Video Article

Using a Virtual Store As a Research Tool to Investigate Consumer In-store Behavior

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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.

Video Link

The video component of this article can be found at https://www.jove.com/video/55719/

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)[1].

Virtual reality applications have considerable research history. As early as 1965, Sutherland[2] 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[3,4]. The sense of "presence," of being in the computer-generated world, has consequently become a key to virtual-reality experiences[5,6]. Presence has been defined as the "subjective experience of being in an environment, even when one is physically situated in another".[7] 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[8] 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[1] or as a screening tool for mild cognitive impairment[9]. 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[10,11,12], different setups of point-of-sale displays[13], different packaging options[14], different nutritional labels on the backsides of product packages[15], and stock levels[16]. In addition, the virtual store is currently used to help create and test public health interventions to stimulate healthier food choices among children[17]. 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[8]. 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[14,18].

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. 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 program), three 42 inch LCD screens, a computer screen for displaying the data management program, connecting cables, electronic sockets, a 3D space navigator, 2 mice, and 2 keyboards.
2. **Connect all the equipment together, as demonstrated in Figure 1.**
   1. Connect one PC to a computer screen, a keyboard, and a mouse to use the data management program.
   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.
   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.
   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.

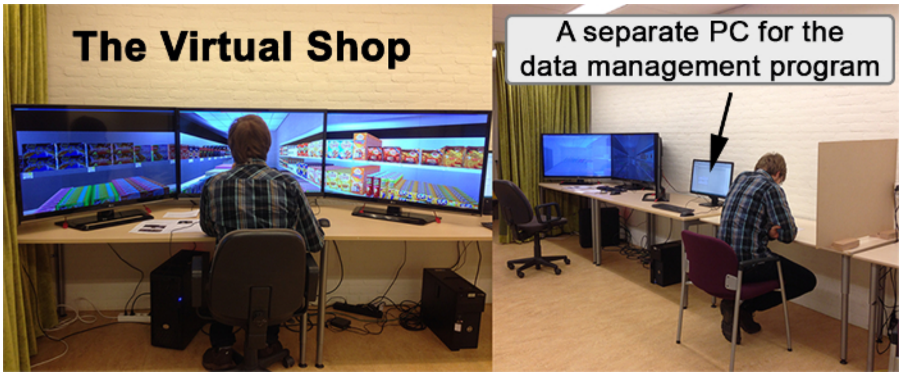

Figure 1: The virtual store setup. The virtual store uses one PC equipped with three 42 inch LCD screens that render 180° visibility. A separate PC is added to accommodate the data management program. This PC enables a research coordinator to monitor the progress and to start new virtual environments without interrupting participants. Please click here to view a larger version of this figure.

2. Building Virtual Stores for Experiments

1. Open the virtual store builder interface (called the editor) by double-clicking on the "VirtualShop_Editor.exe" icon on the desktop.
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).
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.
   1. Replace existing products with products of interest, where needed.
      1. Use the right mouse button and move the mouse to zoom in and out to product shelf. And use the left mouse button and move the mouse to change the viewpoint.
      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)).
      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.
      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 shelfs.
      5. Double-click on an existing product and subsequently press the "Delete" button on the keyboard to delete this product.
      6. Click on the "blue 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).
      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.
      8. Add or replace all the products to match the research interests by repeating the steps from 3.1.1-3.1.4.

   2. **Relocate entire shelves.**
      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. 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.
      3. Relocate all necessary shelves to match research interests by repeating steps 2.3.2.1 and 2.3.2.2.

