Virtual Product Experience: Effects of Visual and Functional Control of Products on Perceived Diagnosticity and Flow in Electronic Shopping

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ABSTRACT: The development of electronic commerce has been constrained by the inability of online consumers to feel, touch, and sample products through Web interfaces, as they are able to do in conventional in-store shopping. Previous academic studies have argued that this limitation could be partly alleviated by providing consumers with *virtual product experience* (VPE), to enable potential customers to experience products *virtually.* This paper discusses *virtual control,* a specific type of VPE implementation, and identifies its two dimensions: *visual control* and *functional control.* Visual control enables consumers to manipulate Web product images, to view products from various angles and distances; functional control enables consumers to explore and experience different features and functions of products. The individual and joint effects of visual and functional control were investigated in a laboratory experiment, the results of which indicated that visual and functional control increased the perceived diagnosticity (i.e., the extent to which a consumer believes the shopping experience is helpful to evaluate a product) of their corresponding attribute factors, and that both visual and functional control increased consumer overall perceived diagnosticity and flow.

KEY WORDS AND PHRASES: B2C e-commerce, direct manipulation, e-commerce, e-tailing, flow, multimedia, perceived diagnosticity, virtual control, virtual product experience.

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UNLIKE TRADITIONAL IN-STORE SHOPPING, where shopping information is conveyed to consumers through multiple channels, including the store environment, displays of products, product trials, and service [72], business-to-consumer (B2C) electronic commerce (e-commerce) depends solely on Web interfaces to communicate such information and to manage customer relationships [7, 22]. Two notions bear particular importance in relationship management: para-social presence [41] and product perception [32]. The former refers to the "distance" between consumers and Web sites, and the latter refers to the "distance" between consumers and products. Accordingly, the current study investigates the effectiveness of a special interface feature, *virtual control,* to reduce these two distances by improving consumer interactions with Web interfaces and by augmenting consumer perceptions of product quality.

To date, improvements in e-commerce interface designs have led to easier navigation, more attractive graphic interfaces, more powerful plug-in components, and other advances [21, 37, 51, 52, 62, 65, 89]. Despite the development of these features, many researchers continue to doubt the effectiveness of electronic shopping environments [11, 70, 87]. They have argued that Web interfaces are constrained, since online consumers can only passively receive the product information presented, without feeling, touching, or sampling products online. The lack of direct experience limits the ability of consumers to judge product quality and leaves them less emotionally engaged in shopping experiences; hence, consumers are less willing to buy on the Internet. For example, Peterson et al. have noted: "Internet-based marketing would seem to be a poor substitute for traditional transaction channels, where the good is available for inspection" [67, p. 335]. Rose et al. [70] have also argued that this technological limitation has been a major impediment to the growth of B2C e-commerce.

To overcome this problem, various methods of providing better product presentations have been suggested [48]. One emerging approach is to enable online consumers to sample and experience products virtually, via Web interfaces. This type of experience is labeled *virtual product experience* (VPE). For example, using their mice and keyboards, customers can *rotate* cameras three-dimensionally and view them from different angles on www.olympus.com; they can *get in* a car and obtain a panoramic view of interior settings on www.honda.com; they can *manipulate* various functions of a sports watch by pressing its functional buttons on www.timex.com; and they can *try on* different clothes with a personal virtual mannequin on www.landsend.com. Unlike three-dimensional computer games, such as DOOM, where computer users are "immersed" in a virtual environment all along, most current virtual product experience technologies, for the ease of implementation and customer navigation, do not attempt to simulate the entire shopping experience, but display some products in the manner of virtual experience, and organize other product information by HTML pages.

Exploratory research in marketing [16, 44, 45, 46] has already suggested that VPE has the potential to improve consumer product knowledge and attitudes toward brands, while enhancing consumer purchase intentions. However, most previous studies have treated VPE as a black box, without investigating the effects of VPE from an information technology (IT) perspective.

Focusing on the *product evaluation* stage of the consumer decision-making process [64], the present study identifies two types of VPE technology, visual control and functional control, together labeled as virtual control, and investigates their individual and joint effects on those products that have three-dimensional visual appeal and contain varied functionality information. Visual control and functional control are analyzed by integrating theories of direct manipulation and multimedia. A controlled experiment is employed to test empirically whether or not visual and functional controls lead to higher *perceived diagnosticity* and *flow.* Perceived diagnosticity is defined as the extent to which consumers believe the shopping experience is helpful to evaluate products [35]; flow represents computer users' affective responses to computer usage, characterizing playfulness and exploration as defining characteristics of human–computer interactions [39, 85].

Background: Visual and Functional Control

VPE UTILIZES ITs TO ENABLE CUSTOMERS to feel, touch, and try products virtually, via their interaction with their computers [71]. Li et al. [46] have contended that VPE resembles direct (in-store) product experience, because both are interactive in nature, but it differs in that VPE generates *presence* indirectly, through a communication medium [41].

An Analog: Direct Product Experience

Direct product experience is also termed *product trial.* It is generally believed to be one of the most effective ways, albeit one of the most expensive, to introduce a product to consumers [38].

Kempf and Smith [35] and Hoch and Deighton [27] have argued that attention to, and memory of, product trials should be compelling to consumers for several reasons. First, direct experience involves multiple sensory cues, including vision, tactile feelings, smell, sound, and taste. Combined together, these cues generate a vivid, informative, and impressive presentation of products. Second, as customers themselves experience products directly, they are motivated to evaluate the products, and their attention and engagement should be more aroused. Third, all product information is directly attained by customers themselves, and therefore possesses the highest credibility and trustworthiness.

According to Nelson [61], two different types of product attributes are related to direct product experience: *search attributes* and *experience attributes.* Search attributes are those whose information is conveyed most effectively through secondhand sources, including advertising, catalogs, and word of mouth, rather than through the direct trial of products. For example, price, content, and storage capacity are search attributes. Experience attributes, on the other hand, are those that can be evaluated only by using products directly. Examples include the taste, feel, and workmanship of the products. The effects of direct product experience are therefore best demonstrated for experience attributes, rather than for search attributes [88].

Virtual Control

The present study focuses on two types of VPE implementation: *visual control* and *functional control* (together labeled as *virtual control*), which are used to emulate direct product experience.

Visual control, enabled by software such as QuickTime[1] and Flash,[2] allows consumers to manipulate product images with their mice and keyboards—for example, to move, rotate, and zoom in and out a product's image so as to view it from different angles, perspectives, and distances. On the other hand, functional control, supported by software such as Shockwave,[3] enables consumers to sample different functions of products through their computers. For example, when the functional buttons of an electronic product (e.g., an electronic watch) are activated, the cyberproduct will react virtually according to its functional mechanism, just as the real product does. The reactions are represented or conveyed in several ways, such as by emitting alarm sounds, through the movement of particular parts of the product, or through changes in the appearance of the product. Integrated together, these reactions provide users with a vivid impression of how the product responds to their actions.

Functional control is fundamentally different from visual control, inasmuch as functional control encompasses a product's behavior and functions—that is, how the product *works*—whereas visual control relates to a product's appearance or form—that is, how it *looks* (see [73]). With functional control, users manipulate a product's functionality, and the consequences are the behavior of the product (i.e., at least one part of the product exhibits change or movement relative to other parts). Visual control does not involve manipulation of the product's functionality, and hence no information about its behavior is provided. However, visual control provides information about the look of the product over and above the single perspective or view provided by functional control. In other words, users see only one fixed view of the product through functional control tools, whereas in visual control the product image can be enlarged in size and rotated for examination from multiple perspectives. Thus, visual control and functional control differ both from a theoretical (form and function) and an implementation point of view.

Visual and functional control may not be appropriately applied to all product categories [43, 53]. For example, there is little need to visually or functionally manipulate a textbook or a box of cereal. Many products may be described by both functional and visual control, though both do not need to be always available. For example, home furnishings, such as a sofa or a vase, may be best understood by visual control only. A calculating device that does not necessarily have visual appeal, on the other hand, would be evaluated most effectively solely by functional control.

Analysis of Virtual Control

Virtual control can be best understood from the perspective of its supporting technology—namely, virtual reality—and the effects of the corresponding technological components: direct manipulation and multimedia (Figure 1).

