Designing Interactivity in Media Interfaces: A Communications Perspective

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ABSTRACT
Interactivity has become ubiquitous in the digital media landscape. Numerous interactive tools are designed, tested, deployed and evaluated. Yet, we do not have generalizable knowledge about the larger concept of interactivity and its psychological impact on user experience. As a first step toward a theory of interface interactivity, this paper identifies three species of interactivity corresponding to three central elements of communication – source, medium, and message. Interactivity situated in any of these three loci of communication can provide cues and affordances that operate either individually or together to capture users' attention and determine the nature and depth of their processing of online content as well as contribute to their perceptions, attitudes and behavioral intentions. This paper discusses psychological mechanisms by which the three classes of interactivity tools affect users, with the specific purpose of drawing out design implications and outlining UI challenges for strategic development of interactive interfaces.

Author Keywords
Interactivity, modality, source, message, user engagement.

ACM Classification Keywords
H5.2. Information interfaces and presentation, Miscellaneous theory and methods.

General Terms
Human Factors, Performance, Theory

INTRODUCTION
The concept of "interactivity" is foundational to human-computer interaction. Most, if not all, modern-day interfaces are interactive, empowering the user to take action in highly innovative and individualized ways. The emergence of a variety of digital communication media over the last two decades has dramatically magnified the range and scope of interaction between humans and media artifacts, be they web-based interfaces, mobile technologies such as cell phones and PDAs or virtual environments such as games.

From scroll-bars in mobile texting devices to customization options in Web portals to chat functions on social-networking sites, the proliferation of interactive tools has attracted the attention of designers as well as scholars. Numerous studies have been conducted to document the impact of individual interactivity tools. For example, some studies have found that website interactivity positively influences learning outcomes for children and adolescents [21]. They spend more time learning, remember more, and are more satisfied with the learning process when they use tangible user interfaces [21]. Interactive tools are also found to boost individuals' willingness to interact when searching for health related information [24], facilitate favorable judgment in online shopping experience [2], and enhance enjoyment in artistic experiences [5].

While usability studies of specific interfaces have documented the advantages of various interactive tools on desired outcomes, we do not yet have a theoretical understanding of the psychology of interactivity. Is interactivity a distinct unified concept that cuts across all these devices, about which we can make some global generalizations, in terms of defining it, designing with it, and evaluating its impact? Beyond the simple advantage of affording greater user interaction with the system, does interactivity enhance or hinder user experience in predictable ways? Or, are there different types of interactivity, and do they lead to different kinds of communication outcomes? If so, what are the underlying technological and psychological reasons? How would that be reflected in interface design? This paper tries to answer these questions by synthesizing extant literature in the field of communication using the framework of a new model of interactivity effects.

WHAT IS INTERACTIVITY?
As a theoretical concept, interactivity has been defined and explicated in many ways [8, 32]. An early definition [23], viewed interactivity as the extent to which media would let the user exert an influence on the content and/or form. Rafaeli [18] defined it as responsiveness of the medium toward a user. Rice and Williams noted that it should be two-way exchange, immediate, and real-time [19]. Some research examines this concept focusing more on the

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human-to-human communication perspective [18, 19], whereas others [6, 32] discuss it more as a feature of the medium. Noting that most interactivity studies have focused on just one aspect of it, Kweon, Cho, and Kim suggested that this concept should be multidimensional, [8]. As they note, the blurring boundaries between source (or communicator), audience, message, and medium make it harder to define interactivity appropriately. Even though the various definitions dominate extant work on interactivity, the role played by interactivity in HCI has not invited systematic study by scholars. As a result, little is known about the relative value of adding interactivity to systems.

Fundamentally, interactivity converts a system into a communication medium, by eliciting user interaction with the interface. Mediated communication involves transmission of information from one entity to another. Most traditional models of communication identify three central elements for transmission of information, and these are *source*, *medium*, and *message*. Source is the creator/originator and/or sender of communication content. Medium is the channel through which the content is shared. Message is the content of communication, be it mass communication or interpersonal communication [3, 22]. Based on this, one could conceptualize interactivity as a set of system affordances that enable users to alter the source, medium, and message of their communications using the system [26, 27]. Each of the three species of interactivity influences user experience through a distinct theoretical mechanism—while interactivity as a medium feature operates by increasing/decreasing perceptual bandwidth, source interactivity does so by offering customization options and message interactivity by building contingency in user-system exchanges. They all contribute in different ways to user engagement, with consequences for psychological outcomes of interest (usually classified in terms of cognition, attitude, and behavior). Based on this framework (see Figure 1), the following sections provide detailed discussions of modality, source, and message interactivity, their manifestations in existing interfaces, and the psychological mechanisms underlying their influence on user experience, leading to suggestions for design strategies. In this paper, we focus on the left-hand side of the model, which links system interactivity with user psychology, so that we can derive insights for UI design.

