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Chang Jung Christian University, hueymin.sun@gmail.com

Hsun-Hung Cheng  
Chang Jung Christian University, hongppp@hotmail.com

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THE ANALOGICAL TRANSFER EFFECT OF USER'S EXPERIENCE ON USABILITY FOR GESTURE CONTROL INTERFACE

Huey-Min Sun, Dept. of Information Management, Chang Jung Christian University, Tainan City, Taiwan, R.O.C., hueymin.sun@gmail.com
Hsun-Hung Cheng, Dept. of Information Management, Chang Jung Christian University, Tainan City, Taiwan, R.O.C., hongppp@hotmail.com

Abstract

This study explores the effect of operating a new interface for experienced and casual users, specifically, on the effectiveness and efficiency of usability. We have developed a gesture control interface for a browser created by an open source onto a mouse interface integrated with Java SDK. When users surf web pages using this new interface, we want to examine the following features from the theory of analogue transfer: The surface feature, i.e., whether the new interface is the same as using a mouse. The structure feature, i.e., whether the browsing result of the new interface is the same as a mouse. And, finally, we want to know how to have an impact on usability for both complex and simple web content.

Keywords: Analogue transfer theory, Surface feature, Structure feature, User feature.
1. INTRODUCTION

With the technology of human-computer interaction on the rise, the interface of full-body control is popular in interactive applications. Low-cost depth-sensing cameras have become commercially available, including the widely publicized Microsoft Kinect, Asus Xtion Pro Live, and Leap Motion Control, which have made it possible to sense the full-body pose for multiple users without the use of markers or handheld devices (Suma et al, 2011).

Cognitive psychology applied to the field of human-computer interaction has been increasing so exploring the effect of the user’s experience with this new full-body interface is more and more important. Our goal is to understand the analogical transfer of surface and structure features for the cognitive transfer of user experience.

For the field of cognitive psychology, the definition of structure is characterized by the causal relation of achieving the goal, while that of surface has no concern with causal relation. In the application of web browsing, the same structure means that user’s manipulation will achieve the same goal as a hyperlink or button press to an identical web page. Whereas, the different structure stands for the destroyed structure of the original web page path.

On the other hand, the presentation of the interface, such as hyperlink or button, is the surface feature. Likewise, the surface feature has two types of status; the same surface (i.e., using the hand as a mouse) and the different surface (using each finger for different modes of input). Structure destroyed can be recognized by whether the goal has changed (Holyoak & Koh, 1987). Therefore, the target web page browsed is a structure feature. Holyoak and Koh (1987) proposed a mechanism of multiple source base that increasing the sources of analogical transfer would solve the target problem by the accumulation of similar solutions from multiple sources. The most solutions cannot be gained by the structure feature, but by the surface feature.

Typically, spontaneous analogical transfer was hard to verify with experiments. However, recent studies applied in the real world have presented the consistent result of spontaneous analogical transfer (Bearman, Ball, & Ormerod, 2007). The study indicated that context feature was one factor of the analogical transfer problem. In fact, the research issue of analogical transfer problem still has many difficulties, such as a combination of multiple features.

Therefore, this paper hopes to find an understanding of how the user’s effects of structure and surface features on usability with the new interface of gesture control. Our experimental context focuses on the analogical transfer of user experience for both simple and complex tasks.

2. LITERATURE REVIEW

The theory of this study includes user interface, surface and structure features, and usability. User interface allow users to interact with web pages. The design concept provides human-computer interaction by mixing gesture control with the Kinect device. The theory of surface and structure features describes how a user’s experience influences usability for web page browsing. The theory of usability indicates the measurement of effectiveness, efficiency, and usability.

2.1. User interface

Morris (2012) analyzed a series of typical functions for browsing web pages, including opening and closing browsers, search engine queries, links, going back or forward, opening links in a separate tab, switching tabs, searching a website page, selecting your region, opening a new tab, entering a URL, reloading a page, bookmarking a page, and closing a tab. This study provided the deep understanding of web page browsing for the new gesture control type used in our study. Takala et al. (2012) surveyed the issues of 3D user interfaces, development teams, and their developments. The authors found that fifty-six teams from the surveyed seventy-one teams have been developing 3D user interfaces,
especially focusing on gesture and pose tracing applications. The results indicated that the application with 3D interface rarely had high level interaction. Therefore, a lot of development teams worked hard to implement some functions with common characteristics such as 3D object manipulation and browsing. Schultheis et al. (2012) presented that gesture operating was four to five times faster than that of a mouse. Belinda et al. (2012) developed a health recovery system, called Jewel Mine, that employed the Kinect to trace upper body movement in virtual reality. Gotsis et al. (2012) built a mixed prototype system with virtual and augmented reality for health recovery. Scapin et al. (2012) examined fifteen countries from around the world, generalizing the process, structure, and method from all user experiences gathered from thirty teams in North America, fifty-two teams in Europe, and three teams on other continents. Bianchi-Berthouze (2012) discussed the classification of movement controls and their influence on the user interface of full-body control for gaming. Suma et al. (2011) developed a middleware, called FAAST (Flexible Action and Articulated Skeleton Toolkit), based on OpenNI, to replace the keyboard with body poses. Boulos et al. (2011) proposed a browsing interface with Google Earth operating using body movement control. Yu et al. (2010) presented the design and evaluation of touchscreens for the browsing of a 3D environment devoted to science. This evaluation compared a touchscreen to a traditional mouse. The authors found that a touchscreen performed better than a traditional mouse. The advantage of this new method was that it could be learned and used easily, especially for the task of browsing and searching. Li et al. (2010) created a 3D model that allowed customers to try new clothes on a mirror image of themselves. They accomplished this using the human model mapping for different statures and postures. The authors combined a variety of skeleton-driven adaptable and versatile bodies into a 3D virtual model for new clothes. ISO 9241-210 (2010) also defined the user experience that goes through the system use.

