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Abstract

"To the end users, the user interface is the system." This slogan has been widely used in human-computer interaction field to stress the importance of user interface design. In the Internet and electronic commerce area, the website is not only the system, but it also projects an image of the organization in cyberspace. The design of websites is central to businesses as they create the first impression of organizations to visitors. For a virtual organization, the website is also the only medium that visitors rely on to form their impression of the organization. In this paper, we look at theories and frameworks from cognitive psychology, particularly the Informational and Computational Equivalence theory, and investigate their implications on website designs. A weaker version of the theory, Weak Informational and Weak Computational Equivalence, is also proposed.

Introduction

The growth of the Internet has been the most astonishing technological and social phenomenon of this decade. In 1990 only a few academics have heard of the term Internet; now, more than 50 million people are using it. By the turn of the century, that figure could be 100-200 million. So far, the network's only constant has been that the number of new users has doubled almost every 12-18 months. As of now, most organizations have or will soon have Internet access. Its recent explosive growth, particularly in the commercial domain, is due to the lifting of restrictions against commercial use of the Internet and the presence of World Wide Web, or simply known as the Web or WWW. The number of personal and commercial websites has been growing exponentially. Even Bob Dole introduced his personal website to the American public during his presidential campaign in 1996.

Despite the popularity of websites, theories and frameworks that address the design and evaluation of websites are still in its infancy. Although general guidelines for website design and evaluation can be found on the Internet, they are usually rules-of-thumb that were derived based on common sense. Unfortunately, our common sense can be misleading at times. As researchers, we need to base our arguments on sound theories and frameworks. One reference discipline that is relevant to this research is cognitive psychology. In this paper, we will use the theories and frameworks in cognitive psychology, particularly the Informational and Computational Equivalence theory, to discuss website design and evaluation issues.

Due to the limitation of space, we will not review the existing literature on website design and evaluation. Most of the existing literature can be obtained from the web. The rest of the paper is organized as follows: The next section reviews the Theory of Informational and Computational Equivalence. This is followed by a discussion on the implication of the Theory of Equivalence on evaluating website designs. A weaker version of the theory, Weak Informational and Weak Computational Equivalence, is then proposed.

Equivalence of Representations

Simon (1978), in proposing the Theory of Equivalence of Representations, argued that it is impossible to find an entirely neutral language to describe representations of information, for a language itself is a form of representation. This difficulty can be overcome, at least in part, by not attempting to describe representations directly, but by discussing them in terms of their equivalence of representations. At the core of this theory is the notion of Informational and Computational Equivalence of representations (Larkin & Simon 1987, Simon 1978).

Informational Equivalence

Two representations are informationally equivalent if all of the information in one is also inferable from the other, and vice versa (Larkin & Simon 1987). Simon (1978) argued that in an appropriate information-processing system, the statements "Distance equals average velocity times time" and "S=W*T" are informationally equivalent.

In the case of web-design, the use of frame-based versus no-frame-based design is a good example to illustrate the informational equivalence concept. For example, if all of the information presents in the frame-based representation is also found on the no-frame-based representation, then the two designs are informationally equivalent. In other words, the transformation from one to the other entails no loss of information – i.e., one can be constructed from the other.

The concept of informational equivalence comes with a presupposition – it is for an appropriate information-processing system. This is an important condition. Using the Simon's example, the information-processing system not only needs to know the meanings of S, W, and T, but it also has to understand that "=" is "equal," and "*" is the same as "times" in the other statement. In other words, two representations can be informationally equivalent for individual A but not informationally equivalent for individual B – if B does not have the necessary production knowledge to infer the same information from both representations. One example to illustrate this is the city information for air travel. Two websites may provide the same information. For one website, the information is given in layman's terms and in English (e.g., the departing city is Lincoln and the arriving city is Singapore). On another website, the same information is presented using the travel industry codes (e.g., the departing city is LNK and the arriving city is SIN). The information is the same but the information on the two websites is only equivalent if the reader has the knowledge to understand both types of representations.

For certain representations, training and experience can make two initially informationally inequivalent representations informationally equivalent – as in the case of travel industry codes for travel agents.

Computational Equivalence

Two representations are computationally equivalent if the same information can be extracted from each representation (the same inferences drawn) with about the *same amount of computation*. Based on the definition, there are two conditions to be satisfied for computational equivalence (Larkin & Simon 1987):

(a) the two representations must be informationally equivalent and,
(b) any inference that can be easily and quickly drawn from the information given explicitly in one can also be drawn easily and quickly from the information given explicitly in the other, and vice versa.

Refer back to the frame versus no-frame example. Assume the frame-based and no-frame-based designs present the same information -- i.e., they are informationally equivalent. Further assume that for the no-frame-based representation, the navigation links (e.g., home, previous, next) are presented at the bottom of the webpage and the webpage is more than a screen length. To get to the navigation links, the user will have to scroll to the end of the webpage. For the frame-based representation, the navigation links will (usually) be on the left-hand column of the screen. Although the two designs present the same information, they are not computationally equivalent[1]. To get to the navigation links in the no-frame representation, the user will have to scroll to the bottom of the webpage – an additional step.

