Usability Evaluation of Dynamic RSVP Interface on Web Page

Ya-Li Lin and Darcy Lin

Department of Statistics, Tunghai University,
Taichung, Taiwan 40704
yllin@thu.edu.tw

Abstract. The usability of rapid serial visual presentation (RSVP) interface was evaluated using subjective preference questionnaire and performance measurement methods. Forty-two students voluntarily participated in this study. The results indicated the shelf interface moving from bottom-left to upper-right along a linear trajectory with moving speed of 20~30 frame per second (FPS) are most preferable. The carousel interface following circular trajectory in clockwise with moving speed of 10~15 FPS are most preferable. "Meets user experience", "aesthetic and simple design", "effective to use", and "easy to learn" all conform to the usability goals. In addition, the results based on performance measurement showed a logistic regression model with RSVP mode and moving speed are fitted very well. There is the highest probability estimation of correct recognition for the carousel interface and moving speed of 30 FPS, however, the shelf interface and 15 FPS has the lowest probability estimation of correct recognition.

Keywords: Dynamic Interface, Subjective Preference, Rapid Serial Visual Presentation (RSVP), Usability Evaluation.

1 Introduction

Search for stock and weather information, prices for flights and mortgages, and new book issued is common in Internet search. A typical search session consists of: (1) formulating and entering the query, (2) browsing the search results, and (3) viewing selected result page. Our work aims to investigate and provide a user-centered interface for browsing the search results in the process of search session. Once a user has launched a query, the search engine must look in a variety of databases and return a set of relevant results. There are multiple ways to deliver information to the user and multiple ways to let the user use the result. However, there must be a phased implementation of content searches, both from a consumer usability perspective, as well as an advertiser/merchant perspective. Performance measures will be carrying out on the second phase of browsing the search results.

Foster (1970) first used Rapid Serial Visual Presentation (RSVP) to mean rapidly displaying words in a sequence in the same visual location. RSVP originated as a tool for studying reading behavior [3], but lately has received more attention as a

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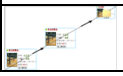
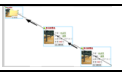
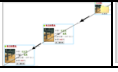
presentation technique with a promise of optimizing reading efficiency, especially when screen space is limited [9]. The reason for the interest is that the process of reading works a little different when RSVP is used and that it requires much smaller screen space than traditional text presentation [8]. RSVP is a method of displaying information using a limited space in which each piece of information is displayed briefly in sequential order [2, 4, 5, 11]. With the development of dynamic design, fast-moving RSVP interface could emphasize its advantage of showing more image information at a time, but compared with slow-moving RSVP interface, its relative advantage could be less mental workload [8]. Can user experience of search results be improved by using dynamic RSVP interface? The images of shelf RSVP interface shown in the fixation area are used to compare with carousel RSVP interface [2, 11]. We are going to provide usability evaluation of image visualization of dynamic RSVP interface in this study.

The objective of this study is to evaluate the usability of RSVP interface using subjective preference questionnaire and performance measurement methods. A prototype of simulated E-bookstore system is designed to collect the subjective preference ratings of predetermined designing factors at the beginning of the study. To evaluate the usability for web users, usability evaluation is used to achieve specified goals with effectiveness, efficiency, learnability, memorability, and user satisfaction [7]. Both RSVP display (carousel and shelf) and moving speed (10, 15, 20, 30, and 40 FPS) were varied in the simulated interface of E-bookstore. We would like to propose the following researcher's hypotheses: (1) Could the design factors, such as RSVP, moving speed, and moving direction affect the subjective preference rating on dynamic RSVP interface? (2) Could the design factors affect the performance of recognition on dynamic RSVP interface? (3) Are there usability goals conforming to user experience?