According to the above literature, we know that the response of users includes emotion, belief, preference, perception, physiology, psychology, and achievement. Furthermore, user experience is the results of previous experience, attitude, skill, and personality.

2.2. The theory of structure and surface features

Yonelinas (2002) thought recollection and familiarity were two processes that would affect human’s understanding of memory. Recollection was a psychological state of thinking about previous events to understand their memories, while familiarity was also a psychological state perceiving the familiarity of a current situation from previous experiences. Some researchers (Aggleton & Brown, 1999; Cleary & Greene, 2001) indicated that recollection was driven by relational processes, while a sense of familiarity was driven by certain characteristics. In addition, Quamme, Yonelinas, & Norman (2007) suggested that words in pairs employed in the encoding process could increase the usability of familiarity. The study proposed by Rhodes & Donaldson (2007) showed that words displaying the association could encourage usability. Day & Goldstone (2009) verified that analogical transfer was possible even though conscious awareness was rarely experienced. Although subjects who lacked the ability to recognize familiarity participated in the experiment, they could still experience a sense of familiarity.

For the process of cognition, analogical transfer is a symbol of reasoning intelligence. Holyoak & Thagard (1989) thought that analogical transfer had four phases, including characteristic building, clue extracting, domain knowledge mapping, and solution producing. In the phase of clue extracting, the structure and surface features between source and target are important representativeness. Gentner & Markman (1997) proposed four steps for analogical transfer, including encoding of elements, inference of associated rules, mapping of generalized rules, and decision making of application.

For the process of analogical transfer, there are two influences. One is the structure feature that is characterized by the causal relation of achieving the goal, while the other is the surface feature that has no concern with causal relation.

According to the study proposed by Gentner & Markman (1997), the goal of analogical transfer was to reason a novel context through previous familiar context. The familiar context was defined as the base
domain, while the novel context was denoted as the target domain. The problem of analogical transfer needs a way for the base domain to map the target domain. The mapping method referred to the concept of structure mapping theory.

Foss & DeRidder (1987) proposed the advantage of surface features. The authors deemed that similar training could provide better skill transfer. The view of this theory supposed that the application was based on the same structure feature.

According to the study proposed by Novick (1988), experienced and casual users caused the use of unsuitable sources when the surface feature was only shared between source and target. However, experienced users could avoid the unsuitable transfer if multiple sources were employed. Therefore, experienced users and casual users had a different effect on analogical transfer under different structure and surface features.

Finstad (2008) thought that structural features were characterized by their causal relation to the attainment of a target, while surface features had not those causal relations. The author proposed a mixed view with both surface advantage and structure advantage based on the study (Novick, 1988). The results indicated that surface features in some situations would dominate transfer, and structure features in others would determine transfer.

Finstad (2008) inferred that casual users with professional experience would provide advanced ability for solving similar problems. However, those with average experience would lead to more problems in the distractor condition.

Experienced users use the interface of distractor, but they can still determine which things they should do or should not do. This experience can help users avoid an unsuitable transfer. The advantage of multiple sources makes the experienced users help them abstract the structure feature to the new general domain (Schmid, Gust, Kühnberger, & Burghardt, 2003).

In this study, we explore the effect of structure and surface features on web browsing using gesture control. For the process of analogical transfer, we consider two variables concerning the structure and surface features of interface navigation. The structure factor can be characterized by the users achieving the same goal in searching web pages, while the surface factor is whether users can use the interface with the same user experience as they would using mouse or touch screen.

### 2.3. Usability

For the system usability questionnaire, ISO 9241-11 (1998) defined twelve items into the three components, including effectiveness, efficiency, and satisfaction as shown in Table 1. The user-centered definition of the concept of usability emphasizes that a product or system should allow users to feel at ease during operation and effective use, and to be satisfied by achieving the desired goal.

