Modality is the Message: Interactivity Effects on Perception and Engagement

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Abstract
New media interfaces offer a wide variety of modalities for interacting with systems. While typing and clicking remain the staple of most interfaces, several other modalities have emerged in recent years, enabling users to perform a range of other actions, such as dragging, sliding, zooming-in/out, mousing-over and flipping through a revolving carousel of images (as in cover flow). While each modality offers a unique way of interacting with information, it is not clear whether it brings unique psychological advantages. Does a drag engender greater user engagement? Is the mouse-over likely to enhance user's perceptual bandwidth? A scientific assessment of such effects is impossible with existing interfaces given the confounded nature of modality combinations and information provided by them. Therefore, we designed six Web interface prototypes with identical content, differing only in modality, for experimentally isolating the effects of each, using a between-subjects design. Ongoing data collection involves both physiological and psychological measures of perceptual bandwidth and engagement.

Keywords
Modality, Interactivity, Perceptual Bandwidth, User Engagement, Web Interfaces

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Experimentation, Human Factors.

Introduction

Human-Computer Interaction (HCI) researchers have long recognized the importance of multimodal interfaces which allow users to interact with systems using a variety of modalities such as text, audio, gestures, and touch, whose co-articulation can mutually disambiguate user intentions. There has been a tremendous proliferation of interactive interfaces that call for heightened user interaction with technological artifacts, be it sophisticated web browsers, 3G phones with haptic screens, voice-enabled navigational devices or immersive virtual reality environments.

However, innovations in mouse-based modalities of interaction have gone largely unrecognized. Most media interfaces, especially on the Web, rely on simple keyboard and mouse inputs, yet employ a wide range of useful and usable interaction modalities that offer innovative ways for users to interact with underlying content. For instance, slide bars on Websites allow users to push a slider across a timeline to see chronological changes in content. The drag modality helps them explore maps and other spatial content by enabling intuitive way finding and navigation. Rollover modalities provide users the ability to hover the cursor over an image or object for additional information, while still others allow them to flip through a picture album in the form of a virtual carousel (e.g., coverflow modality in iPhones).

Modality Interactivity

Thus, modalities today are not simply sensory channels (e.g., audio vs. visual) that correspond to human perceptual system. Rather, they refer to a wide gamut of tools and features, each offering a unique method, i.e., *mode,* of interacting with the interface. Indeed, modalities are distinguished based on the unique function served by them rather than their ontological status, in recognition of the fact that the same technological feature can often offer more than one function. For instance, the act of scrolling can be considered one technological affordance. However, this could offer two different functions: (a) scrolling up and down a webpage to read all its content and (b) scrolling the mouse-wheel to zoom-in/out of an image. Based on this logic, scrollbar would be considered a modality that is distinct from zoom function even though both may require somewhat similar action on the part of the user. Since the same input modality can have more than one output function, this is also called the "functional" view of interactivity [11] referring to the different *functions* served by a given interaction modality.

Sundar [10] distinguishes this form of "modality" interactivity from "source interactivity" (degree to which the interface allows the user to serve as source or gatekeeper of content, e.g., customization, UGC) and "message interactivity" (the degree of contingency between messages sent and received by the user). Similarly, more recent definitions of interactivity have distinguished between a HCI view (also called *machine-interaction* or *interactivity-as-product* view) and a more CMC (computer-mediated communication) perspective of seeing the interactivity phenomenon via a *human-interaction* angle, also called the *interactivity-as-a process* view [12]. While most scholars have been preoccupied with the aim of creating a comprehensive definition of interactivity and in creating a typology of its various manifestations, not many attempts are being made in trying to understand how specific types of interactivity influence users. One of the aims of this study is to systematically study the distinct effects of different types of modality interactivity.

Perceptual Bandwidth

The underlying psychological phenomenon of *perceptual bandwidth* is being tested in this study as one of the explanatory mechanisms involved in the processing of interactive modalities. Technological artifacts today contain *perceptual interfaces*, or "machines that can accomplish human-like sensory tasks" (p. 65) [9]. Such interfaces contain modalities that simultaneously engage several sensory mechanisms of the user. For example, using a GPS enabled navigational device would occupy several of user's sensory mechanisms at once, such as entering information via touch-screen input, assessing geographical location on a map image by zooming in/out, following pictorial navigational cues, paying attention to audio-commands and so on. The result of such a perceptual interface is that it leads to a greater mental representation of information in the user's mind forming a useful mental model they can follow to achieve their task goals.