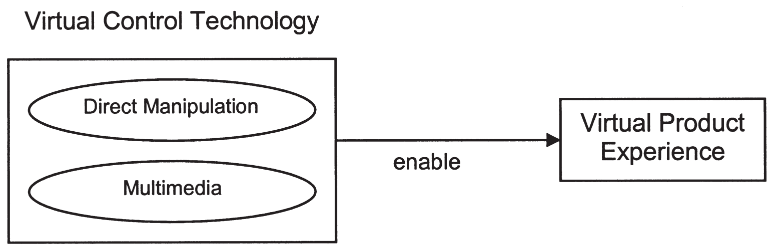

Figure 1. Virtual Control and Its Core Technological Components

Virtual Reality

The technology that supports virtual control is virtual reality [81], viewed by Steuer as "a real or simulated environment in which a perceiver experiences telepresence" [77, p. 76]. Telepresence has been defined as "being there" [24] and "the experience of presence in an environment by means of a communication medium" [77, p. 76].

Steuer has identified two major determinants of telepresence: *interactivity* and *vividness.* Interactivity is "the extent to which users can participate in modifying the form or content of a mediated environment in real time" [77, p. 84], and vividness is "the representational richness of a mediated environment as defined by its formal features; that is, the way in which an environment presents information to the senses" [77, p. 81].

Virtual control depends on direct manipulation and multimedia technologies to generate interactivity and vividness, respectively. First, virtual control allows customers to directly manipulate online products to acquire relevant product information; then, virtual control employs multimedia technology, through which pictures, animation, movies, and sound function synergistically to demonstrate how products react to consumers' inputs.

Virtual Control as Direct Manipulation

Wann and Mon-Williams [83] have contended that a central component of some advanced virtual environment systems is "the ability to interact, and intrinsic to this are the principles of direct manipulation" [83, p. 835]. *Direct manipulation* [74] is usually associated with a graphical representation, and it allows computer users to directly control the objects of their interest. In a direct manipulation interface, "manipulating a representation can have the same effects and the same feel as manipulating the thing being represented" [29, p. 99].

Hutchins et al. [29] have stated that feelings of directness depend on two separate and distinct aspects. The first is the distance between an individual's thoughts and the physical variables of the system under use. In a direct manipulation interface, the users' thoughts are readily translated into physical action and the system outputs can be interpreted easily by the users, and therefore the distance is diminished. The second aspect concerns the qualitative feeling of engagement—that is, direct manipulation allows users to have strong feelings of control over the object of interest [29].

The direct manipulation model has been empirically tested by numerous studies and has received general acceptance [8, 18, 33, 60]. These studies have confirmed that direct manipulation is easy to learn and use, and that it can thus improve users' performance and efficiency. Furthermore, because it provides users with significant feelings of control and interactivity, it enhances their affective engagement, and it tends to be positively evaluated by users.

Virtual Control as Multimedia

Virtual control is different from standard direct manipulation, in that it depends on multimedia technology to represent product reactions to user manipulation. Lim et al. [50] have discussed two unique characteristics of multimedia—namely, rich language and complementary cues. Specifically, they have argued that multimedia can bring together "the symbolic and processing capabilities of various media," and thus create "a richer symbolic system of communication" [50, p. 118]. They have also suggested that different information cues in multimedia (verbal and nonverbal) do not compete with each other for limited cognitive resources, but rather they are complementary to each other and thereby augment the overall effect of the presentation.

Prior empirical studies have suggested the double roles of multimedia. First, inasmuch as multimedia employs multiple sense–rich channels, it enhances users' affective responses to multimedia-based applications. Second, because multimedia is able to portray information vividly and in detail, it can provide accurate information that facilitates users' learning and understanding processes.

For example, Richman-Hirsch et al. [69] have investigated the effect of administration medium by comparing managers' reactions to three versions of assessment. The three assessments contained identical linguistic content, but varied in terms of media: a paper-and-pencil form, a written form administered by a computer (i.e., a computerized page turner), and a multimedia form administered completely by the computer. The study found that multimedia, rather than computerization, induced positive affective reactions toward the assessments. Lim and Benbasat [49] have examined the effects of multimedia on perceived equivocality and perceived usefulness of information systems (IS). Their experimental results suggested the following: (1) for an analyzable task, there is no difference between multimedia and text-based representations in terms of the level of perceived equivocality; (2) for a less-analyzable task, multimedia representation can lead to a lower level of perceived equivocality; and (3) multimedia representation may be perceived by users as more useful than text-based representations.

Research Framework

Dependent Variables

THE PRESENT STUDY EXAMINES THE EFFECTS of virtual control on two dependent variables: *perceived diagnosticity* and *flow*.

Perceived Diagnosticity

In a study of consumer trials of products, Kempf and Smith [35] have used the concept of *perceived diagnosticity,* which represents the extent to which consumers believe that particular shopping experiences are helpful to evaluate products, and it was measured by asking consumers, "How helpful would you rate this shopping experience you just had in judging the quality and performance of the products?" Kempf and Smith observed that perceived diagnosticity positively contributes to the cognitive evaluation of product attributes, and suggested that any research associated with direct product experience consider using this construct.

As virtual control leads to *virtual* product experience, perceived diagnosticity is adopted in this study as a dependent variable. In the context of e-commerce, perceived diagnosticity reflects the perceived ability of a Web interface to convey to customers relevant product information that helps them in understanding and evaluating the quality and performance of products sold online. If virtual control can increase perceived diagnosticity, it means that customers feel that they are more capable of understanding products and likely make more informed purchase decisions.

Flow

The theory of *flow* [15] describes flow as an affective state when individuals are involved in certain activities. In the context of computer-mediated environments, flow is used to represent a subjective psychological experience that characterizes human–computer interactions as playful and exploratory [1, 79, 85].

Webster et al. [85] have studied flow by surveying users of Lotus 1-2-3 and electronic mail. They delineated three subdimensions of flow—control, attention focus, and cognitive enjoyment—and found that flow is positively correlated with experimentation, exploratory behavior, actual technology use, and perceived communication quantity and effectiveness. Hoffman and Novak [28] have portrayed online flow experience as the state that consists of a seamless sequence of responses facilitated by human–computer interactivity, is enjoyable, is accompanied by a loss of self-consciousness, and is self-reinforcing. Novak [63] has found, based on a large sample of online survey, that flow is one of the key components for a compelling online shopping experience, thus further proving that flow is pertinent in studying online consumers' behavior.

Research Objective and Design

Li et al. have conducted several studies to examine the effect of VPE on consumer learning. Specifically, they have traced subjects' verbal protocols during their interactions with VPE-based products, and they have found that consumers provided with a VPE environment pay closer attention to product attributes and are actively engaged in evaluating products [44]. Li et al. [45, 46] and Daugherty et al. [16] have compared subjects' reported product knowledge with three-dimensional versus two-dimensional

Table 1. Four Types of Web Sites

Type	Interface features
Base interface condition.	Static images, hypertexts, and detailed plain text description of products' attributes, including appearance and functionality.
Visual control only.	Base condition plus visual control.
Functional control only.	Base condition plus functional control.
Visual control and functional control.	Base condition plus visual and functional control.

product presentations. The results of these studies indicate that an interactive three-dimensional presentation results in greater product knowledge. Although these prior studies provide a general understanding of the effects of VPE, they have not focused deeply on the technology used. That is, they have not differentiated the effects of different types of VPE technologies, nor have they explained why VPE is beneficial in terms of its supporting technologies.

To address these limitations, the present study examines how and to what extent visual and functional control, as two interface features that can be added to regular e-commerce Web sites, affect perceived diagnosticity of products and consumers' perceptions of flow. The study focuses on products that contain three-dimensional visual appeal that is suitable for visual control and varied functionality information that is suitable for functional control.

A 2×2 factorial design (two levels for visual control and two levels for functional control) was adopted, and four simulated shopping Web sites were constructed, as shown in Table 1.

The research model is outlined in Figure 2 and will be tested using the experimental design shown in Table 2.

Hypotheses Development

We hypothesize that consumers will report higher perceived diagnosticity in shopping Web sites with virtual control (including visual and functional control), compared to regular Web sites where product information is presented only in plain text and static images. This prediction is based on the following two arguments.

