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ABSTRACT

In this paper, the authors argue that Virtual Reality (VR) does have a place in an e-commerce environment. However, VR is not yet ready to supplant standard e-commerce Web interfaces with a completely immersive VR environment. Rather, Virtual Reality in e-commerce (VRCommerce) must rely on a mixed platform presentation to account for various levels of usability, user trust, and technical feasibility. The authors propose that e-commerce sites that want to implement VRCommerce offer at least three layers of interaction to users: a standard Web interface, embedded VR objects in a Web interface, and semi-immersive VR within an existing Web interface. This system is termed the Layered Virtual Reality Commerce System, or LaVRCS.

Keywords

Virtual Reality, E-commerce, Web3D

INTRODUCTION

Businesses use the Web to market goods and services to people and other businesses. Consumers—businesses and people—increasingly look to the Web to provide choices and the means to make informed purchasing decisions. E-commerce transactions have grown faster than most predictions and continue to grow as more businesses improve online offerings (Tygar, 1998). Businesses want to make their Websites easy to use and move people toward intended purchases (Cummins, 2002). Web usability experts work to simplify Web designs and usability so that potential customers find familiar navigation schemes and metaphors (e.g., the shopping cart) to simplify their purchases (Nielsen, 2000).

Still, we hear anecdotal stories of abandoned shopping carts, unsatisfied e-commerce users, and e-businesses that have failed even though they offered quality products or services. There must remain some elusive criteria that have not yet been met to create an environment in which satisfied Web users explore goods and services and complete e-commerce transactions.

The paper posits that although e-commerce sites must first and foremost be secure and offer navigable Web pages and electronic catalogs, they also must allow users to choose how they want to explore the proffered goods and services. This should include an interactive medium so that users can "experience" wares. The interactive medium most suited to offer another experiential layer is Virtual Reality (VR).

However, VR is not yet ready to supplant standard e-commerce Web interfaces with a completely immersive VR environment. Rather, e-commerce must rely on a mixed platform presentation to account for various levels of usability, user trust, and technical feasibility. This paper proposes that e-commerce sites that want to implement VR in e-commerce (or VRCommerce) offer at least three layers of interaction: a standard Web interface, embedded VR objects in a Web interface, and semi-immersive VR within an existing Web interface. The paper terms this system the Layered Virtual Reality Commerce System (LaVRCS).

In order to understand how LaVRCS is critical to allowing users to comfortably and effectively access and benefit from e-commerce, we must first define Virtual Reality and examine its many permutations. Then we will review prior research and implementations of VR as it relates to e-commerce. From here, we will briefly discuss different levels of e-commerce and the suitability of certain goods and services for e-commerce permutations. This will lead us into a working definition of VRCommerce as we consider its challenges. We will then discuss the LaVRCS architecture and how it addresses these challenges. Finally, we will discuss potential prototype applications and testing, and close with implications for future research.

WHAT IS VIRTUAL REALITY?

For most users the graphical user interface (GUI) is the main method to interact with computers. The desktop metaphor, complete with trash cans and recycle bins, helps users take the familiarity of a physical desktop and place it on a computer screen. Users are comfortable with the WIMP (windows, icons, menus, and pointers) interface and this comfort extends onto the Web with Web browsers displaying text and images. A mouse click on a hyperlink allows a user to navigate a 2D Website.

However, methods exist for users to interact with computers beyond the GUI interface: voice recognition, and eye, head, and body tracking devices are a few. Others include 3-D visualizations, biofeedback, and instruments that use stereo sound, smell, and even taste. Using human senses and the body to interact with computers brings us into the VR realm.

Many definitions have been put forth to describe VR. Some focus on the means to enhance communication among people (Greenhalgh & Bedford, 1995; Wexelblat, 1993); some focus on the creation of worlds that mimic our own (Jepson et al., 1995; Stoakley et al., 1995). Others create alternate worlds (Thalmann & Thalmann, 1994). Scholars and researchers also focus on technical (Chim, et al., 2003; Deering, 1995), cultural (Cummins, 2002), social (Pesce, 2000), and philosophical (Rössler, 1998) implications and applications of VR. For our purposes a general definition put forth by Barnes (1996)—which is shared by many researchers—can be used:

> VR is the term used to describe advanced methods of involvement and interaction for humans with a computer-generated graphical (usually 3D) environment. Normally referred to as a VR "world," this environment is experienced by a human participant through the use of special VR equipment.