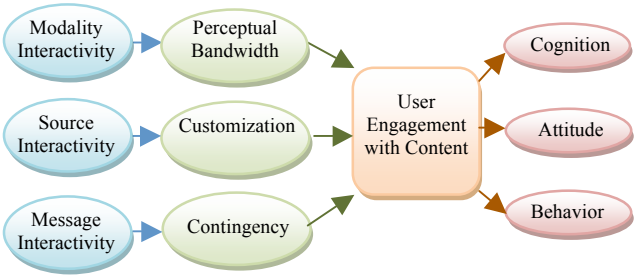

Figure 1. Model of Interactivity Effects

INTERACTIVITY AS A MEDIUM FEATURE

Interactivity as a medium feature comes in the form of different modalities of information dissemination. While a single modality uniquely characterized each traditional medium (print=text; radio=audio), modern interactive media feature a number of modalities within a single medium. Modality therefore is the lowest unit of interactivity within the medium, giving rise to the label "Modality Interactivity," which refers to interface tools that afford users greater activity, resulting in greater depth and breadth of mentally representing and experiencing mediated content. HCI researchers have long demonstrated the powerful influence that modalities of interaction have on humans, as when we adapt to voice-recognition systems by attempting to speak slowly and clearly [15]. However, under our conceptualization, modalities are not limited to those that cater to our senses alone, such as text, audio and visual modes (which have been commonly employed in earlier mass media such as newspapers, radio, and television). Newer digital media interfaces offer a wide variety of modalities that allow us to interact with several of our senses operating together, giving rise to the notion of "multimedia" [25]. Moreover, they also include newer affordances such as clicking on hyperlinks, dragging or scrolling a cursor, using mouse-overs, and so on. For example, the mouse-over function has been employed by most websites with maps to show location information. Figure 2 is an example of a "price area map" of hotels on Priceline.com. After placing the cursor on the particular area that the user would like to stay, the location name and links to additional information are shown. Figure 3 shows how Time.com employs a slide bar to illustrate the changes in brain activity as a consequence of drug use.

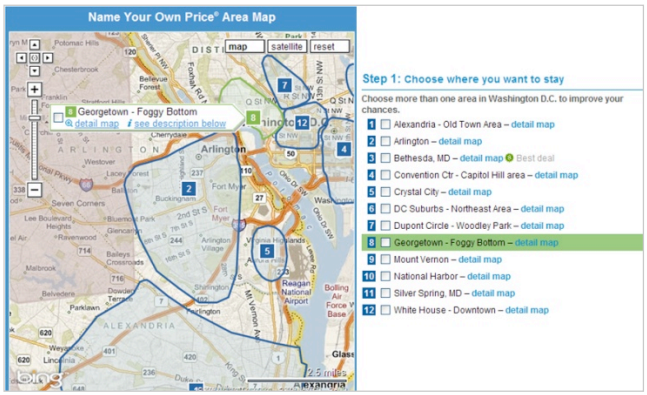

Figure 2. An Example of Mouse-over on www.priceline.com

By offering a distinct functionality, each of these modality-interactivity features offers a new way of accessing and experiencing interface content. This modality view holds true for affordances in both system input (e.g., mouse, keyboard, stylus, touchpad) and system output (e.g., sound, video, animation).