First, compared to a regular Web interface, a virtual control interface allows consumers to interact with and to control products through direct manipulation. According to Ariely [4], high control of product information maximizes the fit between consumers' heterogeneous and dynamic needs and the information available, and therefore increases consumers' abilities to explore and to understand the product information structure. However, Ariely has also noted that high control of product information might be disadvantageous, because it compels consumers to apply extra cognitive efforts to learn and to use information controls. Fortunately, this concern is

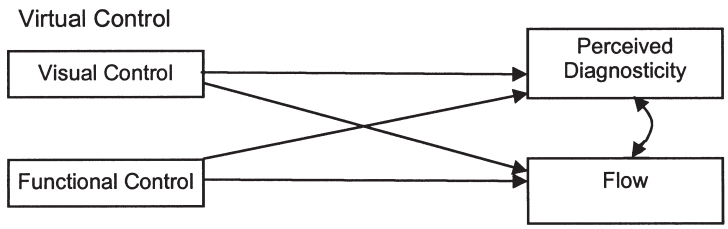

Figure 2. Research Model

Table 2. Experimental Design

Group	First interface	Second interface
Group 1	Base interface condition	Base interface condition
Group 2	Base interface condition	Visual control only
Group 3	Base interface condition	Functional control only
Group 4	Base interface condition	Visual control and functional control

alleviated by direct manipulation, as it allows consumers to easily use the interface and to acquire product information [8, 29].

Second, depending on the multimedia technology used to represent products, an interface with virtual control should contain richer and more comprehensive product information for consumers to evaluate than an interface without virtual control [50]. Furthermore, according to Lim and Benbasat [49], multimedia representations lead to a lower level of perceived equivocality for less-analyzable tasks. Because there is no predetermined procedure for consumers to perceive or evaluate products, the product evaluation process should be regarded as a less-analyzable task. Therefore, the interface with virtual control will be associated with a lower level of perceived equivocality, which means that relevant information is more fully and clearly represented by the added feature of virtual control.

Inasmuch as the above arguments can be applied to both visual control and functional control, the following hypotheses are drawn:

> *H1a: Compared to a regular interface with only plain text and static images, an interface with visual control significantly increases overall perceived diagnosticity.*

> *H1b: Compared to a regular interface with only plain text and static images, an interface with functional control significantly increases overall perceived diagnosticity.*

Research on direct product experience has suggested a match between product experienced and product attributes [61, 88]; that is, the effects of direct experience are best demonstrated for experience attributes, rather than for search attributes. Similarly, it is expected that the effects of virtual control will vary across different attributes. Specifically, visual control affects perceived diagnosticity primarily in relation to appearance attributes of products, and functional control affects perceived diagnosticity primarily in relation to functional attributes of products. Thus, the following hypotheses are posited:

H2a: Compared to a regular interface with only plain text and static images, an interface with visual control increases the perceived diagnosticity of appearance-related attributes.

H2b: Compared to a regular interface with only plain text and static images, an interface with functional control increases the perceived diagnosticity of functionality-related attributes.

It is also expected that the use of virtual control increases online consumers' perceptions of flow. This prediction is based on the definition of flow in Webster et al. [85]. Webster et al. suggest that flow is composed of three subdimensions: control, attention focus, and cognitive enjoyment. First, the direct manipulation made possible by virtual control allows online consumers to exert their control over products "directly"—that is, to manipulate images and to operate various functions—and therefore the feeling of *control* is present [29, 74]. Second, when consumers directly manipulate online products, they need to *focus* on the feedback from products so that they can evaluate it and determine how to proceed. In addition, the multimedia aspects of virtual control present product information through multiple sensory cues and channels [50], which jointly form a rich and attractive information presentation, thereby attracting consumers' *attention.* Third, the high level of interactivity associated with direct manipulation encourages consumers to be exploratory, hence consumer curiosity is expected to be stimulated [29]. When enhanced consumer curiosity is combined with vivid multimedia product presentations, the feeling of *cognitive enjoyment* is also enhanced [84]. Thus, in virtual control, direct manipulation and multimedia can work synergically to enhance consumers' flow.

H3a: Compared to a regular interface with only plain text and static images, an interface with visual control significantly increases consumers' perception of flow.

H3b: Compared to a regular interface with only plain text and static images, an interface with functional control significantly increases consumers' perception of flow.

For products that have a significant proportion of both appearance- and functionality-related attributes, overall perceived diagnosticity and flow will be influenced significantly by both visual and functional control. However, the extents of these two effects are expected to differ.

Visual control taps into appearance-related characteristics, which are relatively evident and directly observable, whereas functional control taps into functionality-related characteristics, which are *hidden* until a manipulation of product features takes place. It is likely that hidden product characteristics elicit more curiosity, interest, and attention from consumers than visual control does. In other words, it is expected that functional control induces a higher flow.

H4a: For products that are associated with both visual and functional control, functional control will lead to a higher flow than visual control.

Higher flow augments more exploratory and experimental behavior [28, 85]. This stronger exploratory tendency in turn can lead to the discovery of more information, thereby enabling consumers to evaluate products more accurately. Therefore, consumers using functional control are likely to report higher perceived diagnosticity than those using visual control.

Hence, the following hypothesis is posited:

H4b: For products that are associated with both visual and functional control, functional control will lead to higher overall perceived diagnosticity than visual control.

As hypothesized, visual control or functional control can increase overall perceived diagnosticity and flow, hence it is expected that an interface with *neither* feature will perform least effectively. However, it is not expected that the existence of both features will necessarily increase overall perceived diagnosticity or flow to the extent of the sum of the individual effects of visual control and functional control. Prior research has suggested that when people are presented with multiple stimulation cues, more salient information cues play a disproportionately more important role than less salient cues [30, 54, 56]. As posited above in relation to H4a and H4b, when both controls are presented together, functional control is expected to be more salient than visual control. Therefore, the effects of functional control will overshadow those of visual control. In other words, the effects of visual control will not be fully represented when both features are presented.

In summary, Web sites with no functional control and no visual control are expected to exhibit the worst performance, but Web sites where both functional and visual control are available are not expected to perform most optimally. Hence, the following hypotheses are asserted:

H5a: For products associated with both visual and functional control, there will be an interaction effect between functional control and visual control in terms of consumers' perception of flow.

H5b: For products associated with both visual and functional control, there will be an interaction effect between functional control and visual control in terms of overall perceived diagnosticity.

Flow is believed to be positively correlated with learning, experimentation, exploration, and perceived communication quantity and effectiveness [28, 85]. Therefore, with higher flow, consumers are more willing and able to learn and examine product information, and they are more likely to feel that the shopping experience is helpful to evaluate products.

H6: Consumers' perception of flow is positively correlated with overall perceived diagnosticity.

Research Methods

Web Site Design

FOUR SIMULATED SHOPPING WEB SITES were constructed to test the above hypotheses, and to address the possible combinations of features considered in the present study (the presence or absence of visual control, and the presence of absence of functional control; see Table 1). These Web sites were designed to sell sports watches, which contain rich appearance and functional information cues, so that both visual control and functional control can be appropriately applied.

Three types of sports watches (Watches A, B, and C) were selected, all of which were available on the Web site www.timex.com and used with the permission of Timex. Two of the watches were adapted for use in the actual experiment, and the third was used to train test subjects. All of the watches have basic features, including time setting, alarms, and night lights, and each watch has its own variety of special features, such as stopwatch functions, timer functions, and pulse measure functions. The brand (Timex) is consistent across different treatment groups. The potential effects of the Timex brand name have also been recognized in the present experiment, as reported in the sixth section.

On the first page of each Web site, the three watches were displayed as small pictures, with the order of display randomly generated by the computer system. Users could select any watch to see the corresponding information pages. On an information page, specifics about a product's attributes were listed beside its image (132×84 pixels). Hyperlinked text and icons also provided more detailed product information. The product image was active upon user clicking, providing static pop-up windows with a larger product image (410×410 pixels).

Following the display of product attributes, two lines of hypertext were presented, contingent upon the treatment each experimental subject was assigned to: "View an interactive 3D movie of the product" and "Try out the watch with our interactive simulation," corresponding to the visual control and functional control treatments, respectively. At the bottom of each page, hyperlinked icons led to detailed explanations for water resistance and night-light features.

QuickTime was used to implement visual control. When users selected the hypertext "View an interactive 3D movie of the product," QuickTime windows with images of the watches emerged in the center of their display. Users could then rotate the images of the watches by dragging their mice (see Appendix A). In addition, the status bar of this window included three active buttons: +, –, and ✛. By pressing "+" (or pressing the SHIFT button on the keyboard), users could magnify the watch image (see Appendix B), and by pressing "–" (or pressing CTRL) they could shrink the image. Users could also press ✛ to shift the watch images. All the scene changes were continuous and vivid, so users would feel that the watches moved and rotated as naturally on the Web site as in a physical environment.