Levels of VR Implementation

VR developers can utilize various components to enable interaction with constructed VR worlds. Of course, the worlds must be suitable; for example, one would not place a head-mounted display (HMD) on a user inside a Cave Automated Virtual Environment (CAVE).

It is not this paper's purpose to go into each hardware and software combination as others have summarized this well (Macredie, et al., 1996). However, we must classify varying VR levels from the standard desktop interface to the completely immersive (e.g., CAVEs). Implementing VR levels within e-commerce sites successfully depends on the correct balancing of Web and VR to make the largest pool of users the most comfortable with the experience.

As we move from the least immersive to the most immersive, note that system requirements (hardware and software) as well as a user's technical skill must increase. Costs also increase, sometimes by thousands of dollars, thereby limiting consumer access. When attempting to reach the largest number of computer users, cost cannot be a prohibiting factor. The more that can be provided to the computer user in the form of free Web plug-ins (e.g., Acrobat Reader), the more likely the adoption.

Entry Level VR System (EVRS)

An EVRS uses a personal computer system that is available to most users. A computer with sufficient hardware resources and a current operating system is adequate for EVRS operation. The EVRS will most likely be limited to a windows on the world (WoW) VR experience using the standard monitor, mouse, and keyboard. Open source VR software programs exist that will run on these systems, such as VR Juggler (Cruz-Neira, 2005).

Software also exists for a small price. In this category are closed system software products. These are intense 3D action games like Atari's Unreal Tournament 2004 (Atari, 2004). In these VR worlds multiple players interact with each other in real time. In most cases the game has a limited number of avatars and specific missions. There are also 3D construction kits for those wishing to author their own VR worlds (Web3D Consortium, 2006).

Basic VR System (BVRS)

The BVRS uses the same hardware structure as the EVRS with the addition of input devices, such as a VR glove, and haptic or force feedback devices, such as the iFeel mouse. PCs with fast CPU speeds, high-end graphics cards, and high-resolution monitors fall into this category. These systems may also include a high fidelity sound system for a surround sound experience. The largest group of users who employ these systems is computer gamers. These systems can be used for intense VR experiences in VR games. They have the processing power to run many basic VR worlds and applications. The purchase price for these systems begins at $3000.

Advanced VR System (AVRS)

AVRS systems are too expensive for the typical user. These systems require a substantial investment for memory, processing power, software, and hardware needs. While a "typical" hardware architecture can be used, many VR professionals move into larger minicomputer workstations to run AVRSes. More input devices, such as the Cyberseat II (Miller et al., 1998), are incorporated.

Immersive VR System (IVRS)

IVRS systems are most likely used in research or the entertainment industry. These systems are what most people think of when they imagine VR. Though still not as elaborate as that in "The Lawnmower Man" (1992), these systems are not readily available.

ON THE ROAD TO VRCOMMERCE

The Advanced and Immersive VR systems require substantial financial investment and, in cases such as the CAVE, substantial physical space. Most users will have neither the funds nor the willingness to commit to these systems.

Thus we are left with either the entry-level VR system (EVRS) or the basic VR system (BVRS). Given that both of these are desktop (or perhaps laptop) computer systems, we can assume that most users will have access to either a EVRS or BVRS. Whether a user will have more than a monitor, keyboard, and mouse is questionable. Some game players may have simple HMDs, but these are expensive and somewhat unreliable at the consumer level. Therefore, for an e-commerce VR system to reach the most users, it must remain at the hardware level of an EVRS or a BVRS with a monitor, mouse, and keyboard.

With a hardware component in place, we must now consider the best method to deliver a VR world to users. If users are interested in e-commerce we can at least assume an Internet connection and a Web browser. From here, we must work to create a platform that is most readily accessed by the largest number of users. Many VR developers choose Java applets or Virtual Reality Markup Language (VRML) plug-ins on the client-side as the interface (Chim, et. al., 2003; Mass & Herzberg, 1999; Varlamis, et al., 2004). On the server-side, developers differ. Some rely solely on VRML (Chim, et. al., 2003; Varlamis, et al., 2004), Web3D (Chittaro, et al., 2003), or a combination of file formats to include XML (Hetherington & Scott, 2004) and X-VRML (Walczak & Cellary, 2003). Most use a database and a combination of other technologies to support information processing, user tracking, and interaction cues.