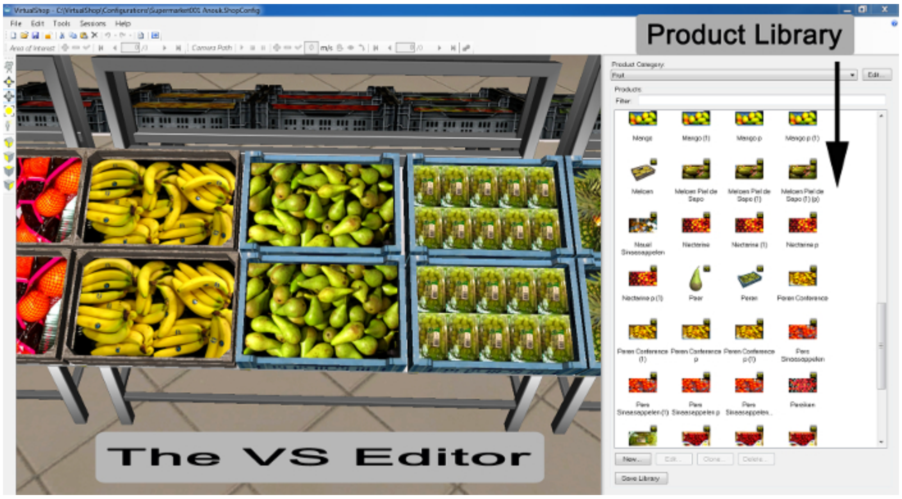

Figure 2: The virtual shop editor and examples of products in the product library. The editor has a drag-and-drop interface to allow researchers to easily select products from the library and directly place them on the shelves. In addition, a pop-up window can be used to either add or edit a product by clicking on a product in the library. Please click here to view a larger version of this figure.

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.
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.
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

1. Double-click on the data management program icon on the desktop to start the program.
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. 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.
4. **Add input variables that represent the experimental conditions (*e.g.*, the store layout and shopping motivation), if desired.**
   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.
   2. Fill in necessary details, such as variable name, variable type, predefined value, and so on.

5. Save the project by clicking on "File" → "Save as." Name the project, "Name of project.vop" and click "Save."

4. Participant Selection Criteria

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

5. Preparation for the Experiment

1. Prepare all the documents needed to carry out the experiments.
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.
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[19], 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.
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

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.
2. **Open the virtual store for a practice session.**
    1. Start the virtual shop program by double-clicking on the VirtualShop_Uviewer icon on the desktop. Click "Begin" to enter the store.
    2. Press the " ` " key on the top-left of the keyboard to open the menu bar of the virtual shop program.
    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: "SpeceNav" allows participants to look freely through the virtual environment, in any direction, using the 3D space navigator. It also enables participants to decide their own walking direction. Nevertheless, it restricts participants to following predetermined walking lines.
    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].
    5. Click on "Reload shop" to open the practice store, and a "Begin" box will subsequently appear.
3. Provide the mouse, 3D space navigator, and keyboard to the participant. Ensure that the front side of the 3D space navigator faces the participant to enable the correct navigation direction.
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.
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. 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

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).
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**).
3. **Prepare the virtual store for the main study.**
    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.
    2. Load the virtual store and select the virtual environment (walking path), according to the experimental conditions.
    3. Keep "SpaceNav" at the box of the Input to obtain the same type of walking behavior as in the practice session.
    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]."
    5. Click on "Reload shop" to open the store for the main test; the "Begin" box will appear.
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.
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.
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.,* Sample 1) and click "OK."
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).
8. **Ensure that the program starts recording data.**
    1. Ensure that the "Status data plugin" and "Status event plugin" windows show green checkmarks.
    2. Ensure that "time" is elapsing.
    3. Ensure that the number of "sample" column in the "Status data plugin" window is growing (shown in **Figure 3**).

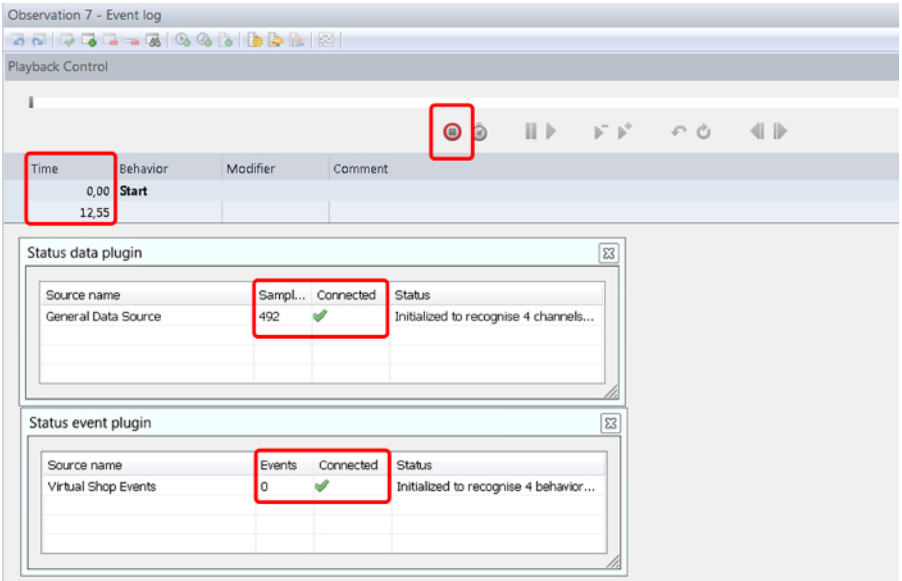

Figure 3: An example of the observation window that signals the recording of data. When the data management program is recording data, the "Status data plugin" window and the "Status event plugin" show a green mark. Also, time should be elapsing and the number of samples should be growing. Please click here to view a larger version of this figure.