Drawing on the analogy of a simple cable wire (or pipe), adding more modalities to an interface will be akin to stretching and expanding the cable wire (or pipe) to indicate more information being mapped and processed by a user. At a more fundamental level, this line of reasoning implies that different forms of modality interactivity differentially impact users' perceptual bandwidth. Ascertaining the perceptual effect of each individual modality is critical to our understanding of the consequences of greater mental representation engendered by newer modalities. To address this, the study proposes to examine two competing theoretical premises. One of them is the Multiple Resources theory [13], which suggests that information delivered via some newer modalities such as mouse-over could be richer than that delivered by traditional modality such as text. The competing hypothesis emerges from theory of Limited Capacity [6], which claims that users have a limited pool of cognitive resources, and the addition of complex modalities to an interface will result in depletion of available resources in working memory and result in negative outcomes, such as poorer performance and learning. Thus, the concept of perceptual bandwidth will serve to test a theoretically meaningful mediating mechanism in how different forms of modality interactivity affect users.

User Engagement

The key practical outcome that this study would like to address is to examine how individual interactive modalities ultimately affect user engagement with media content. Currently, the concept of user engagement is being widely debated across several domains [2] Those interested in web development strategies explore engagement via concepts such as "stickiness" and web analytics data [5]. Those studying virtual environments and gaming equate engagement with immersion, absorption, flow, and presence [3]. Experts in the advertising and marketing industry are looking at cost-per-engagement models in online ads, which summon users to roll over an ad, rate it, forward it and make a product go "viral" [8]. Social media such as Facebook and Twitter have prompted a whole new way of measuring engagement via sharing of content with one's larger social community and networks [14].

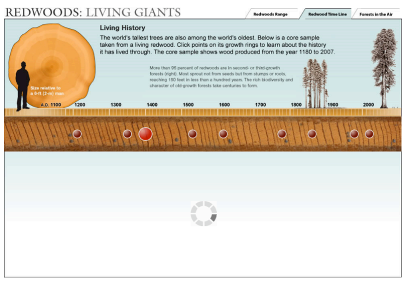

figure 2. Screen capture of click-to-download condition

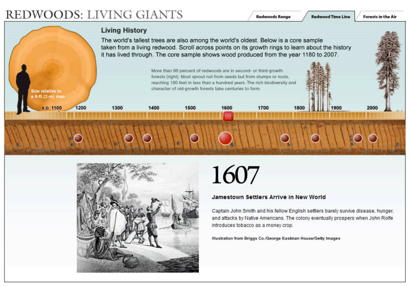

figure 3. Screen capture of slide condition

figure 4. Screen capture of zoom-in/out condition

Thus, there is a growing need for performance-based metrics to measure active user participation and user engagement with not just the interface but also the content in it. In this study, we would like to examine a four-stage model of user engagement, that looks at (i) users' physical interactions (for e.g., playing with a Wii controller), (ii) users' cognitive experiences (sensory and mental abilities involved) that lead to (iii) absorption with content (in this instance, game play) and (iv) social outreach (recommending the game to others, recording and sharing their performance).

Research Design

The present research examines the individual effect of six types of modality interactivity features on user engagement with website content. It also aims to reveal how enhanced perceptual bandwidth, the underlying psychological mechanism of modality interactivity, translates into greater user engagement. A between-subjects experiment will be conducted to shed light on these concerns.

Six prototype websites have been constructed for this experiment based on an online magazine story entitled "Redwoods: Living Giants", developed by NationalGeographic.com (http://ngm.nationalgeographic.com/2009/10/redwoods/redwoods-interactive). Each website has three tabs. The first tab describes the range of redwoods. The second tab provides a time line of one of the world's oldest living trees and discusses the relevant historical events. The third one talks about the life in the crown of a redwood. All six versions of the prototype websites were made to look as similar as possible to avoid any incidental confounds. They shared the same page layout, theme color, and navigational tools. They were identical in content and differed only in the type of modality interactivity feature used in the second tab.