Whatever the case, all e-commerce VR worlds must use technologies that already exist on users' computers (Web browsers, Java, etc.) or are easily obtainable (VRML or Web3D plug-ins) at no cost.

CHALLENGES OF VRCOMMERCE

Before implementing VR into e-commerce, we must be aware that VR is not always appropriate. For example, Amazon.com does well without VR because it primarily sells low- to mid-cost packaged goods, such as books, movies (VCR and DVD), and music CDs. Users know what to expect with a book or a CD format. Amazon.com has also minimized user risk by providing content samples of books or CDs along with user feedback.

However, other items are not as suited to a straight 2D e-commerce site. High-touch goods and services such as vacations, homes, and cars are purchased over the Web in far fewer numbers than books. One reason is because of the higher price point, but another is that users want to "experience" these items before purchasing them. Studies have shown that although users may research high-touch items on the Internet before buying them, the majority complete the purchase in the real world (Gammick & Hodkinson, 2003).

If we want to create a successful VRCommerce site, we must consider how realistic it looks, how easy it is to navigate, what kind of guidance we offer users, and what type of computer system they need to interact with our world. Moreover, we must deal with both technical challenges and human factor challenges: learning curves, user acceptance, and trust.

Realism and Latency

Researchers point to network latency issues (e.g., lag) in almost every discussion of VR system prototypes (Chim, et. al., 2003; Chittaro, et al., 2003; Mass & Herzberg, 1999; Varlamis, et al., 2004; Walczak & Cellary, 2002). Solutions to network latency range from layered 3D objects (Chim, et al., 2003) designed to load and cache incrementally by not sending any 3D data until the user fills out a form requesting certain 3D objects and their associated world (Varlamis, et al., 2004). Some studies simply ignore latency, as researchers are more concerned with other issues.

No matter how a VR system deals with latency, it will always be a challenge in interactive systems like VRCommerce (MacKenzie, et al., 1993). Users connect to the Internet via a variety of means: 56K modems, mobile phones, or broadband connections with high-end workstations. VRCommerce sites must have the flexibility to accommodate every means of access.

Navigation, Learning, and Acceptance

Because VRCommerce will not accommodate advanced or immersive VR systems, such as the CAVE, one would assume that using a mouse and keyboard to navigate an image on the screen would be straightforward. Research has shown this not to be the case with some arguing that over 80% of study participants suffered from at least a mild form of Virtual Reality Induced Symptoms and Effects, such as blurred vision, headaches, disorientation, and nausea (Wilson, 1997). VRISE proved to be dehabilitating in over 5% of the participants. For most users, moving about in a VR world is not second nature.

VR systems have worked to establish more real world metaphors so that users can better identify with the VR world. AWE3D (Chittaro, et al., 2002) places users in a virtual store replete with products arranged on shelves, advertisements along the walls, and customized audio announcing store specials or piping music. AWE3D strengthens this metaphor by adapting a perspective (a view behind a shopping cart) that makes the user more comfortable. Theoretically, the more a user interacts with the world, the more customized and familiar it will become.

AWE3D also employs system learning to customize the store for the user. This, in turn, makes the VR store as familiar as the local grocery store. The authors do admit that customization might need to be curtailed given a user's bandwidth (limit on shelf space) and the fact that if this were to become a shared VR experience with other users, one could not arrange everything on all shelves for each user. However, certain areas of the store could be set aside for individualized customization (e.g., a special shelf) and others could be "standard" to allow for interaction.

Another VR system that emphasizes a real world metaphor is the VR Mall (Mass & Herzberg, 1999). In this system, the authors use a combination of Java and VRML to create an interface that allows merchants to place predefined objects in a space (store). Users can navigate the mall via a Java Applet using a mouse. A 2D map shows them where they are, limiting confusion and making navigation more manageable.

This prototype shows great promise. By integrating 3D with 2D maps, the authors have overcome user resistance to completely immersive VR realms. By only allowing select VR objects to be created, the authors have also simplified the process for merchants who wish to participate but do not have the technical skills.