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.**
    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.

10. Provide the mouse, 3D space navigator and keyboard to the participant. Ensure that the front side of the 3D space navigator faces the participant to enable the correct navigation direction.
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**).
12. Instruct the participant to press "begin" to start visiting the store. Subsequently, leave the participant alone to shop without interruption.
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.
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.
15. Press the "stop" button of the data management program on the other computer to stop recoding (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.
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.
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**.

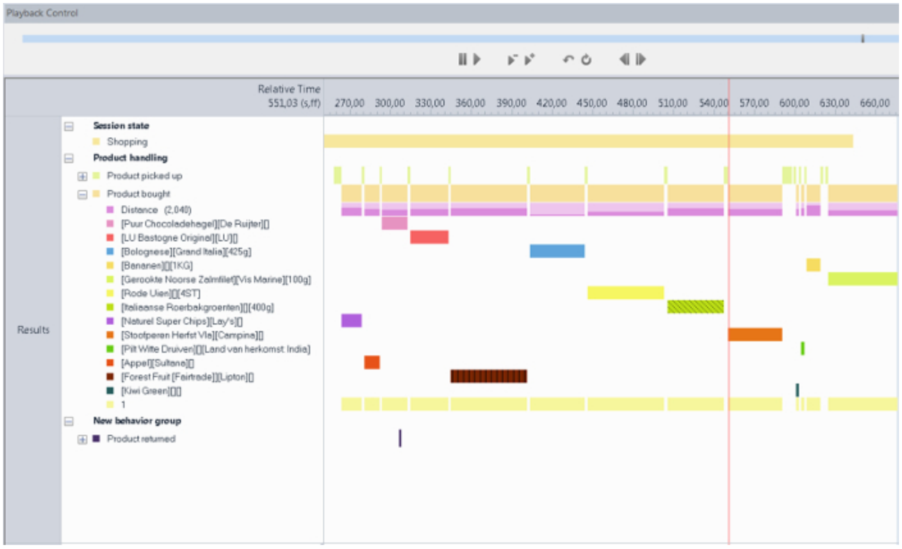

Figure 4: The visualization window displayed in the data management program. The orange bar represents the entire shopping time, since the participant entered the store until he/she pressed "Esc" to indicate the end of the shopping trip. The green bar denotes the time spent on the examined products.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

18. Debrief and give a reward (*e.g.*, a snack product or monetary payment) after the participant finishes.
19. Reload a practice store for a new participant by following steps 5.2.3-5.2.4.
20. Press F9 to close the virtual store after the last participant has finished.
21. Save the data as frequently as possible to avoid data loss.

8. Export the Data

1. **Export the data of shopping-related behavior.**
    1. Set up a filter to select the data of shopping-related behavior.
        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.
        2. Select the "Nest over Behaviors" box under the "Select Intervals" heading; the box of Nested Behaviors will appear.
        3. Select all the behaviors of interest (*e.g.*, shopping duration, products picked up, products bought, and products returned) and click "OK."
        4. Drag the "Nested Behaviors" box and drop it between the "Start" and "Results" boxes.
        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.
    2. Click on "Behavior Analyses" under the "Analyses" folder and then click "New Behavior Analysis" to open the table of behavior-related results.
    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."
    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.

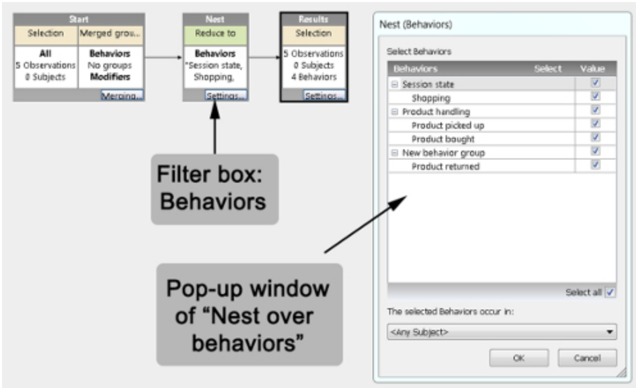

Figure 5: Data profile filter scheme for exporting shopping-related behavior. The data profile filter allows researchers to select and export the data of interest. For example, this scheme opts for shopping-related behaviors (*e.g.*, shopping duration, number of products examined, number of product purchased,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

2. **Export the movement-related data.**
    1. Set up a filter to select the movement-related data.
        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.
        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.
        3. Drag the "Nested Speed" box and drop it between the "Nested behaviors" and "Results" boxes.
        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.