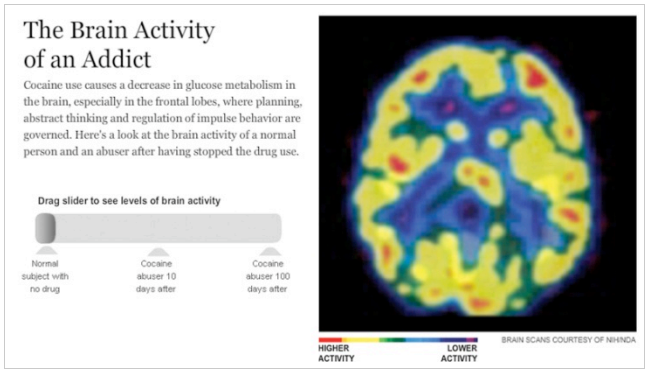

Figure 3. An Example of Slide Bar on www.time.com[36]

In the complex online environment that we currently have, users are not only given several modalities at once, but they are also given opportunities to switch back and forth between these modalities, which makes the experience more interactive. A combination of some of these key output modalities exists in everyday media forms. For instance, a news website may have a combination of text, pictures, hyperlinks, feedback forms, and so on. A website that is meant to share videos online (e.g., YouTube) would allow for a combination of audio and video modalities along with the options to scroll for more videos and to view them in full-screen or half-screen modes. Similarly, a website with an embedded podcast of a program might present audio and text modalities along with opportunities to preview and download files, and also update the information with RSS feeds.

Figure 4. Debate Analysis Tool of First President Debate on www.nytimes.com[13]

Figure 4 is an example of such a flexible multimodal interface. It is a debate analysis tool created by the *New York Times* to allow users to watch the 2008 presidential debates on demand, with the transcript scrolling simultaneously alongside. Users have the option to search the text and jump to a specific part of the debate to find topics that are most important to them. This is something that cannot be done with a traditional modality, like video alone. Figure 5 is yet another example, from Time.com. It combines both cover-flow and mouse-over modality features that are exclusive to new media environments. In this example, images of different kinds of addiction revolve like a carousel until users click on a picture to access additional information. When they place the mouse over different images, various pieces of information are shown. By switching between these two features, users can easily find the relevant information of interest in a highly engaging fashion. Likewise, the iPod Touch provides an animated, three-dimensional graphical user interface for visually flipping through snapshots of pictures, album covers, website bookmarks, and documents (Figure 6).

Figure 5. The Combination of Cover Flow and Mouse-over on www.time.com[36]

Figure 6. The Cover Flow Function on iPod Touch

According to the interactivity effects model [27], these modalities translate into greater engagement by altering *perceptual bandwidth* [20], a concept that refers to the type and number of sensory channels involved during an interaction between media and its users. For example, in a website that has text, pictures, movie-clip, hyperlinks and flash animations, several perceptual abilities that detect sight, sound, and motion are being employed, leading to an elaborate mental representation of this information in the users' mind. The more widespread such mental representations, the greater the perceptual bandwidth, and thus greater is the level of interactivity afforded by such a website. Steuer [23] identified a similar notion when he considered speed, range and mapping of information by human senses as the defining features of interactivity.

The effects of different types of traditional modalities on human information processing activities such as learning and memory have been well documented in the social-science literature. For example, some studies have shown that information presented in audio modality is remembered better than that presented via text, when it is important for users to remember the sequence of a given series of events [11]. Existing studies have consistently demonstrated that

pictures evoke more immediate attention and need very little cognitive resources to be processed as compared to text [9]. Research in experimental psychology has long documented the "pictorial superiority effect" [12] in aiding information encoding.

Scholars have offered two contrasting theories regarding how modalities influence information processing [25, 28]. The cue-summation hypothesis [16] argues that adding relevant pictorial cues to messages will only make that information more memorable, as the additional cues provided by the picture will complement the message in the text. In support of this, researchers working with broadcast media have found that audio-video redundancy improves memory for information from TV messages [1]. On the other hand, theories such as Limited Capacity [9] and Multiple Resources [1] propose a distraction hypothesis, which suggests that highly interesting, emotional and moving images will tend to distract individuals' attention and thus hurt memory. Sundar and Kim [33] found empirical evidence for this effect when they studied the effects of static and animated Interactive Message Units (IMUs) on users' attitudes toward such advertisements and products. Highly interactive IMUs were liked more by users, but failed to increase users' level of involvement with the product advertised in the IMUs. In fact, they found that the use of animation modality in an interactive ad degraded product memory even though it increased ad memorability.