Guidance and Trust

Autonomous agents (Tsvetovatyy, et al., 1997) and Virtual Tour Guides (Chittaro et al., 2003) are effective to guide first-time users through VR sites. However, too much guidance may stop users returning to VRCommerce because part of the VR experience is, in fact, the experience (Cummins, 2002). If users repeatedly follow the same path to purchase an item, then VR is not needed; a bookmarked 2D Web page with the correct product does the job just as well.

An effective VRCommerce site must allow users to choose how they want to reach their destination. In the VR Mall (Mass & Herzberg, 1999) when a user logs in they are presented with a list of past purchases and allowed to reorder items without entering the VR space. After the transaction is completed the user has another option to enter the VR Mall.

Beachtown offers another approach to guiding users yet giving them the freedom of choice (Gammick & Hodkinson, 2003). Users can navigate a familiar 2D e-commerce site for the entire transaction. Or they can choose to enter a VR world to stroll the Beachtown boardwalk.

The Beachtown layered approach to VRCommerce works well because users can choose the medium and their guidance level. The authors also stress that they make sure that users have viewed customized items such as surfboards before allowing users to enter the transaction process. Moreover, the process takes five to six steps before the system asks for personal and credit information. This layered and multi-level transaction builds a relationship between the business and the user before asking the user to supply personal information (Gammick & Hodkinson, 2003). This ultimately builds trust.

OVERCOMING THE CHALLENGES WITH LAVRCS

Most of the current studies discussed so far simply focus on one or more of the challenges. However the business realm is more complex. We must work towards a solution that addresses the challenges of realism and latency; navigation, learning, and acceptance; and guidance and trust if a successful VRCommerce system is to be developed. To accomplish this we need to create a VRCommerce system that can work on a majority of computer systems, has a familiar interface, and can allow users to choose navigation paths and ask for guidance when needed.

To reach this goal and satisfy all conditions, we must build the VRCommerce system within an existing 2D e-commerce Web interface. Moreover, this system must have a multitude of navigational paths and incorporate increasing levels of VR depending on a particular user's comfort with the system and VR in general. The Layered Virtual Reality Commerce System (LaVRCS) permits users to match the level of technology with their comfort level as they navigate the e-commerce site.

LaVRCS System Architecture

In order to reach the largest user population possible, the LaVRCS uses Web-based VR. By creating a system that uses standard Web protocols and Web browsers, LaVRCS allows users to experience various levels of interaction without the need for specialized hardware or software.

LaVRCS client-side requirements have been kept to a minimum in order to allow all users access to the site. A user must have an Internet connection and a current Web browser. All three layers are accessible via a desktop or notebook computer, or any device capable of displaying Web-based content.

To access the first layer, users must only have an Internet connection and a current Web browser to navigate the 2D realm.
In order to access the second and third layer of LaVRCS, users must have a VRML/X3D plug-in player. Users can download free players, such as Blaxxun3D or FreeWRL (Web3D, 2006).

In LaVRCS, the server does most of the processing, thereby enabling lower-level clients access to the VRCommerce site. At a minimum the server must have the Apache Web Server, a MySQL database for tracking items and user movement, and Java. Using the newly approved X3D API (Web3D, 2004), LaVRCS will offer customization options for each registered user, such as favorite products, interaction level, etc.

LaVRCS Interaction Layers

The success of LaVRCS hinges on its ability to allow users to move through chosen layers as they navigate the VRCommerce site. These layers are designed to allow users to interact with technology at their own comfort level. Inexperienced users can stay at the first layer for as long as they desire. As familiarity and trust build with the VRCommerce site, users may want to experience embedded VR with certain products. Once a user is comfortable with manipulating a single 3D object, she may want to move to the third layer of an immersive VR experience akin to those found in entry and basic level VR systems.

In the first interaction layer, LaVRCS mimics a traditional 2D e-commerce site. It uses a standard Web interface with expected navigational cues. All products and services are available for viewing and purchase at this level. 2D images accompany product descriptions along with user reviews and recommendations similar to Amazon.com.

This layer is designed for users with minimal e-commerce experience and VR comfort. For example, if a user wanted to purchase a new golf club, she would search the e-catalog for one with the desired characteristics, read reviews, and the purchase the item. The e-commerce site would have standard encryption for SSL layers, a valid certificate, and other assurances to promote user trust and insure site credibility.

