Effects of scroll bar orientation and item justification in using list box widgets

G. Michael Barnes
California State University Northridge
18111 Nordhoff Street
Northridge, CA 91330-8281 USA
+1 818 677 2299
renzo@csun.edu

Erik Kellener
Hollywood Online Inc.
1620 26th St., #370S
Santa Monica, CA 90404
+1 310 586 2020
ekellener@hollywood.com

Abstract
List boxes are a common user interface component in graphical user interfaces. In practice, most list boxes use right-oriented scroll bars to control left-justified text items. A two way interaction hypothesis favoring the use of a scroll bar orientation consistent with list box item justification was obtained for speed of use and user preference. Item selection was faster with a scroll bar orientation consistent with list item justification. Subjects preferred left-oriented scroll bars with left-justified items and right-oriented scroll bars with right-oriented items. These results support a design principle of locality for user interface controls and controlled objects.

Keywords
List widgets, scroll bar, graphical user interface design, usability study

Introduction
This electronic publication is an updated statistical analysis of Erik Kellener's unpublished masters' thesis, "Are GUI Ambidexterous" completed at California State University Northridge, CA. 1996.

List boxes are used in many graphical user interfaces (GUI) today. Whether its a desktop P.C., a personal digital assistant (PDA) or an information kiosk at the grocery store, list boxes are integrated into most GUIs. The list box GUI component is usually present in an interface that asks a user to make a selection from a list of items. The size of the list of items can vary significantly, however the screen area required by a list box is usually fixed. This allows an application to effectively present large amounts of information [5]. An integral part of the list box is the viewing control or the scroll bar. By manipulating the scroll bar, the user can navigate through a list of items and find a specific entry.

Taking into consideration that list boxes are used in many computing environments, it is essential that their design is effective. Effective design is measured in two ways:

1. How fast does a user accurately perform with a particular list box design?
2. What is the user satisfaction level in interacting with a particular list box design?

To shed some light on these questions, we chose to examine the effects of varying list box designs on user performance and preference.

While researching different list box designs, we primarily focused on desktop GUIs. Aside from slight variations of the list box presentation via the window managers, we found that all list box designs studied, adhere to some standard guidelines for the justification of the text items contained within them [9]. Most of the list boxes surveyed stored alpha numeric text items. All alpha numeric items were left-justified and all numeric items were right-justified. We also came across a fairly consistent list box scroll bar orientation. Most GUIs surveyed placed the

scroll bar on the right side of the list box [5, 6]. Only the NeXTSTEP GUI implemented the list box with a left-oriented scroll bar [8]. Both of these characteristics (justification and orientation) are the focus of this research.

During the development of our research, a design topic controversy arose in a NeXTSTEP focused Internet USENET group (alt.comp.sys.next.advocacy). In April 1997 a flood of email discussions hit the "net" addressing user interface (UI) decisions for Apple's new operating system, code named (Rhapsody). The new operating system is based on a hybrid of their traditional System 7 and their newly acquired NeXTSTEP operation system. One of the key controversies was the merging of the two different GUIs, more specifically the difference in list box widget implementation. The USENET's postings were comprised of both NeXTSTEP advocacy for a left-oriented scroll bar design, and the traditional Apple System 7 implementation of a right-oriented scroll bar. Many of the left-oriented scroll bar advocates justified their opinions of having the left-oriented scroll bar closest to the left-justified text, by referring to "The Principle of Locality" [10]. John Kheit (newsgroup communication) writes, "Fighter pilot's cockpits put as many controls right in the VIEW of the pilots because that is where he tends to look most often". Most of the right-oriented scroll bar advocates, defended their position by attributing the design decision to reflect the dominate "right-handed" user population and that most window controls (e.g., window blinds) are right-oriented, with respect to their controlling mechanisms [1, 7]. It was clear this research touches on an area of usability that is controversial and can lead to future research which could effect design considerations for current and future GUI implementations.