Discussions on the Theory of Equivalence

Based on the Theory of Equivalence, website designs can be evaluated or compared based on two criteria: informational and computational equivalence. Informational equivalence is a useful concept in comparing the information content whereas computational equivalence is valuable in evaluating different possible designs – e.g., frame versus no-frame design, a long page versus several shorter pages, etc.

The Theory of Equivalence, as proposed by Simon, is, however, of little use in evaluating websites from different domains. For example, we cannot evaluate the websites of United Airlines and American Airlines using the concept of informational equivalence. Since the two organizations are different, the information on their websites will be different – informational inequivalent. Also, the concept of computational equivalence is not applicable unless the websites are informationally equivalent.

Although the Theory of Equivalence is helpful in evaluating alternative designs for a website, it is useless when we need to evaluate different websites. In this paper, we propose a weaker version of the theory that will enable us to evaluate websites of different organizations from the same industry.

Theory on Weak Equivalence of Representations

To compare websites from different organizations in the same industry, we introduce a weaker version of the theory -- Weak Informational and Weak Computational Equivalence of representations.

Weak Informational Equivalence

Two representations are in weak informational equivalence if all of the information in one has correspondingly similar information in the other, and vice versa. As an example, "The capitol of US is Washington" and "The capitol of Canada is Ottawa" has weak informational equivalence for an appropriate information-processing system and context. If we are looking at the official websites of US and Canada, then these two pieces of information are weakly informationally equivalent – they are both describing the capitols of the countries.

Weak informational equivalence is useful in evaluating websites belonging to the same domain. For example, we can evaluate the websites of different airlines using weak

[1] In the context of website design, the concept computational equivalence might be better termed as navigational equivalence. But for the sake of simplicity, we will continue to use the term computational equivalence in this paper.

informational equivalence concept. We can compare the information provided on United, American, TWA, and Northwest websites. Do they provide information on fight arrival and departure? Do the websites contain information on frequent flier programs? Another example would be to compare the websites of different universities. Do they provide undergraduate and graduate admission information? Do they provide the same level of information on assistantships and scholarships available in the universities?

Weak informational equivalence concept, however, is of little use in evaluating websites from different domains – if there is such a need. For example, it is inapt to evaluate the website of United Airlines and the website of Amazon.com using this concept. Since the two companies are in different industries, the information content on their websites will be different because their customer bases are different. The information on United website is targeted at airline customers whereas the information on Amazon.com is aimed at book readers.

Weak Computational Equivalence

Two representations are weakly computational equivalent if correspondingly similar information can be extracted from each (the corresponding inferences drawn are similar) with *about the same amount of computation*. Similar to computational equivalence, there are two conditions to be satisfied for weak computational equivalence:

(a) the two representations must be weakly informationally equivalent and,
(b) for any inference that can be easily and quickly drawn from the information given explicitly in one, correspondingly similar inference can also be drawn easily and quickly from the information given explicitly in the other, and vice versa.

Weak computational equivalence is only applicable if the two representations are weakly informationally equivalent. Using the example of airline websites, computational equivalent concept can be used to evaluate the organization of information on the website (e.g., how many clicks are needed to get to a certain piece of information). How many steps are required to access the frequent flier reward programs?

Operationalization of the Concepts

Informational equivalence can be assessed by asking the subjects to visually interpret the websites to see if all information from one website can also be gathered from the other. For weak informational equivalence, we will be assessing whether the websites contain correspondingly similar information. Another way to operationalize the informational and weak informational equivalence concepts is to ask subjects to write down information that can be interpreted from the websites and then compare the interpretation. Verbal protocol (Ericsson & Simon 1993) can also be used to gather the information that is interpretable from the websites.

Computational efficiency and weak computational efficiency can be assessed with time and accuracy measurement. A website is more computationally efficient than another if the same inferences can be made faster (e.g., with fewer clicks) and easier (e.g., with fewer mistakes). Operationally, for time measurement, we can measure the time required for the subjects to respond to questions (e.g., True/False questions) derived from the websites. Verbal protocol (Ericsson & Simon 1993) can also be used to analyze the number of computational (or navigational) steps required before the subject can access or interpret a certain piece of information from the websites.

Conclusion

In this paper, we introduce the concepts of Informational and Computational Equivalence. We then relate the two concepts to evaluating alternative designs for a website. The concepts of Informational and Computational Equivalence, however, cannot be applied to evaluate the designs of different websites from the same domain. A weaker version of Theory of Equivalence, Weak Informational and Weak Computational Equivalence, is then proposed. Examples on how to use the weaker theory in evaluating different websites are given and discussed.

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References

Ericsson, K.A., and Simon, H.A., "Protocol Analysis: Verbal Reports As Data," Revised Edition, The MIT Press, 1993.

Larkin, J.H., and Simon, H.A., "Why a Diagram is (Sometimes) Worth Ten Thousand Words," Cognitive Science, 11, 1987, pp. 65-99.

Simon, H.A., "On the Forms of Mental Representation," in: Minnesota Studies in the Philosophy of Science, Vol. IX: Perception and Cognition: Issues in the Foundations of Psychology, Savage, C.W. (Ed.), Minneapolis: University of Minnesota Press, 1978, pp. 3-18.