    2. Export the walking time.
        1. Click "Behavior Analyses" under the "Analyses" folder and then click "New Behavior Analysis" to open the table of behavior-related results.
        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 8.1.3 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.
        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.

    3. Export the walking speed.
        1. Click "Numerical Analyses" under the Analyses folder and then click "New Numerical Analysis" to open the table of movement-related results.
        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.
        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.

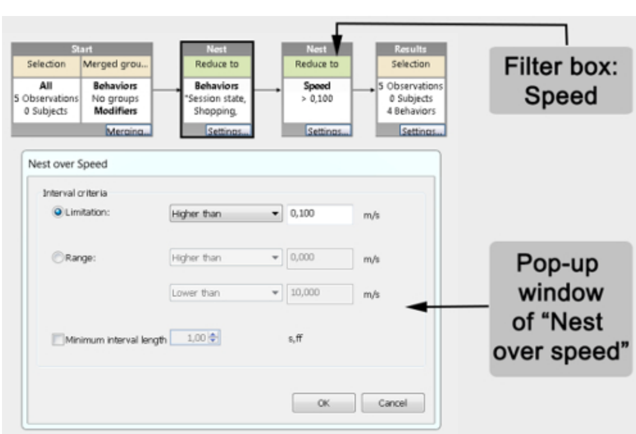

Figure 6: Data profile filter scheme for exporting movement-related behavior. This scheme filters the movement-related behaviors (*e.g.*, moving speed and moving time) that occur when participants move in the store (speed >0.100 m/s). The behaviors and times when participants stand still are filtered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

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 unparalleled arrangement) were varied. These stores are depicted in **Figure 7**.

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. Please click here to view a larger version of this figure.

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)).

Result Containers	Observations	Behaviors	Mean	Total duration	Rate per minute (observation duration)	Total number	Observations	Motivation	Participant number	Store	Duration	Start time	Stop time
Results	Observation 1	Shopping	578.632	578.632	0.0590102	1	Observation 1	1	1	1	1016.77	12:02:43 PM	12:19:40 PM
Results	Observation 1	Product picked up	3.55356	113.714	1.88833	32	Observation 1	1	1	1	1016.77	12:02:43 PM	12:19:40 PM
Results	Observation 1	Product bought	28.1741	366.264	0.767132	13	Observation 1	1	1	1	1016.77	12:02:43 PM	12:19:40 PM
Results	Observation 2	Shopping	400.5	400.5	0.0887163	1	Observation 2	1	2	1	676.314	1:00:08 PM	1:11:24 PM
Results	Observation 2	Product picked up	2.50967	37.645	1.33074	15	Observation 2	1	2	1	676.314	1:00:08 PM	1:11:24 PM
Results	Observation 2	Product bought	29.0326	377.423	1.15331	13	Observation 2	1	2	1	676.314	1:00:08 PM	1:11:24 PM
Results	Observation 2	Product returned	-	-	0.0887163	1	Observation 2	1	2	1	676.314	1:00:08 PM	1:11:24 PM
Results	Observation 3	Shopping	182.537	730.148	0.235446	4	Observation 3	2	3	1	1019.34	1:17:25 PM	1:34:25 PM
Results	Observation 3	Product picked up	5.32313	79.847	0.882924	15	Observation 3	2	3	1	1019.34	1:17:25 PM	1:34:25 PM
Results	Observation 3	Product bought	71.0311	710.311	0.588616	10	Observation 3	2	3	1	1019.34	1:17:25 PM	1:34:25 PM
Results	Observation 3	Product returned	-	-	0.0588616	1	Observation 3	2	3	1	1019.34	1:17:25 PM	1:34:25 PM
Results	Observation 4	Shopping	570.07	570.07	0.0656902	1	Observation 4	2	4	1	913.378	1:34:56 PM	1:50:10 PM
Results	Observation 4	Product picked up	4.32891	99.565	1.51088	23	Observation 4	2	4	1	913.378	1:34:56 PM	1:50:10 PM
Results	Observation 4	Product bought	21.8755	306.257	0.919663	14	Observation 4	2	4	1	913.378	1:34:56 PM	1:50:10 PM
Results	Observation 4	Product returned	-	-	0.13138	2	Observation 4	2	4	1	913.378	1:34:56 PM	1:50:10 PM
Results	Observation 5	Shopping	400.547	400.547	0.129493	1	Observation 5	1	5	2	463.346	2:12:05 PM	2:19:48 PM
Results	Observation 5	Product picked up	2.29655	50.524	2.84884	22	Observation 5	1	5	2	463.346	2:12:05 PM	2:19:48 PM
Results	Observation 5	Product bought	19.8386	277.74	1.8129	14	Observation 5	1	5	2	463.346	2:12:05 PM	2:19:48 PM