In the second interaction layer, users will have the option of manipulating embedded VR objects within the Web interface. Using our golf club example, after searching for the club in the e-catalog, a user could click on a hyperlink marked “Try the Club.” A small JavaScript window with an embedded Java applet would show a 3D image of the club. The user could then use her mouse to rotate the club. This 3D image is stored in the e-catalog database, but it is only accessed when the user clicks the link.

A registered user will have the option of automatically requesting second layer interaction on the VRCommerce site. If this option is selected in the user profile, all item descriptions will be delivered with text reviews and have an accompanying 3D object embedded in the same Web page. Registered users will be able to turn off this option at any time. This embedded VR object allows regular users to become familiar with manipulating 3D objects via a keyboard and mouse.

Once users are familiar with 3D objects, they can choose to move into the third interaction layer. This layer is a semi-immersive (e.g., no HMD) VR world. There are general VR shopping worlds akin to Mass and Herzberg’s (1999) VR Mall. However, LaVRCS offers an alternative to the complete VR Mall experience. Select products and services will be linked to tailored VR worlds in which users can interact with the products in a real world setting, much like Beachtown (Gammick & Hodkinson, 2003).

Using the golf club example, after finding the club (either via VR Mall or 2D e-catalog), the user can enter a VR golf course and test the product using a VR avatar. Users can select from predefined avatars matching gender and ethnicity traits and then enter their height, weight, and other measurements. LaVRCS will then create a custom avatar. Registered users will have more customization options and be able to save their avatar.

LaVRCS Rationale

LaVRCS allows an e-commerce site to implement VRCommerce in a non-threatening manner. It allows users to explore and sample as much or as little of the VR experience as they desire. Advanced users will return to not only shop the general VR Mall but also to try new products in customized VR worlds.

LaVRCS also allows designers to address the four challenges of VR. Realism and latency issues are addressed in that layers one and two accommodate beginning users with less powerful computers. Advanced users with more powerful systems can access all layers with no latency or realism challenges.

LaVRCS helps users learn how to navigate and use 3D and VR with its layered approach. Users can become more comfortable with the 3D objects before exploring a complete VR world. Guidance is offered with instructions at all levels. Although tour guide avatars are not yet present, these could be added for users who want them.

LaVRCS works because ultimately it allows users to choose when they want to use VR for e-commerce. Some may never be comfortable using the third layer, but will still return to purchase products and services at the first or second layer.

IMPLICATIONS FOR FUTURE RESEARCH

LaVRCS is in its infancy. This paper serves as a theoretical discussion of the groundwork to produce the LaVRCS concept as well as explain the rationale behind the LaVRCS prototype. The LaVRCS prototype is currently being constructed using the X3D architecture. Therefore, all users would have access to VR content with the appropriate software (Web browser, Java, etc.) and plug-ins. Much of our discussion will center around the concept's feasibility and implementation challenges.

Once the prototype is complete a user interaction and usability study must be conducted. The study will measure the effectiveness of LaVRCS using variations of Doll and Torkzadeh’s (1988) End User Computing Satisfaction Instrument (EUCS) and Davis’s (1989) Technology Acceptance Model (TAM).