Recent studies have shown that it is not just different types and different combinations of modalities, but also the sheer number or count of multimedia features that will affect information processing, and often adversely, with more and more interactive features taxing the users' cognitive resources [25]. This results in more negative evaluations and outcomes, leading to a phenomenon labeled as "interactivity paradox" [4]. For instance, an early communication study on Website interactivity [31] created a low-interactivity (no hyperlinks to click on), medium-interactivity (some hyperlinks) and high-interactivity (several hyperlinks and an email form) version of a politician's website in order to test its effects on users' perceptions towards the site as well as the politician featured in it. They found that the high-interactivity conditions led to more favorable impressions of the site and its content among those users who were not very politically involved, whereas politically savvy participants showed the greatest affinity to the political candidate in the medium-interactivity version compared to the low- and high-interactive sites. In the realm of online news, studies using a number of modalities have shown that while participants deem audio and video components as the best features of a news site, they learn more and evaluate the site more positively when it is minimalist in its utilization of modality combinations, with the most-favored combination being text plus pictures [25]. On the other hand, at least one study found that the presence of several newer modalities of mouse-based interactions in the form of mouse-overs, drags and tabs led to better recall of information present in a popular news website, but participants gave lower ratings to the overall structure of the news article itself [30].

It appears that there is a cognitive price to pay each time modality interactivity is introduced to an interface. The new Samsung Haptic Phone (see Figure 7) enables 22 different vibrations to simulate actual feel and action. When you see an on-screen radio knob and try to turn it, you hear and feel the clicks of an old-timey dial. The second generation of Haptic Phone further allows users to create personalized haptic effects through touching and dragging icons to represent wave shape, duration, and intensity. All this represents a new modality of interaction with the interface, with a distinct representation in the human perceptual system, but also presents additional stimuli for cognitive processing.

Figure 7. The Enlarged Key Function on iPhone and the Design Interface on Samsung Haptic Phone

Even enhancing the feedback and variety of modalities on an existing interactive tool could be taxing because it serves to expand the user's perceptual representation. For example, the keypad on an iPod (see Figure 7) provides instant feedback by enlarging the individual letter or number entered by the user, thereby increasing the amount of information processing required to interact with this tool. However, this processing burden may serve to alleviate the cognitive complexity of later interactions with the interface, thus calling for design trade-offs between perceptual and cognitive complexity.

In general, theory and research reviewed above indicate that each modality has its own functional role. Clicking on a hyperlink to access a news story is different from using mouse-over to gain additional information on the map, which is again different from sliding to see different images. Not only do these refer to different modalities of user interactions with the interface, they also suggest the three specific functions that occur as a result of such interactions. Each modality and each combination of different modalities has a different influence on the amount of perceptual bandwidth utilized. The effect of these

modalities may not always be linear. For designers, it means that merely adding more functional features on interfaces would not necessarily lead to more desirable outcomes. Too many features exceeding the optimal amount of perceptual bandwidth might serve as distractions and indeed reduce user involvement with interface content.

In sum, designing modality interactivity for media interfaces poses the following challenges:

- Categorizing interactivity tools in terms of the different modes of interaction or reception that each represents and the unique functionality that it provides (e.g., click-based vs. touch-based input; audio + text vs. video),
- Assessing the perceptual bandwidth consumed by each form of modality interactivity in order to allow for variety, rather than overload, of particular tools of perceptual representation (so that we can be cautious when adding more functionality to existing tools of modality interactivity), and
- Recognizing that bandwidth consumed by different forms of modality interactivity is not simply additive, but quite often interactive (e.g., animation modality has a multiplicative effect on the bandwidth consumed by mouse-over modality).

It must be recognized that the expansion of perceptual bandwidth caused by modality interactivity may not always have positive consequences. Under certain conditions, greater perceptual bandwidth could lead to an enhanced ability to process media content delivered by the interactive tools, while under other conditions, it could prevent a thorough appraisal of content because the tools themselves exhaust cognitive capacity. An important limitation of the interactivity-effects model is that it does not specify the conditions under which effects of interactivity would be positive and conditions under which they would be negative. The model generally assumes that user engagement with interactive tools will translate into engagement with content, but the nature of the resulting reception of content is under-specified.

INTERACTIVITY AS A SOURCE FEATURE

Interactivity fundamentally rests on the idea of an active user; the notion is embedded in the word itself as inter-*active*. The users are accorded the status of communication sources (or senders) in that they not only get to pick and choose what information they would like to process and in which format, but they also get to gatekeep information. A more commonly used term to describe this phenomenon of gatekeeping is customization, defined as the extent to which the user feels that he or she is the source or gatekeeper [28]. Customization allows users to be unique and distinct, and gives them an opportunity to spell out their likes and dislikes and needs and wants.