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. Please click here to view a larger version of this table.

Observations	Result Containers	Behaviors	Modifiers	External data	Minimum	Maximum	Mean	Total duration	Observations	Minimum	Maximum	Mean	Number of samples	Motivation	Participant number	Store	Duration	Start time	Stop time
Observation 1	Results			PositionX	0	0	0	0	Observation 1	-4.6	5	-0.176754	1549	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 1	Results			PositionY	0	0	0	0	Observation 1	0.9	1.4	1.39335	1549	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 1	Results			PositionZ	0	0	0	0	Observation 1	-4.5	4.5	-0.0838864	1549	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 1	Results			Speed (m/s)	0	0	0	0	Observation 1	0.11	1.45	0.522647	1549	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 1	Results	Product picked up	Distance		0.94	2.02	1.62353	0.15121	Observation 1	0	0	0	0	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 1	Results	Product bought	Distance		0.94	2.67	1.68418	128.295	Observation 1	0	0	0	0	1	1	1	1016.77	12:02:43.20	12:19:39.97
Observation 2	Results			PositionX	0	0	0	0	Observation 2	-4.6	5	-0.437635	1183	1	2	1	676.314	13:00:07.63	13:11:23.94
Observation 2	Results			PositionY	0	0	0	0	Observation 2	0.4	1.4	1.30374	1183	1	2	1	676.314	13:00:07.63	13:11:23.94
Observation 2	Results			PositionZ	0	0	0	0	Observation 2	-4.51	4.48	-1.24505	1183	1	2	1	676.314	13:00:07.63	13:11:23.94
Observation 2	Results			Speed (m/s)	0	0	0	0	Observation 2	0.11	1.45	0.713719	1183	1	2	1	676.314	13:00:07.63	13:11:23.94
Observation 2	Results	Product bought	Distance		1.01	2.58	1.82566	114.5	Observation 2	0	0	0	0	1	2	1	676.314	13:00:07.63	13:11:23.94
Observation 3	Results			PositionX	0	0	0	0	Observation 3	-4.6	4.59	-0.080736	2376	2	3	1	1019.34	13:17:25.23	13:34:24.57
Observation 3	Results			PositionY	0	0	0	0	Observation 3	0.4	1.4	1.32214	2376	2	3	1	1019.34	13:17:25.23	13:34:24.57
Observation 3	Results			PositionZ	0	0	0	0	Observation 3	-4.5	2.83	-1.4068	2376	2	3	1	1019.34	13:17:25.23	13:34:24.57
Observation 3	Results			Speed (m/s)	0	0	0	0	Observation 3	0.11	1.52	0.645114	2376	2	3	1	1019.34	13:17:25.23	13:34:24.57
Observation 3	Results	Product bought	Distance		1.09	2.63	1.48896	229	Observation 3	0	0	0	0	2	3	1	1019.34	13:17:25.23	13:34:24.57
Observation 4	Results			PositionX	0	0	0	0	Observation 4	-4.6	5	-1.55204	1813	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 4	Results			PositionY	0	0	0	0	Observation 4	0.4	1.4	1.28645	1813	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 4	Results			PositionZ	0	0	0	0	Observation 4	-4.5	4.5	-0.0923607	1813	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 4	Results			Speed (m/s)	0	0	0	0	Observation 4	0.11	1.54	0.579024	1813	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 4	Results	Product picked up	Distance		1.82	1.82	1.82	0.029213	Observation 4	0	0	0	0	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 4	Results	Product bought	Distance		1	2.5	1.29811	100.1	Observation 4	0	0	0	0	2	4	1	913.378	13:34:56.22	13:50:09.60
Observation 5	Results			PositionX	0	0	0	0	Observation 5	-4.6	1.2	-0.582384	1265	1	5	2	463.346	14:12:04.95	14:19:48.29
Observation 5	Results			PositionY	0	0	0	0	Observation 5	0.4	1.4	1.29858	1265	1	5	2	463.346	14:12:04.95	14:19:48.29
Observation 5	Results			PositionZ	0	0	0	0	Observation 5	-4.5	2.8	-0.590524	1265	1	5	2	463.346	14:12:04.95	14:19:48.29
Observation 5	Results			Speed (m/s)	0	0	0	0	Observation 5	0.11	1.51	0.683273	1265	1	5	2	463.346	14:12:04.95	14:19:48.29
Observation 5	Results	Product bought	Distance		1.13	2.37	1.51552	82.4	Observation 5	0	0	0	0	1	5	2	463.346	14:12:04.95	14:19:48.29