Shockwave was used to implement functional control. When users selected the hypertext "Try out the watch with our interactive simulation," their browsers led the users to a page with the watch images on the left and text instructions on the right (see

Appendix C). Users could follow the instructions to learn the procedures of how to use functions such as time setting, alarm, stopwatch, and night light, and then try out these functions by pressing and controlling functional buttons by themselves (see Appendix D for stopwatch function as an example). This manipulation was shown to be effective in a pilot test, because it was easy for users to learn how to use functional control features. To maintain the information equivalent in different conditions, the same instructions were provided in all cases; that is, for each of the four Web sites, a separate page was linked from each product information page to show the usage of functions in text and simple images.

Recognizing that the size of product images might influence consumer reactions to online shopping experiences [42, 68], and to avoid potential confounding effects, the static images on the pop-up windows and on the functional control pages were presented in the same size (410×410 pixels). For the visual control window, because image size is changeable by zooming in or out, the midpoint size was established equivalent to the above two sizes (the smallest image size for the visual control window is 200×200 pixels, the largest is 620×620 pixels). Thus, users were exposed to images of nearly the same size.

Experimental Design

Measurement of Perceived Diagnosticity

Both Kempf [34] and Kempf and Smith [35] measured overall perceived diagnosticity by a single question: "Overall, how helpful would you rate the trial experience you just had in judging the quality and performance of X?" To increase the content validity and reliability of this measurement, another question was added, and the two questions were adapted to the context of the experiment conducted for the present study. The two questions used in the experiment are as follows:

- Overall, how helpful was the shopping experience to familiarize yourself with the watch?
- How helpful would you rate the shopping experience you just had in influencing your overall evaluation of the watch?

Responses were recorded on a seven-point scale, with the endpoints labeled as "not helpful at all" and "extremely helpful." The experiment also measured perceived diagnosticity across a product's salient attributes ([35]; the elicitation of salient attributes will be discussed in the Identification of Salient Attributes section below). For each salient attribute, subjects were asked: "To what extent did this shopping experience enable you to judge attribute X?" Responses were also recorded on a seven-point scale, with the endpoints labeled as "did not enable me" and "fully enabled me."

Measurement of Flow

Webster et al. [85] developed an instrument to measure computer users' perception of flow. Their measurement was tested in a LISREL measurement model with a goodness of fit at 0.90 and adjusted goodness of fit at 0.84, which has been adopted for the present study. Altogether, 11 items were used to measure the 3 subdimensions of flow: control, attention focus, and cognitive enjoyment (2 items for control, 3 for attention focus, and 6 for cognitive enjoyment). Subsequently, flow was calculated by aggregating the 11 items.

Identification of Salient Attributes

Prior to the experiment of the present study, data about the salient attributes of watches was collected, so that we could analyze the perceived diagnosticity by attributes. Fifty-three undergraduate and graduate students from a large west coast university volunteered as participants. University students are appropriate subjects, because they are a typical consumer segment for Internet shopping [31].

The free elicitation method recommended by Fishbein and Ajzen [19] was utilized. This method has been employed by Kempf and Smith [35] and reportedly worked well. The student subjects were asked to write down between four and six criteria that would be most important for them to evaluate watches. It was specified that they should not include factors related to price and brand names, which were not product quality characteristics per se, but potential indicators of product quality.

Six salient attributes for watches were generated upon coding: appearance (mentioned by 96.2 percent of the respondents), comfort (47.2 percent), durability (47.2 percent), functionality (45.3 percent), water resistance (34.0 percent), and accuracy (28.3 percent).

Pilot Test

In a pilot test, the subjects were randomly assigned to different groups, and perceived diagnosticity and flow were measured for each group. However, the results of the pilot test suggested that the difference between different groups was not interpretable, because most of the subjects rated each question solely in the context of the interface corresponding to their assigned group. There was no common reference point between the groups, allowing for a definitive measure of perceived diagnosticity and flow. This is consistent with Helson's Adaptation-Level Theory [25], which suggests that people's judgments are based on (1) the sum of their past experiences, (2) a context or background, and (3) a stimulus. As the past experience of all subjects cannot be assumed to be equal, the creation of a single context or background was required as a common benchmark [49]. Toward this end, subjects were asked to compare their assigned interfaces to the base interface (without visual or functional control), and then to report the *difference* in perceived diagnosticity and flow. Therefore, all values of perceived diagnosticity and flow reported in the paper are comparative values based on a common reference point—that is, the base interface. Comparative values are appropriate for the current study, because people's perceptions are always relative rather than absolute.

The questionnaire from the initial design stage was accordingly redesigned (see Appendix E), and a follow-up pilot test indicated that data from this design was interpretable.

Experimental Procedures

The experiment was conducted as follows:

- Step 1 (*training*): Each subject was randomly assigned to one of the four interface groups. A research assistant trained the subjects how to use and navigate the assigned Web interface, using Watch C as an example. The subjects did not proceed to the second stage until they understood how to use the Web site.
- Step 2 (*test*): Each subject was asked to choose one of two watches (Watch A or B) to start the actual test and to examine the watch on the base interface.[4] Next, the subjects were shown the same watch on the treatment interface corresponding to their group (see Table 2).[5] The research assistants refrained from interfering with the subjects, but verified that the subjects used the treatment feature(s).

  After examining the watches in the treatment interfaces, subjects were asked to compare the treatment interfaces with the base interface, in terms of perceived diagnosticity and flow. This step was then repeated for the second watch.
- Step 3 (*brand effect check*): Subjects were asked another question to check the effects of brand name and trademark.

The entire questionnaire for this study is shown in Appendix E.

A total of 84 student subjects volunteered to participate in the study. Each was given $15 and a chance to win the watch they had picked at the end of the experiment. Subjects were randomly assigned to the four interface groups. During the experiment, subjects were asked to behave as if they were examining online products in real shopping Web sites, and they were asked to avoid being influenced by the brand name or trademark that they would see.

Data Analysis

Brand Effect Check and Initial Data Screening

ONE SUBJECT MISUNDERSTOOD THE INSTRUCTIONS and did not circle his answers in the right way, therefore his data was discarded. For the remaining 83 subjects, their answers were checked against the question on brand name effect (see step 3 of the experimental procedures). The answers were on a seven-point scale, and most of the subjects selected 1 or 2, indicating that the brand name did not significantly affect their answers to the questions. Three people selected 3, which revealed that the brand name influenced their answers to some extent, albeit minor. Therefore, the data from these three subjects were also discarded, leaving 80 valid responses, with 20 in each of the four treatment groups.[6]

Table 3. Factor Analysis of Salient Attributes

	Factor	
	1	2
Comfort	0.99	–0.16
Appearance	0.57	0.23
Accuracy	4.90E-03	0.81
Functionality	4.25E-03	0.69
Durability	0.38	0.40
Water resistance	0.10	1.11E-03

Among these 80 subjects, 53 were female and 27 male. Eleven were graduate students, and the other 69 were undergraduate students with an average of 2.74 years at the university. Fifty-three were from a business school, whereas others were from several different faculties. Correlations between gender, undergraduate/graduate program, area of study, numbers of years at the university, and the two dependent variables—that is, perceived diagnosticity and flow—were low and not significant. *t*-tests were also conducted, showing that gender, program and area of study did not affect the dependent variables. Therefore, demographics are not considered as moderators.

Potential outliers were checked using Box Plot function in SPSS, which indicated that data of two subjects might be considered as outliers. However, because no strong reasons to drop those data were identified, they were retained in subsequent data analysis to increase generabilizability [23]. Supportively, a follow-up analysis was also conducted to compare the statistical results from the data that retained these outliers to those from the data that dropped these outliers, and it showed almost no difference.

Factor Analysis of Salient Attributes

A sphericity test conducted on the perceived diagnosticity of the six salient attributes indicated that the data were factorable. A subsequent exploratory factor analysis, using unweighted least squares as the extraction method and varimax as the rotation method, showed that *comfort* and *appearance* loaded heavily on the first factor,[7] and *accuracy* and *functionality* loaded heavily on the second factor (see Table 3). The factor patterns for *water resistance* and *durability* were not clear. The former had a weak loading on each factor, and the latter loaded almost equally on both factors.

As noted, the first factor included *comfort* and *appearance,* which is reasonable, because test subjects can somewhat judge whether a watch is comfortable to wear by examining its appearance. Hence, this factor is thus labeled the appearance-related factor. The second factor encompasses *accuracy*[8] and *functionality* and was labeled the *functionality-related factor.*

Perceived diagnosticity of the appearance-related factor was further calculated by averaging the responses on *comfort* and *appearance;* whereas perceived diagnosticity of the functionality-related factor was calculated by averaging the responses on *accuracy* and *functionality.* Because durability and water resistance information is unlikely to be revealed from either visual control or functional control, these two attributes were not considered for the following analysis.