2 Design of the Dynamic RSVP Interface

The simulated E-bookstore interface would contain contents of web searching result. The searching results will be shown on the dynamic RSVP interface as the experimental Web pages. Two kinds of RSVP interfaces were considered based on their trajectory. The carousel RSVP interface is defined as a series of images display appear successively running from the bottom of page in a clockwise (Carousel I) or counterclockwise (Carousel II) along the circular trajectory. The shelf RSVP interface is defined as the linear trajectory of the images followed the diagonal running from bottom-left to upper-right (Shelf-I), from bottom-right to upper-left (Shelf-II), from upper-right to bottom-left (Shelf-III), and from upper-left to bottom-right (Shelf-IV). Specifications of design factors and their factor levels for subjective preference questionnaire and performance measurement are shown in Table 1. The prototypes of simulated E-bookstore interface used in the preference-based phase were illustrated in Table 1. The layer design and the number of frames per second (FPS) were used to produce the moving effect of image visualization. FPS in Micromedia Flash MX means the moving speed for each image [6]. The exposure times for one image are 20, 13.3, 10, 6.67 and 5 seconds corresponding to 10, 15, 20, 30 and 40 FPS. The task assigned to each participant is to browse the searching results after entering a query.

Table 1. The specifications of design parameters and their factor levels for dynamic RSVP interface

Design parameter	Factor level					
RSVP	Carousel I	Carousel II	Shelf I	Shelf II	Shelf III	Shelf IV
Trajectory	Circular	Circular	Linear	Linear	Linear	Linear
Moving direction	Clockwise	Counter-clockwise	Bottom-left to upper-right	Bottom-right to upper-left	Upper-right to bottom-left	Upper-left to bottom-right
Image size	Growing to Shrinking	Growing to Shrinking	Constant to Shrinking	Constant to Shrinking	Growing to Constant	Growing to Constant
Image position	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic
Position of the maximum image	From 9-12-3 o'clock	From 3-12-9 o'clock	Bottom-left	Bottom-right	Bottom-left	Bottom-right
Number of images visible	5	5	5	5	5	5
Total number of images	10	10	10	10	10	10
Example						

3 Research Methods

Before the usability experiment the preparation work included the selection of participants and experimental factors, construction and design of the experimental Web pages and the dynamic RSVP Interface, and design of searching results.

3.1 Subjective Preference Questionnaire

The subjective preference questionnaire is a structured field of usability assessment. It is useful in the early stages of user-centered design development. The International Organization for Standardization (ISO) defines usability of a product as "the extent to which the product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." Usability is generally regarded as ensuring that interactive products are easy to learn, effective to use, and enjoyable from user's perspective [10]. More specifically, usability is broken down into the following goals: effectiveness, efficiency, safety, utility, learnability, and memorability.

3.2 Participants

Forty-two undergraduate and graduate students (21 females and 21 males) coming from Tunghai University voluntarily participated in the subjective preference questionnaires. The distribution of age ranged form 23 to 30 years old (mean age of 24.6 years old and standard deviation of 1.72 years old). They all had the experience of surfing the internet and had normal vision or corrected vision reaching at least 20/25 and no color-blindness.

3.3 Experimental Design

Dynamic RSVP interface consisted of ten images shown in turn on the Web page of E-bookstore (see Figure 1). Objective function is defined as the correct recognition of targeted image. Design factors are RSVP mode and moving speed. RSVP modes include clockwise and counterclockwise carousel RSVP and four types of shelf RSVP modes (shelf I-IV) (see Table 1). Moving speeds include five levels of 10, 15, 20, 30, and 40 FPS which their exposure time for each frame is 20, 13.3, 10, 6.67, and 5 seconds respectively. Each participant continuously viewed sixteen different searching results imposed on Web pages of E-bookstore and a recognition task was assigned.