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. Please click here to view a larger version of this table.

Result Containers	Observations	Behaviors	Mean	Total duration	Rate per minute (observation duration)	Total number	Observations	Motivation	Participant number	Store	Duration	Start time	Stop time
Results	Observation 1	Shopping	1.16466	154.9	7.84835	133	Observation 1	1	1	1	1016.77	12:02:43.20	12:19:39.97
Results	Observation 1	Product picked up	0.0504033	0.15121	0.17703	3	Observation 1	1	1	1	1016.77	12:02:43.20	12:19:39.97
Results	Observation 1	Product bought	1.30913	128.295	5.783	98	Observation 1	1	1	1	1016.77	12:02:43.20	12:19:39.97
Results	Observation 2	Shopping	1.37558	118.3	7.6296	86	Observation 2	1	2	1	676.314	13:00:07.63	13:11:23.94
Results	Observation 2	Product bought	1.41111	114.3	7.18602	81	Observation 2	1	2	1	676.314	13:00:07.63	13:11:23.94
Results	Observation 3	Shopping	1.39882	237.8	10.0065	170	Observation 3	2	3	1	1019.34	13:17:25.23	13:34:24.57
Results	Observation 3	Product bought	1.40491	229	9.59444	163	Observation 3	2	3	1	1019.34	13:17:25.23	13:34:24.57
Results	Observation 4	Shopping	1.20867	181.3	9.85353	150	Observation 4	2	4	1	913.378	13:34:56.22	13:50:09.60
Results	Observation 4	Product picked up	0.029213	0.029213	0.0656902	1	Observation 4	2	4	1	913.378	13:34:56.22	13:50:09.60
Results	Observation 4	Product bought	1.26709	100.1	5.18953	79	Observation 4	2	4	1	913.378	13:34:56.22	13:50:09.60
Results	Observation 5	Shopping	1.30412	126.5	12.5608	97	Observation 5	1	5	2	463.346	14:12:04.95	14:19:48.29
Results	Observation 5	Product bought	1.42069	82.4	7.51059	58	Observation 5	1	5	2	463.346	14:12:04.95	14:19:48.29

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. Please click here to view a larger version of this table.

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, η_p^2 = .02) and the number of products purchased (F (1,237) = 3.47, p = .06, η_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 ($M_{short} \pm SD_{short}$ = 16.12 ± 5.37, $M_{long} \pm SD_{long}$ = 17.12 ± 5.99, F (1,237) = 0.81, p = .37, η_p^2 = .00), nor the number of products purchased ($M_{short} \pm SD_{short}$ = 12.00 ± 2.77, $M_{long} \pm SD_{long}$ = 12.22 ± 2.37, F (1,237) = 0.24, p = .63, η_p^2 = .00). In contrast, when the orientation of the shelves was unparalleled, shorter shelf lengths stimulated a higher number of products examined ($M_{short} \pm SD_{short}$ = 17.62 ± 6.48, $M_{long} \pm SD_{long}$ = 15.23 ± 6.45, F (1,237) = 4.65, p < .05, η_p^2 = .02) and purchased than longer shelf lengths ($M_{short} \pm SD_{short}$ = 12.30 ± 2.15, $M_{long} \pm SD_{long}$ = 11.35 ± 2.37, F (1,237) = 4.61, p < .05, η_p^2 = .02).