A Check for Order Effect and Watch Type Effect

In the experiment, subjects examined the two watches, one at a time. As a result, a learning effect might influence the test results, because subjects' experience with the first watch might influence their experience with the second. The possible impact of this effect on the outcome variables was tested in a preliminary analysis.

A 2×2 analysis of variance (ANOVA) was conducted for the first watch and the second watch separately (Table 4).

For both watch order conditions, visual control and functional control exerted similar effects on perceived diagnosticity of the appearance-related factor and the functionality-related factor, overall perceived diagnosticity and flow, with only two exceptions. First, functional control appeared to influence perceived diagnosticity of the appearance-related factor at a significant level ($p < 0.05$) only for the first watch, but this effect became insignificant for the second watch. The other exception, albeit a minor one, was that visual control has an effect on flow at a level of 0.01 for the first watch, but at a level of 0.05 for the second watch.

The *watch type* effect was also examined—that is, comparing Watch A and Watch B, as detailed in Table 5.

Watch A and B exhibited a high consistency in the analysis of perceived diagnosticity and flow, and only three exceptions were identified. Most prominently, visual control appeared to have a significant effect on perceived diagnosticity of the functionality-related factor for Watch B, but not for Watch A. The other minor differences that appeared were: (1) the interaction effect (visual control × functional control) on appearance-related factors appeared to be significant at 0.05 for Watch A, but at 0.01 for Watch B; and (2) the effect of visual control on flow appeared to be significant at 0.01 for Watch A, but 0.05 for Watch B.

Because the watch type and order did not exert significant difference for perceived diagnosticity and flow analysis, and more importantly, in the absence of a theory that predicts that such differences would exist, the data of the two watches was pooled for each subject (by averaging).

Results on Perceived Diagnosticity and Flow

A 2×2 factorial ANOVA was conducted on the pooled data to examine the effects of visual control and functional control on perceived diagnosticity and flow. The two items to measure overall perceived diagnosticity were created for this study. The corresponding Cronbach's alpha was 0.88. Therefore, it was reasonable to average them as *overall perceived diagnosticity.*

Table 4. Comparison Between First Watch and Second Watch

	Functional control effect		Visual control effect		Functional control * visual control	
	First watch	Second watch	First watch	Second watch	Second watch	Second watch
Appearance-related factor	**(+)***	**n.s.**	(+)***	(+)***	*	*
	(0.046)	**(0.389)**	(0.000)	(0.000)	(0.011)	(0.026)
Functionality-related factor	(+)***	(+)***	n.s.	n.s.	n.s.	n.s.
	(0.000)	(0.000)	(0.061)	(0.231)	(0.37)	(0.406)
Overall diagnosticity	(+)***	(+)***	(+)*	(+)*	**	**
	(0.000)	(0.000)	(0.020)	(0.019)	(0.001)	(0.007)
Flow	(+)***	(+)***	**(+)****	**(+)***	(+)***	(+)***
	(0.000)	(0.000)	**(0.002)**	**(0.030)**	(0.000)	(0.000)

Notes: * is significant at the 0.05 level; ** is significant at the 0.01 level; and *** is significant at the 0.001 level; "+" means positive effect, "–" means negative effect; figures shown are the corresponding *p*-values; boldface type highlights the difference between Watch A and Watch B.

Table 5. Comparison Between Watch A and Watch B

	Functional control effect		Visual control effect		Functional control * visual control	
	Watch A	Watch B	Watch A	Watch B	Watch A	Watch B
Appearance-related factor	n.s.	n.s.	(+)***	(+)***	*****	******
	(0.166)	(0.123)	(0.000)	(0.000)	**(0.047)**	**(0.005)**
Functionality-related factor	(+)***	(+)***	**n.s.**	**(–)***	n.s.	n.s.
	(0.000)	(0.000)	**(0.371)**	**(0.029)**	(0.204)	(0.657)
Overall diagnosticity	(+)***	(+)***	(+)*	(+)*	**	**
	(0.000)	(0.000)	(0.019)	(0.020)	(0.001)	(0.004)
Flow	(+)***	(+)***	**(+)****	**(+)***	(+)***	(+)***
	(0.000)	(0.000)	**(0.003)**	**(0.018)**	(0.000)	(0.000)

Notes: * is significant at the 0.05 level; ** is significant at the 0.01 level; and *** is significant at the 0.001 level; "+" means positive effect, "–" means negative effect; figures shown are the corresponding *p*-values; boldface type highlights the difference between Watch A and Watch B.

Table 6. Perceived Diagnosticity on Appearance-Related Factor

	Without functional control	With functional control	Mean
Without visual control	0.09	1.04	0.56
With visual control	2.96	2.73	2.84
Mean	1.53	1.88	
Significance level of visual control	0.00		
Significance level of functional control	0.06		
Significance level of the interaction effect	0.00		

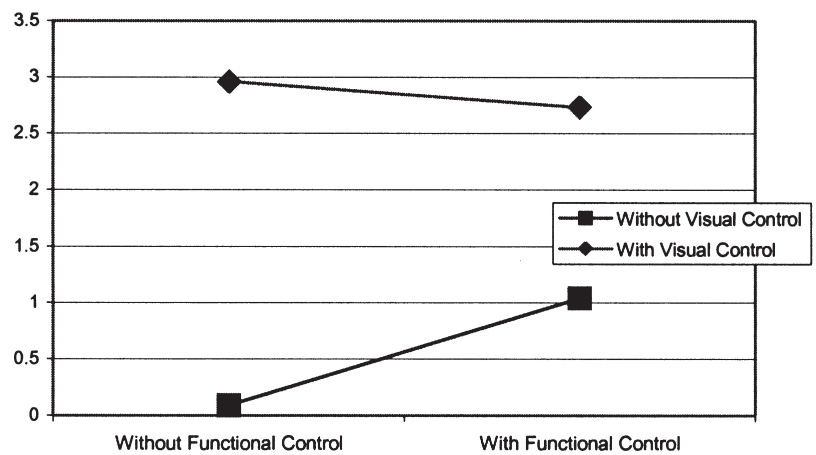

Figure 3. Perceived Diagnosticity of Appearance-Related Factors

Cronbach's alphas for flow and its three dimensions (control, attention focus, and cognitive enjoyment) were 0.95, 0.93, 0.80, and 0.94, respectively, which lent support to the reliability of the measurement. For the purpose of easing understanding on a five-point scale, which was also used for calculating perceived diagnosticity, the measurements of flow were reported by averaging the 11 items; the results are shown in Tables 6 through 13 and Figures 3 through 6.

Visual control seemed to exert a significant and positive effect on the perceived diagnosticity of the appearance-related factor (Table 6, Figure 3), but functional control did not (at $p < 0.05$). The interaction effect also appeared to be significant, demonstrating that the effects of functional control depend on whether visual control exists or not. An added test for multiple comparisons was performed (Scheffe test, see Table 7). The results indicated that if visual control was not provided, the use of functional control would improve perceived diagnosticity of the appearance-related factor, but to a much lesser degree than visual control. However, if visual control was provided, the addition of functional control would not add any improvement in per-

Table 7. Scheffe Multiple Comparisons of Perceived Diagnosticity on Appearance-Related Factor

Group A	Group B	Mean difference (A – B)	Significance
Base interface condition	Visual control only	–2.88	0.00
	Functional control only	–0.95	0.01
	Visual control and functional control	–2.64	0.00
Visual control only	Base interface condition	2.88	0.00
	Functional control only	1.93	0.00
	Visual control and functional control	0.24	0.86
Functional control only	Base interface condition	0.95	0.01
	Visual control only	–1.93	0.00
	Visual control and functional control	–1.69	0.00
Visual control and functional control	Base interface condition	2.64	0.00
	Visual control only	–0.24	0.86
	Functional control only	1.69	0.00

ceived diagnosticity. On the other hand, visual control seemed to increase the perceived diagnosticity of the appearance-related factor regardless of whether functional control was provided or not. Therefore, H2a is supported.

Functional control seemed to significantly increase the perceived diagnosticity of the functionality-related factor (Table 8, Figure 4). Thus, H2b is supported. Neither visual control nor the interaction effect of visual with functional control is significant. Both functional control and visual control exhibited similar effects on overall perceived diagnosticity and flow.