(a) (b)

Fig. 1. Illustration of (a) shelf RSVP and (b) carousel RSVP shown on the simulating E-bookstore interface

3.4 Experimental Procedure

After filling in the self-reported background document, the rules of answering subjective preference questionnaire were explained by the experimenter. The varied combinations of RSVP interface on the simulated E-bookstore Webpage were shown one factor at a time. Subjective preference questionnaire was implemented associated with a simulated E-bookstore interface. The favorite display type of RSVP interface on the simulated E-bookstore Webpage was chosen individually by each participant until she/he has finished all the question items of subjective preference questionnaire. In addition, each participant continuously viewed sixteen different searching results presented on Web pages of E-bookstore and a browsing task was assigned. The participants are asked to correctly recognize whether a targeted image has been shown or nor after they finished the browsing task. The questionnaire for user interface satisfaction (QUIS for short) will be implemented after finishing the experiment of performance measurement.

3.5 Apparatus and Materials

This study uses a Pentium IV desktop computer (CPU1.62GHZ, 896MB RAM) with Microsoft Internet Explorer 6.0, a 17-inches TFT-LCD monitor (1280×1024 pixels). Micromedia Flash, Dreamweaver and Firework MX 2004 (copyright @Cyberlink Corporation) were used to design the simulated E-bookstore Webpage.

3.6 Model Building of Recognition

Based on the design of experiment, the objective function of browsing task is collected. Logistic regression model is appropriate for the fitting of probability of correct recognition [1]. Design factors include RSVP mode and moving speed. RSVP modes include carousel and shelf RSVP displays based on the major difference of circular and linear trajectory (Table 1). Moving speeds include four levels of 10~15 (the groups of 10 and 15 FPS being combined due to the consideration of sample sizes), 20, 30, and 40 FPS with the exposure time of 20~13.3, 10, 6.67, and 5 seconds per frame respectively. In addition, gender and college background variables are considered as individual difference. Define Y as the recognition variable of targeted image. The value of Y equals 1 if the participant could correctly recognize the targeted image; otherwise, Y equals 0. Let π be the probability of correct recognition, we have the odds of correct recognition to be $[\pi/(1-\pi)]$. The *logit* function $\log[\pi/(1-\pi)]$ of π, symbolized by "$\text{logit}(\pi)$," is the log odds of correct recognition. Whereas π is restricted to the 0-1 range, the *logit* can be any real number. The proposed model for the fitting of probability of correct recognition initially concludes the main effects of gender, college, RSVP mode, and moving speed as well as the interaction of RSVP mode and moving speed and is shown as follows:

$$\pi = P(Y = 1 \mid X) = \frac{exp(X\beta)}{1 + exp(X\beta)}, \tag{1}$$

where X denotes the design matrix of two-factor interaction of RSVP mode (RSVP for short) and moving speed (FPS for short), gender (G for short), and college (C for short), that is, $X' = [1 : G, C, RSVP \mid FPS]$ (use "|" for interaction), β is the parameter vector corresponding to X, the logistic regression model is expressed as follows:

$$logit[P(Y = 1)] = logit(\pi) = log\left(\frac{\pi}{1-\pi}\right) = X\beta, \tag{2}$$

The nominal-scale explanatory variable with k categories in Equations (1) and (2) is appropriate to be treated using (k-1) indicator variables. For example, design factor RSVP is a categorical variable with two categories using one indicator variable. FPS may be regarded as continuous or regarded as categorical with four categories. If FPS is regarded as nominal-scale explanatory variable, it is going to use three indicator variables to describe their four categories. The frequencies of recognition for the groups of 10 and 15 FPS are combined and renamed as FPS15. We have the value of FPS15 equals 1 if the moving speed is 10 FPS or 15 FPS; otherwise, FPS15 equals 0. Similarly, the value of FPS20 equals 1 if the moving speed is 20 FPS; otherwise, FPS20 equals 0. The value of FPS30 equals 1 if the moving speed is 30 FPS; otherwise, FPS30 equals 0. The value of FPS40 equals 1 if the moving speed is 40 FPS; otherwise, FPS40 equals 0. Let ($\boldsymbol{G}, \boldsymbol{C}, \boldsymbol{RSVP}, \boldsymbol{FPS}15, \boldsymbol{FPS}20, \boldsymbol{FPS}30$) each take values 0 and 1 to represent the nominal-scalar categories of explanatory variables. The coding values of indicator variables corresponding to the nominal-scale explanatory variables are described as follows:

$$\boldsymbol{G}=\begin{cases}1, & \text{if Female}\\ 0, & \text{if Male}\end{cases},\qquad \boldsymbol{C}=\begin{cases}1, & \text{if major in Art and Design}\\ 0, & \text{if major in Management}\end{cases}$$

$$\boldsymbol{RSVP}=\begin{cases}1, & \text{if carousel mode}\\ 0, & \text{otherwise}\end{cases},\qquad \boldsymbol{FPS}15=\begin{cases}1, & \text{if FPS}=10\text{ or }15\\ 0, & \text{otherwise}\end{cases},$$

$$\boldsymbol{FPS}20=\begin{cases}1, & \text{if FPS}=20\\ 0, & \text{otherwise}\end{cases},\qquad \boldsymbol{FPS}30=\begin{cases}1, & \text{if FPS}=30\\ 0, & \text{otherwise}\end{cases}$$

Rewrite Equation (2) as following:

$$\text{logit}[\boldsymbol{P}(\boldsymbol{Y}=1)]=\text{logit}(\boldsymbol{\pi})=\log\left(\frac{\boldsymbol{\pi}}{1-\boldsymbol{\pi}}\right)=\boldsymbol{\beta}_0+\boldsymbol{\beta}_1\text{G}+\boldsymbol{\beta}_2\text{C}+\boldsymbol{\beta}_3\text{RSVP}+\boldsymbol{\beta}_4\text{FPS15} \tag{3}$$
$$+\boldsymbol{\beta}_5\text{FPS20}+\boldsymbol{\beta}_6\text{FPS30}+\boldsymbol{\beta}_7\text{RSVP}\times\text{FPS15}+\boldsymbol{\beta}_8\text{RSVP}\times\text{FPS20}+\boldsymbol{\beta}_9\text{RSVP}\times\text{FPS30},$$

The parameter corresponding to indicator variable RSVP in Equation (3) are $\boldsymbol{\beta}_3$. The value of $e^{\boldsymbol{\beta}_3}$ represents the odds ratio defined as the ratio of correct recognition odds between carousel and shelf RSVP interfaces. The values of $\boldsymbol{FPS}15=1,\boldsymbol{FPS}20=0,\boldsymbol{FPS}30=0$ in Equation (3) are being substituted for moving speed of 15 FPS. The values of $\boldsymbol{FPS}15=0,\boldsymbol{FPS}20=1,\boldsymbol{FPS}30=0$ are being substituted for moving speed of 20 FPS. The values of $\boldsymbol{FPS}15=0,\boldsymbol{FPS}20=0,\boldsymbol{FPS}30=1$ are being substituted for moving speed of 30 FPS. The parameters corresponding to indicator variables $\boldsymbol{FPS}15$, $\boldsymbol{FPS}20$, and $\boldsymbol{FPS}30$ in Equation (3) are $\boldsymbol{\beta}_4$, $\boldsymbol{\beta}_5$ and $\boldsymbol{\beta}_6$. The value of $e^{\boldsymbol{\beta}_4}$ represents the odds ratio defined as the ratio of correct recognition odds between 15 FPS and 40 FPS. Similarly, the values of $e^{\boldsymbol{\beta}_5}$ and $e^{\boldsymbol{\beta}_6}$ represents the odds ratios of correct recognition between 20 FPS and 40 FPS as well as between 30 FPS and 40 FPS.