The examples below will illustrate how this notion of customization can range on a continuum of low to high. If a news website allows a visitor to only read what is automatically presented on its home page, it would not be considered interactive. This would be the lowest form (or near absence) of customization where the owner/manager of the website determines what is to be read by users. Whereas, if the website allows users to choose between different types of news such as Business, Politics, Entertainment, Sports, etc through selecting different tabs based on their own preferences, that would be considered a low level of customization or user-initiated interaction.

A medium level of customization would allow users to exercise their choice at a deeper level. For instance, if users can not only choose the news type, but also choose what kind of news stories they would like to read by specifying their own idiosyncratic news categories and determine what specific news source they would like to get their stories from, then that would reflect a medium-customization level (see Figure 8 for examples of customization functions on www.nytimes.com).

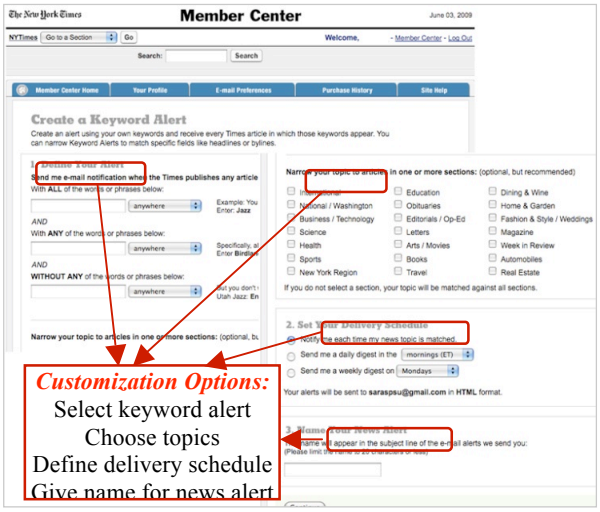

Figure 8. An Example of Medium Customization Website (www.nytimes.com)

Figure 9. An Example of High Customization Website (www.ireport.com)

A good example of high source-based interactivity is when a website allows users to create their own content, as in

wikis and blogs. In such contexts, users are not just making conscious choices or making gatekeeping decisions, but are also actively creating content, emphasizing the notion of sourceness. User-generated websites, such as iReport.com (see Figure 9), fall into this category. On these websites, media content is completely created by users without any screening by professional editors. Users can also tag the submitted content to have them easily searchable.

Empirical studies have demonstrated how different types and levels of customization affect users' attitudes. A typology of online news sources reflecting this differing degree of sourceness was tested with a between-subjects experiment [35] wherein participants were led to believe that the news stories they read for the study were chosen either by news editors, or a system (computer algorithm), or other readers, or the participants themselves. Even though the news stories across the four conditions were identical, evaluation of outcomes showed that participants considered news to be of higher quality, more representative and more likable when they thought that it was other users who had selected them, and not by a group of news editors or even themselves. Other findings in the study demonstrate how differences in the level of *sourceness* lead to different user perceptions of quality, liking and attitudes toward the news stories and their source.

In the domain of health communication, the idea of customization has been studied via the notion of "tailoring" where health messages are presented in a manner that suits an individual's needs and characteristics [10]. Theories in persuasion studies have upheld the claim that by increasing personal relevance of information, that is, by linking some aspect of the persuasive message to a specific aspect of the message recipient's "self," one can induce systematic processing [17]. Hence, this premise of matching information to individual users can have wide-ranging implications for how they consume and interact with online content. Research with customizable Web portals has found that higher levels of matching information to individuals' personal preferences leads to more positive attitudes toward the portal, with *perceived interactivity* (or user perceptions of the interactivity afforded) mediating the positive attitudinal effects of source-based interactive features on the interface [7]. Studies [34] have also examined competing theoretical propositions to find out what makes customization such an appealing factor among users. Is it because it results in highly relevant content given that it is tailored to individual users? Or is it the sense of agency and own-ness felt by the user during the process of customizing and expressing one's preference [29]? At least two studies have discovered an interesting interaction effect wherein the *sense of agency* (or the ability to be the source) determined power users' positive attitudes towards a news aggregator website, whereas non-power users' attitudes were positively influenced simply by the degree of content tailoring. A study with interactive TV movies showed that participants with higher cognitive capacity enjoyed the movie more when they were able to manipulate the movie plot whereas those with lower cognitive capacity enjoyed it more when they watched the passive, non-interactive version [37]. Thus, examining the role of such individual differences and information-processing styles (for e.g. power and non-power-users, high and low computer self-efficacy) would be a useful approach to understand how users' dispositional variables affect their responses to different forms of source-based interactivity. In general, expert users prefer user-tailored content (user as source) whereas novice users seem to prefer system-tailored content (system as source).