GUI Design

Looking back at the evolution of GUIs, we found a common thread to today's designs. XEROX-PARC's STAR prototype put forth an effort that became a widely accepted standard in modern GUIs [11]. Among these commonly practiced designs was the list box widget. The STAR GUI prototype contained a list box widget with a right-oriented scroll bar. Many modern GUIs have followed, standardizing on a right-oriented scroll bar for their list box designs. David Warren of Microsoft confirms (personal email communication), "The scroll bars to the right of scrollable objects is a design that has its roots in XEROX-PARC prototypes, and is confirmed again through countless versions of Microsoft Windows." We found no evidence of any usability research to support NeXTSTEP's left-oriented scroll bar design. Keith Olfs, the lead UI engineer for early versions of NeXTSTEP (personal email communication) wrote, "We just thought it made sense to put the list box scroll bar on the left side."

Related Experimental Work

We have been unable to locate any studies on list box design or usability. However, there has been some related research on GUI widgets. There has even been some work with GUI widgets and their interaction with menu interfaces. Additionally, we found some research that specifically compares performance and preference metrics on GUI usability.

In 1993, Benbasat and Todd [3] researched text versus iconic interfaces and direct manipulation versus menu interfaces. Their research concluded iconic interfaces produce no advantage over text interfaces. They also concluded that only short-term advantages were obtained for direct manipulation when compared with menus.

Most GUI menu-oriented research has been focused on studying the effects of menu breadth and depth. Johnsgard's [4] research considered subject performance and preference for conducting selection tasks with various interface controls (e.g., list box, check box, radio button, combo box). The results conclude that no single GUI control (widget) is optimal for all cases. In fact, the discussion section mentions that some tasks were intentionally not included in the study because there didn't exist a standard selection widget to accommodate extremely large data sets.

With our research, there are two main observable variables: User performance and user preference. Preference studies usually run hand in hand with performance. Many usability studies use a set of preference metrics to determine the goodness of the interface. R. Bailey conducted a survey comparing performance and preference metrics of various GUI experiments [2]. He claims interface engineers tend to use preference metrics to conduct a usability study, which generally ignores performance attributes. He further hypothesizes that both are equally

Figure 1.

A center justified item, left-oriented scroll bar, large sized list box with wide width list items experimental trial.

important and that one cannot be inferred from the other. Bailey reports numerous cases where preference data was not only asymmetrical with performance metrics, but in some cases, yielded inverted results.

Hypotheses

We expected that list item justification and list box scroll bar orientation would be related for item selection time and preference of list box layout. That is, left-justified items would be selected faster and preferred more when using a left rather than a right-oriented scroll bar. Similarly, right-justified list items would be selected faster and preferred more when using a right rather than a left-oriented scroll bar.

We conducted an experiment to test this hypothesis. The experiment examined list boxes with high experimental control. We used color blocks as list items so that we could assess the effects of item size and list box width as well as item justification and scroll bar orientation. We had no hypotheses concerning list box size or list item width – these factors were exploratory.

Experiment

Twenty-eight subjects voluntarily participated. The subjects were students in a fourth year (senior) Computer Science course on Human Computer Interaction, at California State University Northridge. The experiment was conducted on the second day of the class. All subjects were experienced computer users, were familiar with GUIs and were right handed. Eighty six percent of the subjects were familiar with Microsoft Windows. The remaining were evenly divided between other GUIs (Macintosh, Motif, Solaris, etc.). None of the subjects were familiar with NeXTSTEP, thus had little experience using list boxes with left-oriented scroll bars. Approximately 25% of the subjects had experience with languages that are read from right to left.

There were four factors in this experiment: item justification (left, centered, or right), scroll bar orientation (left or right), list box size (small 25% or large 75% of list box), and list item width (narrow 25% or wide 75% of the list box width). The experiment was controlled through an interactive computerized task. The experiment measured the subject's performance by evaluating their ability to complete a set of tasks. Each task displayed a target color "block" item and a list box containing many different color block items. The target block was contained somewhere in the list of items beyond the first set of displayed distractor items. The subjects were required to use the scroll bar to search and select the same color block in the list box. To complete each task, the user was required to make a selection. Each search task was drawn from a pool of the four experimental variables (Figure 1). The system recorded response time and number of errors that occurred while conducting the tasks.