Specifically, both visual control and functional control had significant and positive effects on overall perceived diagnosticity and flow. The interaction effects between visual control and functional control were also significant, thus supporting H5a and H5b. An additional multiple comparison using the Scheffe test (Tables 10 and 12) demonstrated that if functional control was not provided, the individual use of visual control would enhance overall perceived diagnosticity and flow; however, if functional control was provided, the addition of visual control would not have a significant effect. Thus, H1a and H3a are true only under conditions where functional control does not exist. In contrast, regardless of whether visual control is available or not, the addition of functional control appears to consistently and significantly increase overall perceived diagnosticity and flow. Therefore H1b and H3b are fully supported.

The interaction effects provide evidence that functional control is stronger than visual control in enhancing overall perceived diagnosticity and flow, simply because the former dominates the latter. A further comparison of the overall effects of visual and functional control should examine the significance levels of the two main effects.

Table 8. Perceived Diagnosticity on Functionality-Related Factor

	Without functional control	With functional control	Mean
Without visual control	0.34	2.88	1.61
With visual control	0.16	2.25	1.21
Mean	0.25	2.56	
Significance level of visual control	0.08		
Significance level of functional control	0.00		
Significance level of the interaction effect	0.32		

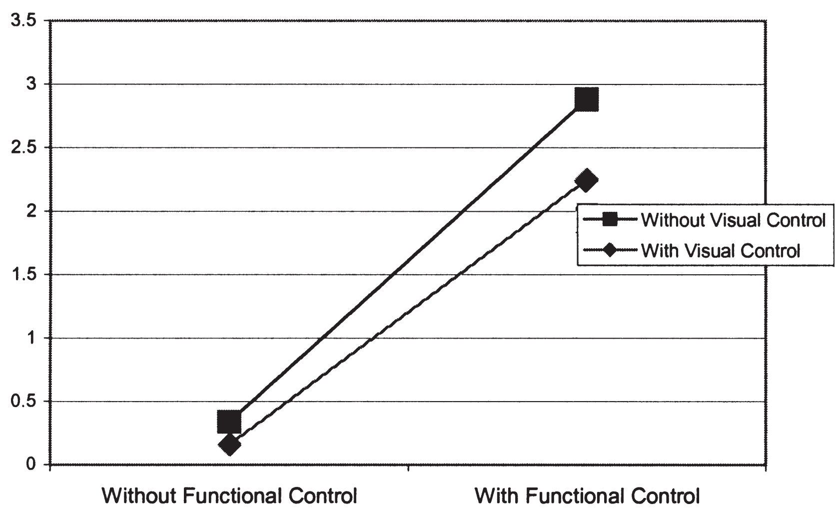

Figure 4. Perceived Diagnosticity of Functionality-Related Factors

Specifically, visual control is significant at 0.01 for overall perceived diagnosticity and flow, whereas functional control is significant at 0.001. The absolute increases of the mean values of overall perceived diagnosticity and flow make the comparison more obvious (see Tables 9 and 11). Functional control increases the mean values more sharply (for overall perceived diagnosticity: from 1.36 to 3.79; for flow: from 0.59 to 2.91) than visual control does (for overall perceived diagnosticity: from 2.19 to 2.96; for flow: from 1.43 to 2.06). Therefore, it is apparent that functional control is more compelling than visual control, and that it increases overall perceived diagnosticity and flow, and thus H4a and H4b are supported.

The correlations among different levels of perceived diagnosticity and flow are listed in Table 13. Overall perceived diagnosticity has a significant ($p < 0.001$) and positive (0.84) correlation with flow, which proves H6.

Table 9. Overall Perceived Diagnosticity

	Without functional control	With functional control	Mean
Without visual control	0.48	3.91	2.19
With visual control	2.25	3.66	2.96
Mean	1.36	3.79	
Significance level of visual control	0.002		
Significance level of functional control	0.000		
Significance level of the interaction effect	0.000		

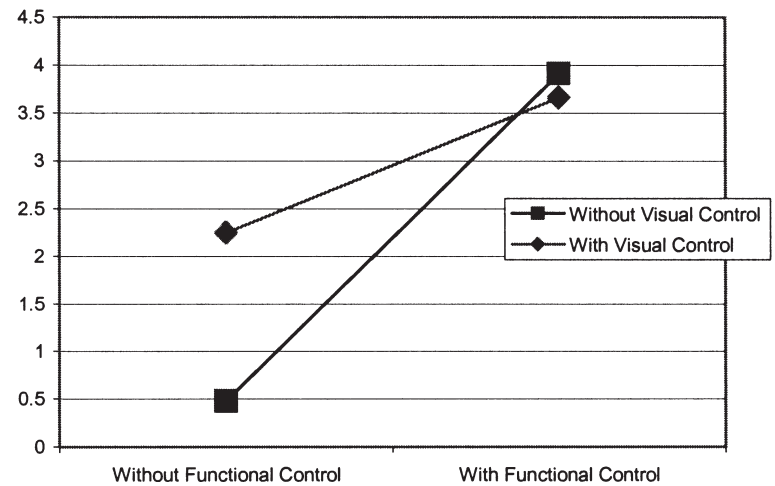

Figure 5. Analysis of Overall Perceived Diagnosticity

Summary of Results

Visual control and functional control increase the perceived diagnosticity of appearance-related and functionality-related factors, respectively. In addition, functional control increases the perceived diagnosticity of appearance-related factors slightly, but only in the absence of visual control.

Results of the experiment also suggest that both visual and functional control effectively increase overall perceived diagnosticity and flow. However, functional control dominates visual control in this effect—that is, visual control has an effect only in the absence of functional control.

Discussions

THIS STUDY INVESTIGATES THE EFFECTS of virtual control (specifically, visual and functional control) on perceived diagnosticity and flow. Perceived diagnosticity, a

Table 10. Scheffe Multiple Comparisons of Overall Perceived Diagnosticity

Group A	Group B	Mean difference (A – B)	Significance
Base interface condition	Visual control only	–1.78	0.00
	Functional control only	–3.44	0.00
	Visual control and functional control	–3.19	0.00
Visual control only	Base interface condition	1.78	0.00
	Functional control only	–1.66	0.00
	Visual control and functional control	–1.41	0.00
Functional control only	Base interface condition	3.44	0.00
	Visual control only	1.66	0.00
	Visual control and functional control	0.25	0.91
Visual control and functional control	Base interface condition	3.19	0.00
	Visual control only	1.41	0.00
	Functional control only	–0.25	0.91

Table 11. Effects of Visual and Functional Control on Consumer Perceptions of Flow

	Without functional control	With functional control	Mean
Without visual control	–0.25	3.12	1.43
With visual control	1.44	2.69	2.06
Mean	0.59	2.91	
Significance level of visual control	0.002		
Significance level of functional control	0.000		
Significance level of the interaction effect	0.000		

concept adopted from marketing research, represents the extent to which consumers believe a product experience is helpful for them to understand and evaluate products. In their study of direct product experience, Kempf and Smith [35] have argued that perceived diagnosticity is very important for physical product trials, because high perceived diagnosticity can strengthen consumers' beliefs about product performance and enhance their confidence in their product decisions. In the online environment, consumers' capability to diagnose product information appears even more critical than in the physical shopping environment, because the Web interface is known to be a poor channel for conveying product information, especially for information about the experience attributes of products [3, 13, 67, 70]. Inasmuch as virtual control has been found in this study to enhance overall perceived diagnosticity of products, and

Table 12. Scheffe Multiple Comparisons of Consumer Perceptions of Flow

Group A	Group B	Mean difference (A – B)	Significance
Base interface condition	Visual control only	–1.69	0.00
	Functional control only	–3.38	0.00
	Visual control and functional control	–2.94	0.00
Visual control only	Base interface condition	1.69	0.00
	Functional control only	–1.68	0.00
	Visual control and functional control	–1.25	0.00
Functional control only	Base interface condition	3.38	0.00
	Visual control only	1.68	0.00
	Visual control and functional control	0.43	0.49
Visual control and functional control	Base interface condition	2.94	0.00
	Visual control only	1.25	0.00
	Functional control only	–0.43	0.49

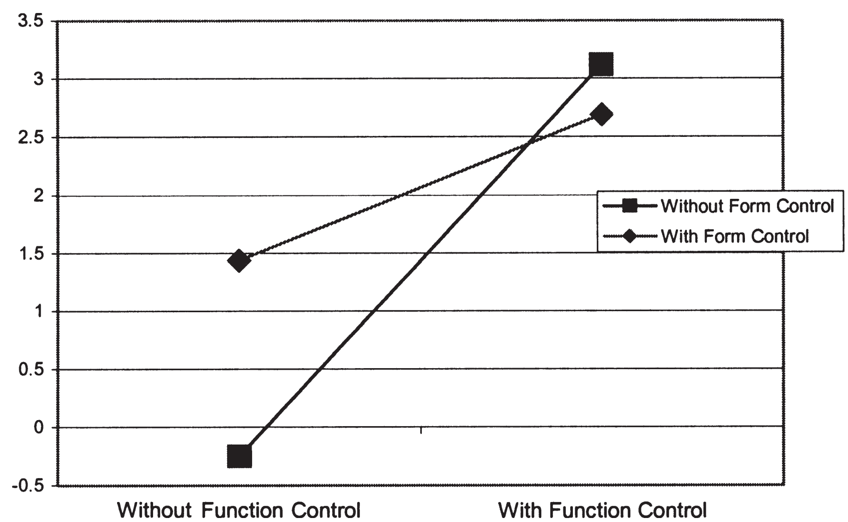

Figure 6. Analysis of Flow

in particular, the perceived diagnosticity of experience attributes (i.e., appearance and functionality), based on Kempf and Smith's [35] findings it is likely that with virtual control online consumers will have stronger beliefs about their product knowledge and will be more confident in their product choice. In other words, one can view virtual control as a personal "decision support system" for customers to make better and more informed purchase decisions.