It is also important to note that apart from having and choosing a wide range of interactive features, users must psychologically perceive this sense of agency or sourceness for the effects of source-based interactivity to manifest itself in a powerful way. Often, highly interactive features exist but if users do not perceive them nor make use of them, then their effect cannot be easily hypothesized or examined. In fact, in many instances, the perception of interactivity is said to have more influence than the existence of actual interactivity [7] reiterating the distinction made by Norman [14], pertaining to "real affordances" and "perceived affordances". Therefore, perceived customization could mediate the effect of actual interactive features presented in technologies on user attitudes and behaviors on media interfaces.

Several contemporary examples of source-based interactivity help articulate the importance of users perceiving a sense of sourceness. The ability to create avatars like the Wii Mii (see Figure 10) in the Wii Fit game console entrenches user agency by attaching each user's personal identity to their interactions through that interface.

Figure 10. The Avatar of Wii Mii (left) & Personalized File (right) in Wii Fit Game

Users can create their avatars in a way that they would like to appear. They can customize several aspects of the avatar, like gender, hair and skin color, facial features, name and body type. Apart from cosmetic (or appearance-related) customizable features, Wii Fit also allows users to create their own personal profile, choose and enter information such as age, height and weight (see Figure 10). Further, it allows them to enter and track changes in their Body Mass Index (BMI) thus keeping a record of their daily workouts. These user-initiated interactive exchanges with the gaming system serve to enhance their sense of agency and sourceness.

Personalized ringtone is another good example of source-based interactivity. Several phones as well as chat applications such as Skype allow users to create a specialized ringtone for every individual in their address book. These ringtones could be announcements or statements, such as "John is calling," a celebrity voice or a favorite song. The user can thus customize every contact in his or her phone-list with distinctive ringtones.

The essence of customization, therefore, lies in the fact that users get to manipulate the source of information. It ranges from configuration of content to persistent manipulation of content to generation of new content. Psychologically, this translates to the users feeling that they are the agents of interaction. This notion of agency has been defined as "the degree to which the self feels that he/she is a relevant actor" and "the extent of manipulability afforded by the interface to assert one's influence over the nature and course of the interaction" [28, p. 62]. With tools and opportunities for user-generated content, media interface designers could heighten users' sense of customization and subsequently lead to favorable attitudes and behavioral intentions toward the interface, by promoting user identity, involvement and control [28].

In sum, designing source interactivity for media interfaces poses the following challenges:

- Providing ample opportunities for users to choose, categorize, control, and wherever possible, create media content,
- Including identity-enhancing devices that help individual users to assert their uniqueness, and
- Identifying and diverting users with different expertise levels (e.g. power users) toward customization options that are appropriate for realizing their agency (e.g., system-tailoring for regular users and user-tailoring for power users).

For example, employing customizable avatars or other features that would make user identity more salient might potentially relieve the under-contribution problem in online public forums by increasing users' sense of agency. Although not illustrated in the model, we recognize that individual-difference variables, such as expertise in technology use, would potentially moderate the effect of interactivity features. Therefore, customizable options catering to different levels of user expertise would be more effective than uniform calls for customization to all users.

INTERACTIVITY AS A MESSAGE FEATURE

Interactivity as a message feature is evident when media content obtained by the user is a direct function of the user's previous actions, as in a threaded exchange of messages in a chat forum. On media interfaces, interactivity as a message feature is best illustrated as hyperlinks and buttons embedded in website content. The hyperlinks function as invitations for users to interact with media content. Users make decisions about where to start, what to ignore, and when to stop. Each user creates his/her own idiosyncratic browsing path with a series of interlinked messages by navigating through various layers of an interface. In this manner, we can say that the user is interacting with the message.