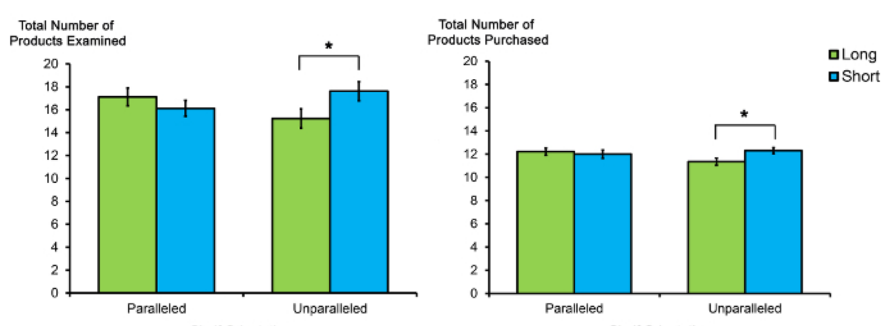

Figure 8: The total number of products examined (left) and the total number of products purchased (right) in a supermarket with different store layouts (short versus long shelves placed in a paralleled or in an unparalleled orientation). The total number of products examined (packages or items) increased 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 <0.10^{+}, p <0.05*, p <0.01**, p <0.001*** Please click here to view a larger version of this figure.

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.

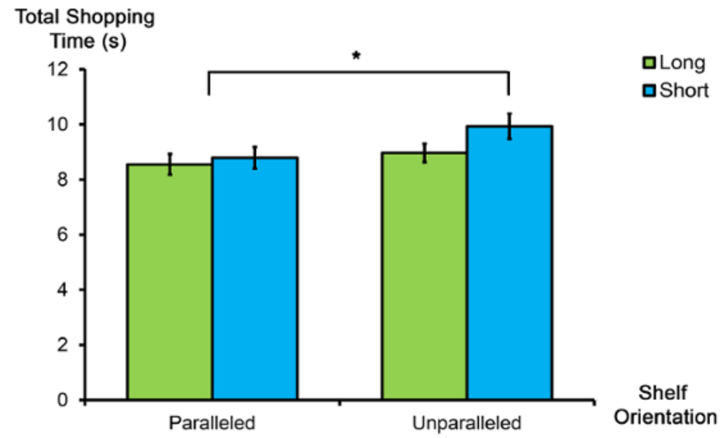

Figure 9: Total shopping time (s) participants spent in the supermarket with different shelf lengths and shelf orientations. The total shopping time accounts for the time participants spent between entering the store and leaving the store. The data management program also allows researchers to filter out the time that participants spent in a specific area. $p < 0.10^{+}$, $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$ Please click here to view a larger version of this figure.

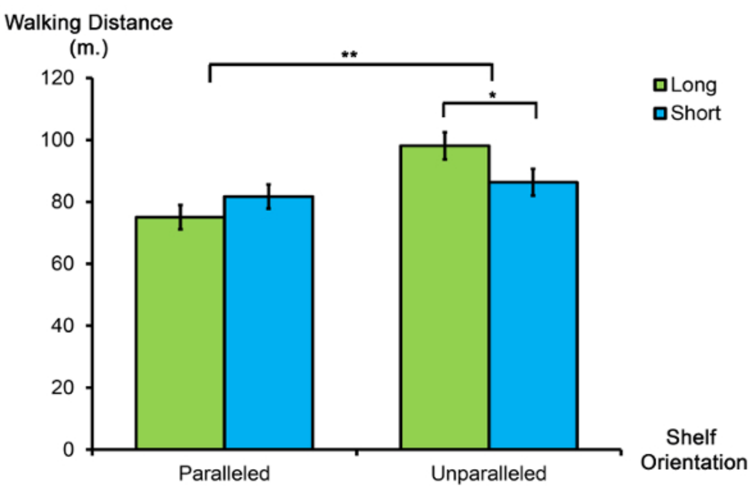

Figure 10: The walking distance of participants in the supermarket with different shelf lengths and shelf orientations. The walking distance was determined by multiplying the moving time (s) with the average shopping speed (m/s). The duration of the moving time used to calculate walking distance differs 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. $p < 0.10^{+}$, $p < 0.05^{*}$, $p < 0.01^{**}$, $p < 0.001^{***}$ Please click here to view a larger version of this figure.