Table 13. Correlation Among Variables

	Perceived diagnosticity of appearance-related factor	Perceived diagnosticity of functionality-related factor	Overall perceived diagnosticity
Perceived diagnosticity of appearance-related factor	—	—	—
Perceived diagnosticity of functionality-related factor	0.07	—	—
Overall perceived diagnosticity	0.44**	0.73**	—
Flow	0.43**	0.68**	0.84**

** Significant at the 0.01 level (two-tailed).

The second dependent variable, flow, on the other hand, portrays consumers' experiences with computers as characterized by engaging and exploratory affective responses. In the context of online shopping, as Hoffman and Novak [28] and Novak et al. [63] have indicated, flow is the key construct for a compelling shopping experience. Koufaris [39] applied the theory of flow and the Technology Acceptance Model [17] to study online consumers' unplanned purchases and their intentions to return to Web-based stores. He has found that one dimension of flow, shopping enjoyment, significantly affects consumer intentions to return to a Web site. Since virtual control increases customers' perception of flow, it is evident that the incorporation of virtual control into e-commerce Web sites will benefit consumers by creating an enjoyable shopping experience and will help vendors in attracting and retaining customers.

The double-edged approach to investigating virtual control on both perceived diagnosticity (cognitive side) and flow (affective side) is supported by Jarvenpaa and Todd [32] and McKinney et al. [57]. Jarvenpaa and Todd [32], based on a survey, have identified four factors that are salient to consumers when they form their attitudes and intention to shop online. Product perception and shopping experience are among these four factors. McKinney et al. [57] developed an instrument to measure Web customers' satisfaction with Web site information quality and system quality variables. They suggested that understandability of information and Web site entertainment were parts of information quality and system quality, respectively. Since perceived diagnosticity is related to product understanding and flow is related to the customers' feeling of entertainment, these two variables will both influence Web customers' satisfaction (see also [78, 82]). Thus, studying perceived diagnosticity and flow together is warranted. Furthermore, the high correlation between perceived diagnosticity and flow found in this study suggests that, in the context of VPE, customers' decision-making is not distinct from their shopping experience; rather, these both are integral to online shopping.

The current study also has practical implications. It offers e-commerce Web designers useful insights into the selection of available VPE methods for presenting products. For example, as our results indicate for products that have both visual and functional attributes to be evaluated, in order to enhance overall perceived diagnosticity and flow it is more effective to provide functional, than visual, control. Furthermore, insofar as no significant differences can be identified between cases with functional control only and cases with *both* visual and functional control in terms of overall perceived diagnosticity and flow, it is more efficient for designers to provide functional control alone than to provide both. However, based on our results that visual control itself is still helpful in the absence of functional control, designers must also keep in mind that visual control can be beneficial if the key attributes of the product are predominantly based on appearance, such as home furnishings. Overall, our recommendations provided above concerning the use of visual and functional control are applicable to products that are represented mostly by experience attributes, but not to products that are mainly understood and evaluated by their *search* attributes, such as the price, weight, and memory size for a laptop computer. Therefore, before adopting visual or functional control, designers should first make a determination of the nature of the attributes on which the customers will mainly base their product evaluations.

The identification of the core technological components of virtual control—that is, direct manipulation and multimedia—and the theoretical approach of integrating the corresponding human–computer interaction theories to justify the effects of virtual control are also practically important. They pave the way for Web designers to recognize the technological composition of virtual control, and to understand that it is direct manipulation that enables customers to control online products and their features, and that it is multimedia that allows products to represent their reactions to customers' inputs.

Three limitations of the study should also be pointed out. First, the effect of virtual control may depend on product type. Visual control is effective for those products that have a three-dimensional visual appeal, functional control for those that are associated with behavioral or functional cues. This high dependency indicates that virtual control may not be as effective for other types of products. Furthermore, even for products that meet these two criteria, the relative power of visual and functional control may still depend on the proportion of appearance-related over functionality-related attributes, or the hedonic/functional nature of products [34]. When particular products have more appearance-related attributes and fewer functionality-related ones, the effects on perceived diagnosticity of visual control may become stronger and those of functional control weaker. This fact, incidentally, is also an important consideration for Web design practitioners to keep in mind. Furthermore, products with a hedonic nature may tend to generate higher affective responses, such as flow, than products that are more functional. In this sense, the present study is best applied to products that have similar attribute structures and hedonic/functional nature, as sports watches do. However, it should be acknowledged that this limitation is common to most lab experiments on product experience [55, 75, 76], because no one product can be considered as general or typical enough. This also points out to the need to expand and replicate this study to investigate products with different characteristics.

Second, the possible negative effects associated with download time in the use of virtual control were not considered. In the experiment conducted for this study, because the server used was local, the download speed was fast enough to avoid this effect. However, in reality, download speed will most likely influence the desirability and use of virtual control, because consumers will not wait long for virtual control features to appear [20, 59, 86]. Therefore, the results of this study are relevant to situations where download speed is not a serious constraint.

Third, as Lightner [47] has indicated, demographic characteristics of online shoppers may significantly affect their shopping behavior. Although the demographics of the experimental subjects in this study were not moderating variables, the reason might simply be that the subjects were from the same university and were rather a homogeneous set. Recognizing that all subjects are university students and the majority of them are from a business program and female, the results of this study may not be suitable to other demographic conditions. It is likely that young women have a greater affinity than other people for interacting with sensory-appealing Web features, such as visual and functional control. Similarly, the subjects' prior knowledge of sports watches and their prior experiences with visual and functional control applications were not controlled in this study. It is also possible that the degree of the prior knowledge and prior expertise might have affected their performances in this experiment [2, 12, 34]. However, since this is an IS-oriented study that focuses on investigating the contributions of IT-based applications to online product understanding and consumers' flow experience, to keep this focus clear the familiarity and expertise factors are not investigated by randomly assigning subjects to different experimental conditions [10].

For future research, more investigation is needed into the relationships between perceived diagnosticity and flow. The present study predicted that higher consumer perceptions of flow leads to more exploratory behavior, which in turn leads to further discoveries of product information and therefore higher overall perceived diagnosticity. This prediction is based on Webster [85]. A future study that manipulates flow (e.g., by designing two interfaces that differ in the quality of flow) to examine its effect on perceived diagnosticity would be one way to illuminate the causal relationship between the two constructs. Also, future research may look at the effects of virtual control on other consumer behavior variables, such as the Technology Acceptance Model variables [17], consumers' attitudes change and satisfaction [36, 57], consumer trust [58], consumers' perception of product risk [66], and consumers intention to purchase and return to the Web sites [40].

It is also promising to study the design of virtual control. Benbasat and Zmud [9] have suggested that IS research needs to be relevant to practice, so design sciences [5, 6] should be part of IS research. Their call resonated in a recent paper by Hevner et al., who argued that IS behavioral science "focuses on developing and justifying theories that explain and predict phenomena" related to IT applications, whereas design science "focuses on creating and evaluating innovative IT artifacts that enable organizations to address important information-related tasks" [26, p. 98]. They have warned that overemphasis on behavioral science research paradigm may lead to failures to adequately anticipate technological trends and capabilities; therefore, they have called for design science in IS research to complement behavior sciences. Employing behavioral research methods, the present study focuses on examining the effects of visual and functional control, but it does not elaborate how to design these two features; so it does not help IS researchers or professionals to build virtual control applications. Therefore, future research addressing the issue of virtual control *design* considerations would be practically important and interesting.