4 Results and Discussion

4.1 Comparison of Subjective Preference

Based on the result of subjective preference questionnaire, the favorite percentage distribution of moving direction for RSVP displays is shown in Figure 2. For shelf RSVP display, 57% of users chose the direction of moving from bottom-left to upper-right as their favorite one, however, only 5% of users chose the direction of moving from bottom-right to upper-left (Figure 2(a)). The differences of subjective preference proportions among four moving directions of shelf RSVP display are statistically significant ($\chi^2=25.62$, *P-value* <0.001). For carousel RSVP display, 69% of users chose the moving direction of clockwise as their favorite one (Figure 2(b)) and there is a significant difference between clockwise and counterclockwise directions ($\chi^2=6.10$, *P-value*= 0.0136). In addition, the disfavored percentage distribution of moving speed for RSVP displays is shown in Figure 3. There are 40% of users choosing 40 FPS (the fastest speed) as their disfavored moving speed and 36% of users choosing 10 FPS (the slowest speed) as their disfavored moving speed (Figure 3(a)). The differences of disfavored proportions among five moving speeds of shelf RSVP display are

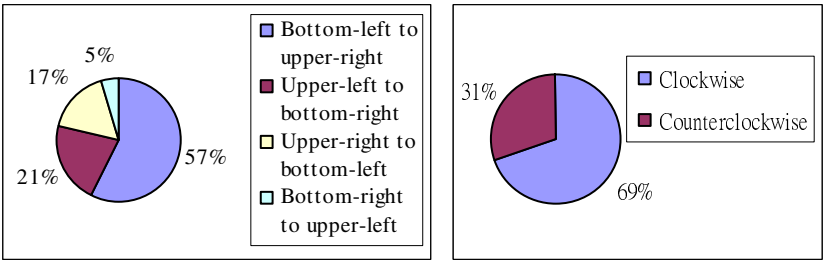


Fig. 2. The favorite percentage distribution of moving direction for (a) shelf and (b) carousel RSVP displays

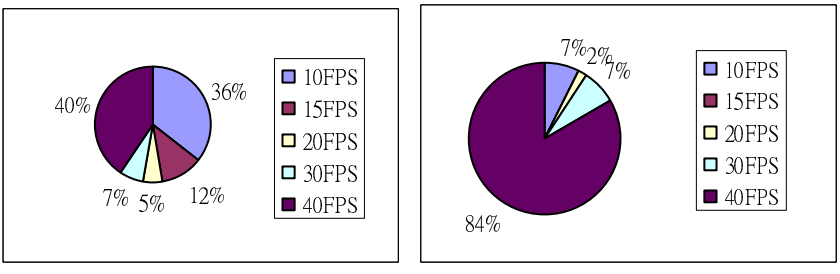


Fig. 3. The disfavored percentage distribution of moving speed for (a) shelf and (b) carousel RSVP displays

statistically significant ($\chi^2 = 23.71$, *P-value* <0.001). For carousel RSVP display, there are as many as 84% of users choosing 40 FPS (the fastest speed) as their disfavored moving speed (Figure 3(b)). The differences of disfavored proportions among five moving speeds are statistically significant ($\chi^2 = 76.48$, *P-value* <0.001).

4.2 Logistic Regression Model Fitting

Iteratively compare models and conduct inference about parameters to fit the recognition data. The best fitting of logistic regression model is

$$\log it(\hat{\pi}) = \log\left(\frac{\hat{\pi}}{1-\hat{\pi}}\right) = 1.276*RSVP - 1.084*FPS15 - 0.023*FPS20 + 1.323*FPS30\text{'} \quad (4)$$

The estimated correct recognition rate (ECRR) is obtained by the following estimated probability of correct recognition.

$$ECRR = \hat{\pi} = \frac{\exp(X'\hat{\beta})}{1+\exp(X'\hat{\beta})} \quad , \quad (5)$$
$$= \frac{\exp(1.515 + 1.276*RSVP - 1.084*FPS15 - 0.023*FPS20 + 1.323*FPS30)}{1+\exp(1.515 + 1.276*RSVP - 1.084*FPS15 - 0.023*FPS20 + 1.323*FPS30)}$$