The contingency principle – the idea that a given message is contingent upon user reception of the previous message and the ones preceding that – can be used to explain the underlying theoretical mechanism of interactivity as a message feature. This principle is also reflected in Rafaeli's [18] definition of interactivity. He regarded interactivity as "an expression of the extent that in a given series of communication exchanges, any third (or later) transmission (or message) is related to the degree to which previous exchanges referred to even earlier transmissions" (p. 111). He identified three ordinal levels of interactivity: non-interactive, reactive, and responsive (or fully interactive) based on the degree to which later messages cohere with those preceding them. Rafaeli's [18] categorization can be explained by using conversations in a chat room as an example. If two individuals post messages without acknowledging each other's messages, then it is non-interactive. If one interactant posts a message as a direct response to another's posting, then it is considered reactive. If the latter interactant then responds to this posting in a manner that takes into account not only the latest posting but also those before them, then it is considered responsive or fully interactive. As a further illustration in a virtual environment or a gaming context, an online agent who responds to user queries in a back-and-forth fashion would be considered more interactive than say a simple text document in question-and-answer format found in most frequently-asked-questions (FAQ) sections. The highest form of message-based contingency would take the form of having an actual human across the computer system attending to queries that a user would pose, in a threaded message sequence. For a message exchange to be fully interactive, the messages should have a flow or coherence, i.e., threaded together in sequence. This kind of message-based interactivity is somewhat easier to conceptualize in the context of computer-mediated interpersonal communication and computer-supported collaborative work (CSCW) scenarios where multiple human interactants exchange messages, either in real time or asynchronously.

In human-to-human communication, message-based interactivity relies on the responsiveness of interactants. However, in users' interaction with media interfaces, messages are already embedded in the interface. Therefore, the manner in which a message is transmitted to users determines the level of contingency-based interactivity employed by the media interface.

Therefore, regardless of whether it is a dialogue in a chatroom or a series of navigational actions, the threadedness of the information is key to realizing message interactivity. How interface designers organize the

information and how this could promote contingent interactions will reflect the interactivity potential of a given media device.

Figure 11. A Scene in the Game of Ice Age 2

For example, in RPG video games, the player needs to talk to the game character to know what to do. After that task has been accomplished, the player would usually communicate with the game character again to learn about his or her next mission. The new mission is usually determined based the player's performance in previous tasks. For example, in one scene of Ice Age 2 (see Figure 11), the player is first instructed to pick up the pebbles. Once s/he gets the pebbles, s/he is then instructed by another animal in the game to throw the pebbles at angry creatures, and so on.

Based on this contingency rationale, a FAQ webpage that only provides a plain-text list of questions and answers would be considered low message interactivity. Aside from the search function, which enables reactivity [18], users are not able to send out any other queries. They need to scroll down the whole Q&A question list to find answers by themselves. In contrast, the FAQ webpage for Amazon.com (see Figure 12) provides not only question lists and topic categories, but also offers online customer service, email and easy "call me" functions. When the user clicks the "call me" button and enters the phone number, an Amazon.com representative actually makes phone calls to customers and addresses their issues in real-time.

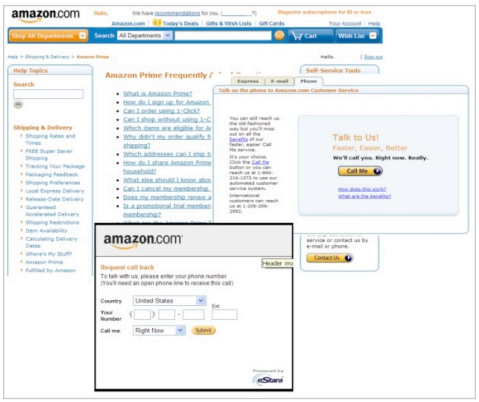

Figure 12. FAQ Website with High Message Interactivity at Amazon.com

On most Web interfaces, the idiosyncratic path or map of clicking activity that taps into the hierarchical structure of hyperlinks that every user follows can serve as an indication of interconnected message exchange that occurs between the user and the system. For example, if a user wants to access hourly weather data in a specific zip code, the first action that the user will perform is to enter the relevant zip code or city in a search box and hit the enter button. Subsequent to this action, the user will get weather information output that matches his or her request for a particular geographical location by clicking on a hyperlink that is specific to his or her city. Additionally, when the user requests for a more detailed report, by clicking on the "Hour-by-Hour" hyperlink, the hourly weather-report information is displayed. Thus, in this three-step sequence, every action was tied to the actions that came before it.

