not specified and at this stage it is not clear, which information will be in it. E.g. Will the example results be discussed in the video or are they just for illustration. If they are just for illustration, I suggest to only present the relevant information in this protocol and refer to a paper for the details.*

**Authors' response:** We apologize for the unclear information. We plan to present a table and several figures to illustrate the results that researchers can acquire from the virtual store and the data management program. Specifically, after presenting how to export the data, Table 1 then illustrates the results from the data management program. Then Figure 8 - 10 show the effect of store layouts on products examined and products bought. The examples demonstrate how to interpret and present data from the VS. In addition, a brief discussion will be presented in a video.

However we have contacted the editor and we have been informed that the introduction, results and discussion will be part of the video but parts of those do not need highlighting.

**Comment4:** *Results*

*The aim of the study should be clearly stated at the beginning of this section - e.g. Testing the effect of different store layouts on the number of product purchases.*

**Authors' response:** Thank you for pointing this out. The aim of the study has now been explicitly stated in the revised paper (line 443 - 446). We additionally provide more details of the experiment to clarify the representative results.

**Comment5:** *If these results are presented as example in the video, this should be mentioned in the extended abstract.*

**Authors' response:** A brief explanation about the example experiment and the representative results has been added to the extended abstract in a revised paper as follows:

The protocol is illustrated by example of a store layout experiment showing that shelf length and shelf orientation influence shopping and movement related behaviors.

**Comment6:** *There are no blue highlights in the 'Representative Results' section, but as I understand, parts of the study will be presented in the video. Highlights in this section would be helpful to decide whether the sections would be useful for inclusion in the video.*

**Authors' response:** We agree with you that highlighting other section will be useful. We however have contacted the editor and we are informed that parts of the introduction, results and discussion do not need highlighting.

**Comment7:** *It is unclear whether the presented results will be published in full detail in a separate paper. If so, a reference to this should be made.*

**Authors' response:** The results presented in this paper are original and have not yet been published in a paper. Consequently, we did not cite such a paper.

**Comment8:** *The authors mention that participants were provided with a utilitarian or a hedonic shopping motivation, but results regarding this manipulation were not presented.*

**Authors' response:** We originally excluded the results of shopping motivation because there are no significant interaction effects of shopping motivation and store layout, and including this additional variable does not add to the illustration. However, you are right that we should make this point clear to readers. We accordingly now briefly mention the effects of shopping motivation (line 512 - 517), in the following text:

In addition to the effects of shelf attributes, the current research also focuses on shopping motivations to understand their influence on in-store shopping behaviors. The results reveal significant main effects of shopping motivations on all in-store behavioral variables. Consumers with a hedonic motivation searched for (clicked on) and purchased more products than consumers with a utilitarian motivation. They also spent more time and walked a longer distance. The interaction effect of shopping motivation and store shelf attributes was not significant.

**Comment9:** *Detailed statistical results, which will not be presented in the video, could be omitted in this manuscript.*

**Authors' response:** Detailed statistical results have been erased to improve the representative results.

**Comment10:** *Figures, Figure 6*

*It would be great if significant differences and interactions can be indicated/highlighted in the video.*

**Authors' response:** We fully agree with you, and these significant interactions in the graph are currently indicated by the \* sign which will be included in the video.

**Comment11:** *Images: the screenshots are too blurry to be read, especially 4 and 5.*

**Authors' response:** We apologize for the blurriness of these screenshots. New screenshots with enhanced resolution have been added.

**Comment12:** *Discussion*

*The discussion is well-written. The advantages and disadvantages are addressed.*

**Authors' response:** We appreciate and thank you for your positive feedback.

**Comment13:** *It would be useful to have some practical advice for researchers who would want to work with the supermarket. E.g. Is this a single license, does the supermarket company offer support with programming,*

**Authors' response:** We agree that practical advice is useful. Licensing agreements (including technical support) can be made on an individual basis through the research company stated in the table of materials/reagents for detailed information.

**Comment14:** *Some more details on the cost effectiveness would be useful: What would a supermarket study with 200 participants cost, compared with a study in a real life setting? Or, how many virtual studies would one need run to make the initial investment in the equipment worthwhile. Do you do contract research? Can external researcher access the infrastructure.*

**Authors' response:** The cost of research is very specific to each study, depending on the study objectives, the types of manipulations involved, and study design. We therefore suggest contacts for contract research / system purchase in the tables of materials/reagents for interested readers.

### Response to the comments of Reviewer 3.

We really appreciate the valuable suggestions. We will respond to your comments one-by-one (repeated in italics).