<table>
<thead>
<tr>
<th>Usability component</th>
<th>Candidate items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>The system can save time.</td>
</tr>
<tr>
<td></td>
<td>There are always errors when I operate the system.</td>
</tr>
<tr>
<td></td>
<td>There are not too many errors when I operate the system.</td>
</tr>
<tr>
<td></td>
<td>I need to spend a lot of time to correct these errors.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>The system can accomplish my tasks.</td>
</tr>
<tr>
<td></td>
<td>I think I need more ways to accomplish my tasks.</td>
</tr>
<tr>
<td></td>
<td>I will not need to supplement this system with an additional one.</td>
</tr>
<tr>
<td></td>
<td>The capability of the system meets my requirements.</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>I am satisfied with this system.</td>
</tr>
<tr>
<td></td>
<td>I prefer another system to this system.</td>
</tr>
<tr>
<td></td>
<td>I will use this system.</td>
</tr>
<tr>
<td></td>
<td>The experience of using this system is depressing.</td>
</tr>
</tbody>
</table>

*Table 1 The questionnaire of system usability.*

Bangor et al. (2008) surveyed the measurement of usability stated by previous studies, including Lewis (1995), Lewis (2002), Kirakowski & Corbett (1993), Igbaria & Nachman (1991), Kirakowski (1994), Lund (2001), and Kirakowski, Claridge & Whitehand (1998). The subjects of these studies included the interfaces of system use, software operation, and web page browsing. Therefore, the indicators of the above studies could be conducted into the three aspects (i.e., Efficiency, Effectiveness, and Satisfaction).

3. RESEARCH APPROACH

The research model has three independent variables, including the surface feature, the structure feature, and the user feature, and one dependent variable, i.e., usability. For the three independent variables, one is the surface feature that has two conditions, the same and different, another structure feature that also has two conditions, structure-preserving and structure-violating, and the user feature which includes experienced users and casual users. Therefore, eight conditions shown in Table 2 were combined with three factors. For the structure-preserving feature, the browsing interface is straight mapping to a mouse if the surface feature is identical, while the browsing interface is a remote analogue to a mouse if the surface feature is different. For the structure-violating feature, the same surface feature distracts users from the browsing interface, while the browsing interface cannot be mapped by a mouse if the surface feature is different.

![Figure 1. The example of surface and structure feature from mouse experience](image)

This experimental design based on Finstad (2008) was run as a $2 \times 2 \times 2$ (Surface Feature $\times$ Structural Feature $\times$ User Feature) mixed design. The structural feature factor had two levels: the same and different. The structure feature used the same model, i.e., structure-preserving, included the two conditions whose structure was analogous to operating a browser: the straight mapping and the remote analogue. Each level within the variable of the structural feature had two levels of surface features, also categorized as the same and different. For the structure feature’s same condition, these conditions were the straight mapping and the remote analogue. The structure feature used a different model, i.e., structure-violating, comprised of the distractor and the unmapped conditions. Our task context is set to browsing and searching web page. According to our literature review, we propose the following hypotheses:
H1: User features such as experienced and casual users have a significant difference in usability under identical surface and structural features (Straight mapping).

H2: User features such as experienced and casual users have a significant difference in usability under identical surface feature and different structural feature (Distractor interface).

H3: User features such as experienced and casual users have a significant difference in usability under different surface feature and identical structural feature (Remote analogue).

H4: User features such as experienced and casual users have a significant difference in usability under different surface feature and different structural feature (Unmapped).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Surface feature</th>
<th>Structure feature</th>
<th>User feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight Mapping</td>
<td>Same</td>
<td>Same</td>
<td>Experienced / Casual</td>
</tr>
<tr>
<td>Remote Analogue</td>
<td>Different</td>
<td>Same</td>
<td>Experienced / Casual</td>
</tr>
<tr>
<td>Distractor</td>
<td>Same</td>
<td>Different</td>
<td>Experienced / Casual</td>
</tr>
<tr>
<td>Unmapped</td>
<td>Different</td>
<td>Different</td>
<td>Experienced / Casual</td>
</tr>
</tbody>
</table>

Table 2. The condition of surface feature, structure feature, and user feature

Tasks may differ in terms of the type of match between the information requested and the actual available information. Van Schaik & Ling (2012) proposed that task complexity was a significant predictor of task performance. Van Oostendorp et al.(2009) indicated that task complexity had an effect on information retrieval performance. We based our experiment on their study. Task complexity was manipulated along two dimensions: path length and path relevance. Path length leading to the target information was varied using different levels of depth. Path relevance - based on semantic similarity - is the relevance of the optimal navigation path to the search task. Therefore, we will explore the effect of task complexity on straight mapping and remote analogue. Hypotheses are as follows:

H5: Task class such as simple and complex has a significant difference in usability under identical surface and structural features (Straight mapping).

H6: Task class such as simple and complex has a significant difference in usability under different surface feature and identical structural feature (Remote analogue).

4. CONCLUSION

A 12-item questionnaire was developed to determine the general computing abilities of participants with questions about application experience around computers and usability. Four separate main interfaces were required for this study, with two content sets, i.e., simple vs. complex.

In this study, we have designed a new interface onto a mouse interface integrated with Java SDK. With users surfing web pages by this new interface, we want to examine the surface feature and the structure feature from the theory of analogical transfer, and discover how to have an impact on the usability for complex and simple web contents.

Acknowledgments. This work was supported by the National Science Council of the R.O.C under Contract NSC 102-2410-H-309-014.
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