In one experiment on interactivity and political communication, researchers created three different versions of a political candidate's website that were identical in their content, but differed in the degree to which they afforded contingency in the interaction [32]. In the low interactivity condition, the content was organized under headings and subheadings, all on just one page. In the medium interactivity condition, the content was distributed on different webpages necessitating users to click the hyperlinked headings to access additional information about one particular issue. In the high interactivity condition, there were more layers of webpages. Information was further fragmented into different pages. After clicking on a heading in a particular page, users would face yet another set of clickable subheadings. The results of the study showed that participants' ratings of perceived interactivity significantly differed across all three conditions in the predicted direction, providing user-centered verification of a contingency-based definition of message interactivity.

However, the effect of these sites upon users' perception of the political candidate featured on the site was not so clearly linear. In fact, it was curvilinear indicating that moderate amount of message interactivity was optimal for promoting positive impressions of site content. Message-based interactivity is quite demanding of user involvement in the interaction, making it critical for us to identify an optimal level. Perhaps more important, this study showed that politically apathetic users were as likely as politically involved users to become involved in content when presented via message-based interactivity, in line with other studies which have shown that message contingency boosts user engagement with the interface. There even appears to be a physiological basis for this claim. One study using heart-rate measures found that higher levels of message-based interactivity led to greater clicking activity, which evoked more conscious allocation of attention (greater deceleration in heart-rate). This conscious processing also led to important changes in memory related measures, where participants' recognition memory for news stories was better with higher levels of interactivity [30].

For interactivity at the level of messages, concepts such as connectedness, contingency, reciprocity, responsiveness

and specificity of responses could trigger quick positive evaluations of the underlying content [29], leading users to demonstrate iterative and prolonged forms of involvement and engagement with media interfaces.

In sum, designing message interactivity for media interfaces poses the following challenges:

- Creating contingency in user interactions with the system, by embedding tools for person-to-person communication and/or building a multi-layered interface that facilitates hierarchically sequenced release of information,
- Capitalizing on the interface's ability to involve the uninitiated, by providing inviting opportunities to novice users for engaging in a sustained interaction with or through the interface, and
- Determining the optimal point for message exchanges beyond which message-based interactivity results in negative impressions of content.

The above mentioned rationale and challenges for the effect of message interactivity will help designers decide when, where, and how to effectively employ features with different levels of contingency. For example, is it necessary to incorporate instant messaging tools in social networking sites as a way of enhancing reciprocity among users? Would it be necessary to distinguish different threads of online messages in a chatroom? And what are some visualization strategies for conveying a heightened sense of threadedness? Different designs can convey the sense of message contingency in different ways, thereby triggering distinct cognitive heuristics (relating to responsiveness, reciprocity and son on), which dictate user engagement with content [29].

CONCLUSION

A scientific understanding of the psychological effects of interactivity is quite critical for a society that is becoming saturated with interactive digital media. As key communication elements for situating the concept of interactivity, Source, Medium, and Message provide a rich variety of conceptual and operational definitions, leading to a number of design issues at all levels of user interactions with media interfaces. The advantage of a broad theoretical framework is that it can be fruitfully applied to a whole range of devices and tools, including those that are emerging or forthcoming. For example, the recent success of microblogging and social bookmarking sites can be attributed to their heightened source interactivity whereas the appeal of augmented-reality and mash-ups could be due to the fact that they are new forms of modality interactivity that serve to expand our perceptual bandwidth for processing the underlying information. The proposed psychological mechanisms of perceptual bandwidth for modality interactivity, customization for source interactivity, and contingency for message interactivity provide a rich array of generalizable user-based guidelines for UI designers and as testable hypotheses for UI researchers interested in investigating the various ways in interactive tools in current-day media contribute to user engagement with content, among other outcomes of interest. The framework suggested here will likely spawn a new wave of theoretically driven interactivity research that will feed directly into design of interfaces for a variety of purposes, from learning systems to serious games.

Ongoing research in our lab systematically addresses the claims of the model through a series of experiments. Empirical validation of the distinctive operation and effects of the three species of interactivity is critical for deriving effective strategies for design of future interactive UIs.

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