#### **Comment1:** *Minor Concerns:*

*The authors describe presence-theory by primarily Witmer and Singer, but there are quite many variations of presence and immersion. While Witmer and Singer has more of a perceptual view on immersion, e.g. Mel Slater views it as a property of the system i.e. the higher the fidelity of e.g. displays, tracking etc. all contribute to a greater level of immersion. The authors should consider at least mentioning some of the alternative definitions of immersion and presence (I can recommend "Slater (2009) - Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments"*

*(<http://rstb.royalsocietypublishing.org/content/364/1535/3549.short>)*

**Authors' response:** In response to your feedback, we have consulted other definitions of immersion and presence. This topic has been included in the paper on line 92 – 105.

**Comment2:** *This leads to the next concern. There's a consensus within the field that there is different levels of immersion depending on the VR-system. One somewhat crude categorisation classifies 3 states: 1. Non-immersive VR (Desktop VR), 2. Semi-immersive VR (projection e.g. CAVE-systems), 3. Fully-immersive (head-mounted displays e.g. tethered). It seems the authors are using primarily desktop VR (3 monitor setup), and I consider whether or not that may influence the level of immersion hence also effects the 'response-as-if-real' in the presented VE. Have the authors conducted, or are familiar with comparative studies to evaluate whether or not there's a significant effect of the different categories?*

**Authors' response:** This is an interesting point. From our experience we would say that the VR-system would indeed influence the level of immersion. However, since the other VR-systems are in an early stage of development, there is no literature comparing their effects. Moreover, Slater (2009) stated that, currently, a comparison of immersion among different VR systems is problematic because each system is supported by different sensorimotor contingencies. We therefore suggest the comparison among different VR-system as an opportunity in future research, in the discussion section (line 696 - 700).

#### **Comment3:** *Additional Comments to Authors:*

*The described application and the pipeline for conducting consumer behavior research in virtual reality is really thorough and interesting. I would like the to experience a demonstration if the opportunity should arise. The authors are welcome to contact me for additional inquiries and other recommended reading.*

**Authors' response:** We really appreciate your offer. It would be our pleasure to host you and arrange a demonstration session if you come to our group. We will try to arrange this event and contact you back when we are ready.

#### **Response to the comments of Reviewer 4.**

We would like to thank this reviewer for the feedback to improve our manuscript. We have changed our manuscript according to these suggestions (repeated in italics).

##### ***Comment1: Major Concerns:***

*The authors did not cover alternative Virtual Reality techniques that could have been adopted in order to obtain similar results.*

##### **Authors' response:**

Thank you for pointing this out. We have added information about alternative virtual reality techniques in the discussion (line 669 - 700). Since the use of VR is in an early stage of development, studies describing and comparing different virtual reality technologies are scarce. The objective of the current study is to present one specific virtual store and provide detailed instructions on its use in consumer behavior studies, which is now more clearly stated in the abstracts and introduction. Given this objective, alternative techniques are mentioned but not explained in detail.

***Comment2:*** *On top of this, the issue of realism of the virtual models could have been addressed in a more extensive manner, taking into consideration presence and immersion principles.*

**Authors' response:** In response to your feedback, we discuss the view of Slater on immersion in line 92 – 105. Slater argues that the fidelity of displays (which would relate to the realism of the 2D and 3D models) influences the experience of immersion. We now also mention our experience about the likely effects of these models on feelings of presence and immersion in the discussion (line 618 - 621). However, to our knowledge there is no empirical data available on this issue. We therefore suggest this for future research.

##### ***Comment3: Minor Concerns:***

*A more extensive description of the conditions presented in the representative results could be addressed for clarity.*

**Authors' response:** We apologize for this unclear description of the experimental conditions. A detailed description of the experimental conditions and pictures of the store in each condition have been added (line 450 - 453 and line 461 - 473) for clarification.

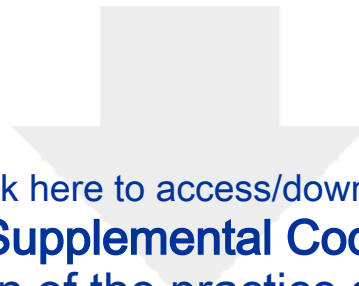


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**Supplemental Code**

[1\\_Instruction how to maneuver in the virtual store.docx](#)

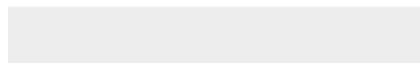
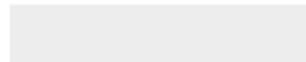




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**Supplemental Code**

**2\_Instruction of the practice session.docx**





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**Supplemental Code**

[3\\_Instruction for the manipulation task.docx](#)







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**Supplemental Code**  
**4\_Instruction for the shopping task.docx**