The second tab of each website employs one of the six commonly found modality features: click-to-download, drag, mouse-over, slide, zoom-in/out, and cover-flow In the mouse-over condition (Figure 1), participants can access the additional information when putting the cursor over the red-colored points on the growth ring along the center of the screen. In the click-to-download condition (Figure 2), participants are able to click the points on the redwood growth ring to see images and text of the relevant history events. In the slide condition (Figure 3), information about historical events changes when participants move the slider over

figure 1. Screen capture of mouse-over condition

points along the growth ring. In the zoom-in/out condition (Figure 4), points along the grown ring have been replaced by the thumbnails of images relevant to historical events. When participants move the mouse over the thumbnails, a plus or a minus sign indicating either a zoom-in or a zoom-out function will show up

figure 5. Screen capture of drag condition

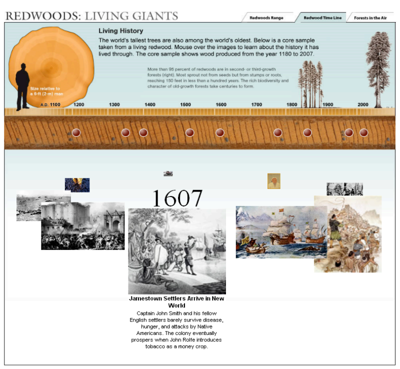

figure 6. Screen capture of cover-flow condition

with the cursor of mouse. Participants will be able to click to zoom-in/out the image and text. In the drag condition (Figure 5), participants need to drag a red circle over points on the growth rings to access the additional information. In the cover-flow condition (Figure 6), the images of history events representing different points along the redwood growth ring move automatically. Participants are able to flip to change the direction of flow and mouse-over to get the additional text information.

Procedures

Undergraduate students from a large northeastern university in the US will be recruited to participate in this study. They will be randomly assigned to one of the six conditions. They will be first asked to fill out an online questionnaire about their technology use, then browse one of the six stimulus websites, and complete a questionnaire following exposure to the website.

Data Collection/Measures

Dependent variables of interest include engagement with website content, attitude and behavioral intention towards website content, attitude and behavioral intention towards website. Engagement with website content is considered as a multifaceted concept evaluated through three aspects: 1) actual behavioral interaction, which is captured by the screen capture function of QuickTime 10 and will be further categorized into total time spent on the website and on interactivity feature, and number of actions (enabled by interactive features) on the website; 2) self-reported absorption, which is measured by 14 items based on [1], such as "Time appeared to go by very quickly when I was browsing the website"; 3) cognitive experience, which is measured by open-ended thought-listing questions asking them to type down any thoughts about the websites. Their answers will be then coded into different categories representing either high or low levels of elaboration. Attitude towards website and website content is measured with adjectives based on Sundar [11]. Behavioral intention towards website and website content is measured by items developed based Hu and Sundar [4].

Mediating variable of perceptual bandwidth will be captured through three aspects: 1) attention, 2) arousal, and 3) memory. Attention will be measured by psychophysiological measure of heart rate (ECG) and secondary task reaction time. When participants are browsing the website, two pop-up ads and two pop-ups factoids will appear in random order. Log files will record the total time taken by participants to close those pop-ups. Based on theories of secondary task reaction times [7] it can be argued that longer the time taken to close each pop-up, the more attention participants have paid to the website or its content. Arousal will be measured by both self-reported arousal and skin conductance (EDA). Memory will be measured by both recall and recognition [6] about website content and interactive features.

Current State of Research

The development of prototype websites is now complete. A pretest with 15 subjects was conducted to assess the usability of prototype websites, effectiveness of log file, screen-capture software, and psychophysiological measures. Based on the pretest results, revisions have been made towards stimulus websites and questionnaire. The data will be collected and analyzed by the time of the CHI2010 conference.

Implications and Discussion

By focusing on the individual effects of six types of commonly used forms of modality interactivity upon cognitive processing of website content, our study will shed light on the big debate about the consequences of interactivity. Do interactive interface tools actually enhance processing of interface content or do they diminish our ability to acquire information? Which particular tools are effective and which ones are counterproductive? In examining the role of perceptual bandwidth, the study also extends our understanding of the psychological mechanism by which interactivity affects human information processing. The findings of this project will have practical implications for user-interface designs, by suggesting optimal solutions for deploying tools of modality interactivity for enhancing user engagement with mediated content.

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