Another promising avenue for future research is to study other types of virtual product experiences. For example, online clothing Web sites allow customers to try clothes on virtual mannequins, and real estate Web sites allow users to enter and view houses or rooms. The effects of these VPE methods and their implementation deserve research to fully explore the effect of VPE on consumer behavior in e-commerce environments.

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Notes

1. Apple Computer, Inc.
2. Macromedia, Inc.
3. Macromedia, Inc.
4. In order to bring the experiment closer to the real shopping experience, we did not impose the order by which subjects examined the two watches (Watch A and B), and allowed them to examine the watches as long as they preferred. This is in line with Urban et al. [80, p. 52].
5. For the interface without visual or functional control, subjects were asked to view the interface two times, without being told whether the two interfaces they saw were the same or not. Most subjects reported zero as relative perceived diagnosticity and flow because the two interfaces were the same. However, some perceived slight differences and reported –1 or 1. These differences may be due to experiment history or maturation effects, which could also affect other groups. In other words, the group without visual or functional control was used to control the potential confounding effects.
6. The pilot test revealed that the effect size of the experiment was considerable. Therefore, if the Type I error is set to 0.05 and the effect size index f to 0.33 (medium to large), then 20 subjects per cell can guarantee the power to be over 0.80 [14]. As a matter of fact, since all main and interaction effects were found to be significant in the later data analysis, the Type II error was not an issue in this study.
7. Hair et al. [23], as a rule of thumb, have suggested that for a sample size of 80, loadings great than 0.617 are considered as statistically significant. According to this criterion, the loading of appearance on the first factor 0.57 is marginally low. However, given that Hair et al. agree that their criterion is "quite conservative" and that "lower loadings" can be "considered significant and added to the interpretation based on other considerations" [23, p. 111], and recognizing that there is a considerable difference between 0.57 and the third largest loading on the first factor, 0.38, it is justifiable to combine comfort and appearance together to form the first factor.
8. Whereas accuracy may not appear to be an experience attribute and thus is not expected to benefit from a virtual product experience, its inclusion is justified by two considerations.

First, there are cases where accuracy-related information may be derived based on functional control, such as observing that the chronometer function of a sports watch has subsecond accuracy, as was the case with the two watches used in step 2 of this study (see also www .gophysical.com). Second, from an empirical point of view, functional control appears to favorably influence the perceived diagnosticity of accuracy.

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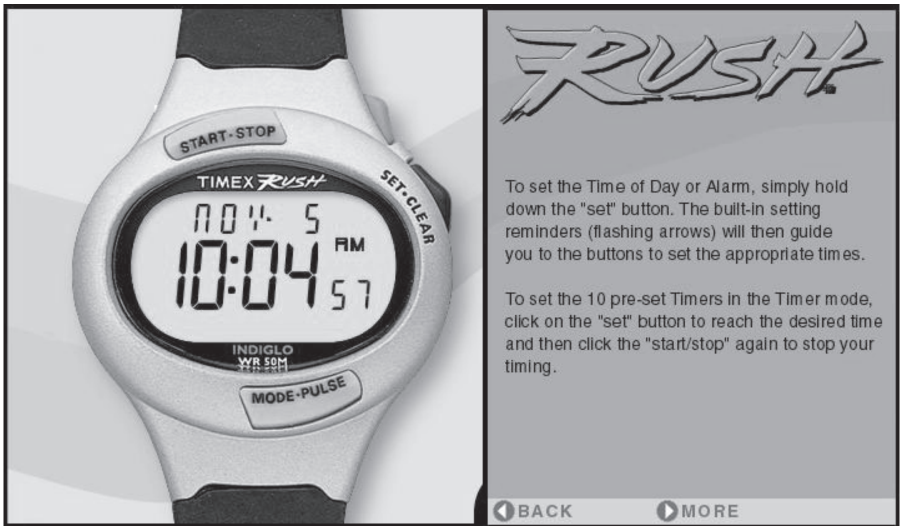
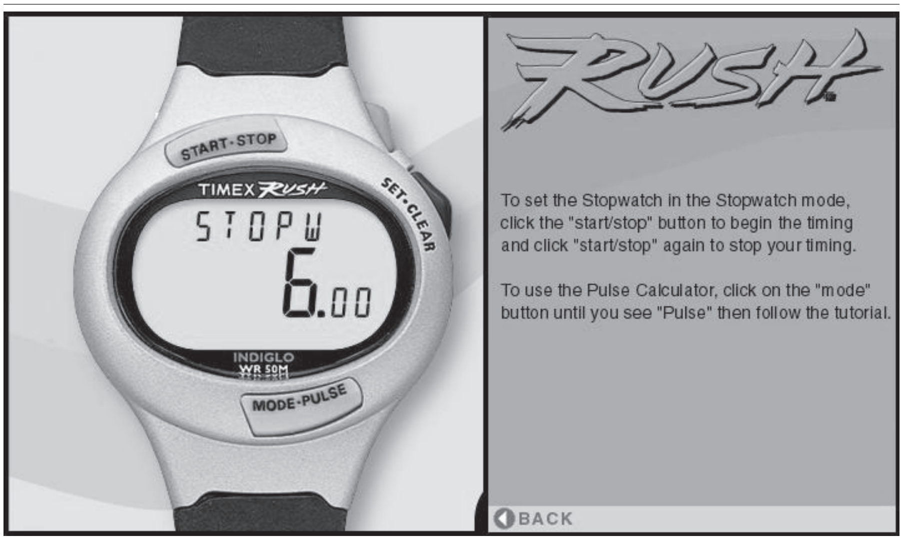
Appendix A: Visual Control Rotation

Appendix B: Visual Control (Zoom In)

Appendix C: Functional Control (Initial Page)



Appendix D: Functional Control (Stopwatch)



Appendix E: A Study of Web Shopping

Questionnaire

Part I

THE FOLLOWING QUESTIONS ASK you to compare the two Web interfaces you have just seen and to indicate to what extent you prefer one or the other.

For example, three persons *a*, *b*, and *c* have the following feeling toward the Web interface they used:

1. person *a* found the first interface *much more* attractive;
2. person *b* found both interfaces *equally* attractive;
3. person *c* found the second interface *a little more* attractive.

Their responses are shown below.

Q: Which interface did you find more attractive?

The first Web interface					Equal					The second Web interface
5	4	3	2	1	0	1	2	3	4	5
	↑				↑		↑			
	a				*b*		*c*			

That is, person *a* would select 4 on the left, person *b* would select 0, and person *c* would select 2 on the right.

Questions

1. Which interface gave you *less control* over your interaction?

The first Web interface					Equal					The second Web interface
5	4	3	2	1	0	1	2	3	4	5

(The same scale was used for the items below.)

2. With which interface was your *imagination* aroused more when examining the product?
3. Interacting with which interface made you more *curious?*
4. With which interface did you *think more about unrelated things* when examining the product?
5. With which interface was examining products more *intrinsically interesting?*
6. With which interface were you more *bored* when examining the product?
7. With which interface were you more *absorbed* in what you were doing?
8. With which interface did you have more *control* when examining the product?
9. With which interface were you *distracted* more by unrelated things when examining the product?

10. With which interface was your *curiosity* excited more by examining the product?
11. Which interface was more *fun* for you to use?

Part II

The following questions ask you about the difference between your impression of the same product on two different Web interfaces. *Note: The higher the absolute value of a score, the more helpful the corresponding interface.*

1. Which Web interface is more helpful for you to judge the watch's *appearance?*

The first Web interface is more helpful ←					Equal	The second Web interface is more helpful →				
5	4	3	2	1	0	1	2	3	4	5

(The same scale was used for the items below.)

2. Which Web interface is more helpful for you to judge *whether the watch is comfortable to wear?*
3. Which Web interface is more helpful for you to judge the watch's *durability?*
4. Which Web interface is more helpful for you to judge the watch's *functionality?*
5. Which Web interface is more helpful for you to judge the watch's *water resistance?*
6. Which Web interface is more helpful for you to judge the watch's *accuracy?*
7. Which Web interface is more helpful in *familiarizing you with the watch?*
8. Which Web interface is more helpful in *influencing your overall evaluation of the watch?*

Check of Brand Name Effect

The brand name and trademark in this experiment influenced my answers to the questions.

No influence at all										Extremely strong influence
5	4	3	2	1	0	1	2	3	4	5