The parameter estimate corresponding to indicator variable RSVP in Equation (5) are 1.276. The value of $e^{1.276} = 3.6$ represents the estimated odds that carousel RSVP

interface provides correct recognition of a browsing task odds are 3.6 times the estimated odds for shelf RSVP interface. It indicates carousel RSVP interface provides higher ECRR than shelf one. Similarly, moving speed of 30 FPS provides higher ECRR than others since the parameter estimates corresponding to indicator variables FPS15, FPS20, and FPS30 in Equation (5) are -1.084, -0.023, and 1.323. The highest ECRR is 0.9839 for the combination of carousel RSVP and 30 FPS, however, the combination of shelf RSVP and 15 FPS has the lowest ECRR of 0.6060. Based on the performance measure of recognition, the best combination of correct recognition is carousel RSVP interface and 30 FPS and the worst combination of correct recognition is shelf RSVP interface and 15 FPS.

4.3 Statistical Tests for QUIS

The result of questionnaire for user interface satisfaction is illustrated in Figure 4. There are 86% of users agreeing upon this interface is easy to learn and reaching statistical significance ($\chi^2 = 21.43$, *P-value* <0.001). It means RSVP interface is not only providing information visualization on Webpage, but also providing the function with ease to learn. There are 69% of users agreeing upon this interface is effective to use and reaching statistical significance ($\chi^2 = 6.10$, *P-value* =0.014). It means RSVP interface would carry out browsing tasks efficiently and provide the function with effective to use in a limited space without scrolling the Webpage. In addition, dynamic

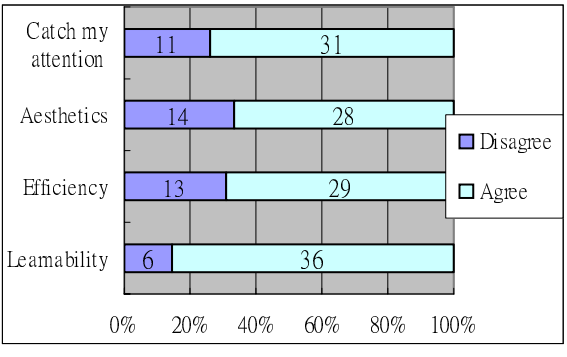


Fig. 4. Frequency (Percentage) distributions of agreeing upon the heuristic principles

Table 2. Usability evaluation for user experience

Chi-squared Test / Criteria	χ^2	*P-value*[1]
Easy to learn	21.43	<0.001*
Effective to use	6.10	0.014*
Efficient to use	1.52	0.217
Aesthetics	4.67	0.031*
Attraction	9.52	0.002*

Note 1: "*" denotes it reaches significance level of 0.05.

RSVP interface would also reduce the time of saccadic eye movement to reach efficiency. Over 60% of users (67%) agree upon this interface conforming to the principle of aesthetics and reach statistical significance ($\chi^2 = 4.67$, *P-value*=0.031). Over 70% of users (74%) agree upon catching user's attention for this RSVP interface and reach statistical significance ($\chi^2 = 9.52$, *P-value* =0.002). It indicates easy to learn, effective to use, aesthetics and attracting user's attention all conform to the usability principles except the principle of efficient to use.

5 Conclusions

Based on the results of subjective preference questionnaire, the design of preference-based search results interface for Web users will be suggested in this study. For shelf RSVP interface, users prefer moving direction from bottom-left shrinking to upper-right and moving speed between 20 and 30 FPS (exposure time is about 6.67~10 seconds). For carousel RSVP interface, users prefer moving direction of clockwise and moving speed between 10 and 15 FPS (exposure time is about 13.33~20 seconds). However, based on the performance measure of recognition, the best combination of correct recognition is carousel RSVP interface and 30 FPS and the worst combination of correct recognition is shelf RSVP interface and 15 FPS. It looks like individual bias exists between users and needs to investigate the possibility deeply. Based on the questionnaire for user interface satisfaction (QUIS), easy to learn, effective to use, aesthetics, and attraction all conform to the usability principles except the principle of efficient to use.

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