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) ($M_{hedonic} \pm SD_{hedonic}$ = 17.97 ± 6.93) and purchased more products ($M_{hedonic} \pm SD_{hedonic}$ = 12.25 ± 2.42) than consumers with a utilitarian motivation (products examined: $M_{utilitarian} \pm SD_{utilitarian}$ = 15.10 ± 4.82, products purchased: $M_{utilitarian} \pm SD_{utilitarian}$ = 11.69 ± 2.43, see Figure 11). They also spent more time ($M_{hedonic} \pm SD_{hedonic}$ = 607.18 ± 205.07 s, $M_{utilitarian} \pm SD_{utilitarian}$ = 480.94 ± 134.25 s, see Figure 12) and walked longer distances ($M_{hedonic} \pm SD_{hedonic}$ = 89.87 ± 31.15 m, $M_{utilitarian} \pm SD_{utilitarian}$ = 80.73 ± 34.08 m, see Figure 13). The interaction effect of shopping motivation and store shelf attributes was not significant.

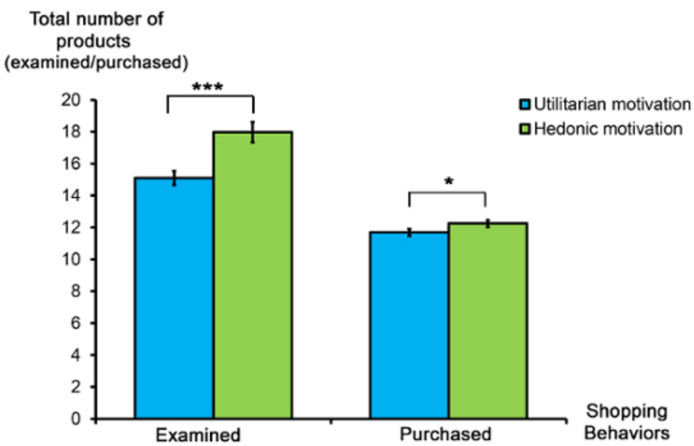

Figure 11: The total number of products examined (left) and the total number of products purchased (right) by participants with utilitarian and hedonic shopping motivation. The number of products examined and purchased are presented across all store layouts. Participants were assigned to shops under either utilitarian or hedonic shopping motivation prior to a shopping task. The shopping motivation was manipulated by a motivation manipulation task and a shopping situation. p <0.10+, p <0.05*, p <0.01**, p <0.001*** Please click here to view a larger version of this figure.

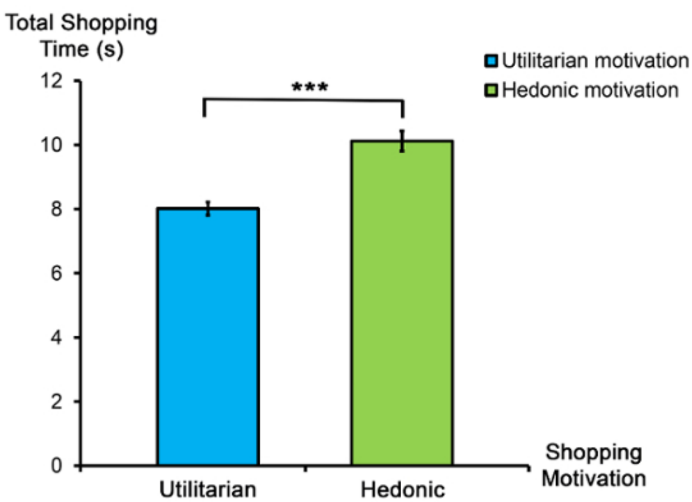

Figure 12: Total shopping time (s) spent in the supermarkets by participants with utilitarian or hedonic shopping motivation. The total shopping time accounts for the entire time that participants with different shopping motivations spent in the virtual supermarket across all store layouts. p <0.10+, p <0.05*, p <0.01**, p <0.001*** Please click here to view a larger version of this figure.

Figure 13: The distance that participants with utilitarian and hedonic shopping motivation walked. This figure shows the average walking distance across all store layouts. p <0.10+, p <0.05*, p <0.01**, p <0.001*** Please click here to view a larger version of this figure.

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 14**). 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.

Figure 14: 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. Please click here to view a larger version of this figure.

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[17,19], 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[20]. 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[21]. 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)[18]. 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[22,23]. 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[18]. 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[24], 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[8]. 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.

Disclosures

The authors have nothing to disclose.

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