REFERENCES

1. Atari. (2004) *Unreal Tournament 2004*, [Video Game], NY, Atari, Inc.
2. Barnes, M. (1996) Virtual Reality and Simulation, *Proceedings of the Conference on Winter Simulation*, (101-110).
3. Chim, J., Lau, R., Leong, H., & Si, A. (2003) CyberWalk: A Web-Based Distributed Virtual Walkthrough Environment, *IEEE Transactions On Multimedia* 5(4), 503-515.
4. Chittaro, L. & Ramon R. (2002) Dynamic Generation of Personalized VRML Content: A General Approach and its Application to 3D E-Commerce, *Proceedings of Web3D 2002*, Tempe, AZ, (145-154).
5. Chittaro, L., Ramon R., & Leronutti, L. (2003) Guiding Visitors of Web3D Worlds through Automatically Generated Tours, *Proceedings of the Eighth International Conference on 3D Web Technology,* Saint Malo, France, (27-38).
6. Cruz-Neira, C. (2005) *VR Juggler: Open Source Reality Tools*, Iowa State University Virtual Reality Applications Center, http://www.vrjuggler.org/.
7. Cummins, N. (2002) Integrating E-Commerce and Games, *Personal and Ubiquitous Computing* 6(5-6), 362-370.
8. Davis, F.D. (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly* 13(3), 319-340.
9. Deering, M. (1995) HoloSketch: A Virtual Reality Sketching/Animation Tool, *ACM Transactions on Computer-Human Interaction* 2(3), 220-238.
10. Doll, W.J & Torkzadeh, G. (1988) The Measurement of End-User Computing Satisfaction, *MIS Quarterly* 12(2), 259-274.
11. Gammick, J. & Hodkinson, C. (2003) Virtual Reality, Involvement, and the Consumer Interface, *Journal of End User Computing* 15(4), 78-96.
12. Greenhalgh, C. & Benford, S. (1995) MASSIVE A Collaborative Virtual Environment For Teleconferencing, *ACM Transactions on Computer-Human Interaction* 2(3), 239-261.
13. Hetherington, R. & Scott, J. (2004) Adding a Fourth Dimension to Three Dimensional Virtual Spaces, *Proceedings of the Ninth International Conference on 3D Web Technology*, Monterey, CA, (163-172).
14. Jepson, W., Liggett, R., & Friedman, S. (1995) An Environment For Real-Time Urban Simulation, *Proceedings Of The 1995 Symposium On Interactive 3D Graphics*, (165).
15. Macredie, R., Taylor, S., Yu, X., & Keeble, R. (1996) Virtual Reality and Simulation: An Overview, *Proceedings of the 28th Annual Conference on Winter Simulation*, Coronado, CA, (669-674).
16. Mass, Y. & Herzberg, A. (1999) VRCommerce -- Electronic Commerce In Virtual Reality, *Proceedings Of The First ACM Conference On Electronic Commerce*, (103-109).
17. MacKenzie, S. & Ware, C. (1993) Lag As A Determinant Of Human Performance In Interactive Systems, *Conference Proceedings On Human Factors In Computing Systems*, (488-493).
18. Miller, M., Clawson, D., Sebrechts, M., & Knott, B. (1998) Interface Design For Inducing And Assessing Immersion In Virtual Reality, *Proceedings Of The Conference On CHI 98 Summary: Human Factors In Computing Systems*, (343).
19. Nielsen, J. (2000) *Designing Web Usability*, Indianapolis, IN, New Riders.

20. Pesce, M. (2000) *The Playful World: How Technology is Transforming Our Imagination*, New York, Ballantine Books, 2000.

21. Rössler, O. (1998) *Endophysics: The World as an Interface*, Singapore, World Scientific.

22. Stoakley, R., Conway, M., & Pausch, R. (1995) Virtual Reality On A WIM: Interactive Worlds In Miniature, *Conference Proceedings On Human Factors In Computing Systems*, (265-272).

23. Thalmann, N. & Thalmann, D., Eds. (1994) *Artificial Life and Virtual Reality*, New York, John Wiley and Sons.

24. Tygar, J.D. (1998) Atomicity in Electronic Commerce, *Mixed Media*, (April/May), 32-43.

25. Varlamis, I., Vazirgiannis, M., Lazaridis, I., Papageorgiou, M., & Panayiotopoulos, T. (2004) Distributed Virtual Reality Authoring Interfaces for the WWW: The VR-Shop Case, *Multimedia Tools and Applications* 22(1), 5-30.

26. Walczak, K. & Cellary, W. (2003) X-VRML for Advanced Virtual Reality Applications, *Computer*, 36(3), 89-92.

27. Web3D Consortium. (2004) *Web3D Consortium Announces X3D Specification Approved as ISO International Standard*, Retrieved February 10, 2006 from http://www.web3d.org/news/releases/archives/000092.html

28. Web3d Consortium. (2006) *X3D Tools and Applications*, Retrieved February 10, 2006 from http://www.web3d.org/applications/tools/

29. Wexelblat, A. (1993) The Reality of Cooperation: Virtual Reality and CSCW, *Virtual Reality: Applications and Explorations*, Ed. Alan Wexelblat, Boston, MA, Academic Press Professional, 23-44.

30. Wilson, J. (1997) Virtual Environments and Ergonomics: Needs and Opportunities, *Ergonomics* 40(10), 1057-1077.