The experiment consisted of twenty-four (24) experimental trials (**O**:2 x **J**:3 x **S**:2 x **W**:2) sampled five (5) times summing to 120 trials per subject. The 24 trials were placed in a random order within each sample. The random ordering was chosen to reduce any fatigue or learning bias, and at the same time record at least one full set of trials before any experience effects were encountered. There were three (3) dependent variables: time, errors, and preference. Preference was assessed after the item selection task.

The dependent variables that were recorded for the item selection task were divided up into two mutually exclusive metrics. If a response time value was recorded, no error had occurred during that trial. Similarly, if an error was denoted, any time associated with that trial was not included as part of the time data. This technique was chosen because the time taken to arrive at a false response is not important. While the frequency of errors was not expected to vary in this experiment we did analyze error. The average of the correct item selection trials was used as the time variable. The preference task randomly displayed the twenty-four (24) experimental conditions to

			Item Justification		
Orient	**Size**	**Width**	Left	Center	Right
Left	Small	Narrow	4295 .06 2.68	4201 .05 3.21	4386 .06 3.32
Left	Small	Wide	4242 .04 1.96	4509 .06 2.14	4495 .04 2.61
Left	Large	Narrow	4161 .06 2.54	4797 .06 3.32	4858 .05 3.43
Left	Large	Wide	4397 .05 2.50	4543 .04 2.14	4739 .03 2.79
Right	Small	Narrow	4218 .04 3.25	4178 .05 3.11	4006 .03 2.29
Right	Small	Wide	4274 .07 2.32	4189 .05 1.89	4046 .06 1.71
Right	Large	Narrow	4740 .05 3.21	4385 .04 2.93	4419 .05 2.14
Right	Large	Wide	4647 .03 2.39	4795 .05 2.25	4536 .08 1.71

Table 1. Experiment 1 Means
(Time in msec., % of errors, preference - 1 is best)

Factor (df)	**F**
Orientation	
Multivariate, F (3, 25)	8.32 **
Time, F (1, 27)	5.86 *
Prefer, F (1, 27)	11.27 **
Size	
Multivariate, F (3,25)	16.62 **
Time, F (1,27)	50.58 **
Width	
Multivariate, F (3, 25)	37.85 **
Prefer, F (1, 27)	104.50 **
Justification x Orientation	
Multivariate, F (6, 22)	8.32 **
Time, F (2, 26)	8.11 **
Prefer, F (2, 26)	14.78 **
Justification x Width	
Prefer, F (2, 26)	6.08 **
Orientation x Width	
Error, F (1, 27)	6.58 *
Size x Width	
Prefer, F (1, 27)	5.74 *
J x O x W	
Multivariate, F (6, 22)	2.70 *
Prefer, F (2, 26)	4.64 *
J x O x S x W	
Multivariate, F (6, 22)	3.07 *
Time, F (2, 26)	4.02 *
Prefer, F (2, 26)	3.86 *
	* $p < .05$ ** $p < .01$

Table 2.
Experiment 1 Statistical Results

which subjects responded to the following question, "The style of this list box is _____ for selecting items within it." The rating was based on a five (5) point scale (Excellent, Very Good, Good, Fair, Poor) with excellent scored as one. Table 1 contains the mean item selection times, percent error, and preference ratings. Table 2 contains the significant statistical results. There was a significant two way interaction effect for error: list box width by scroll bar orientation. More errors were made for left-oriented scroll bars with narrow (5.7%) list items than wide (4.3%). More errors were made for right-oriented scroll bars for wide (5.7%) list items than narrow (4.3%).

Our hypothesized interactions of item justification with scroll bar orientation were obtained for both item selection and layout preference. Figures 2 and 3 illustrate that subjects were faster with, and preferred, similar item justification and scroll bar orientation. Right oriented scroll bars were both faster and preferred for centered justified list items.

Our within subject design was very powerful. We obtained two, three, and four way interactions incorporating item size and list box width that represent reliable but very small effect magnitudes. The four way interactions are shown in Figures 4 and 5. We cannot easily interpret the significant four way interactions. With respect to time the two way interaction appears to be slightly perturb by a generally faster selection with small list boxes relative to large. With respect to preferences the two way interaction appears to be slightly perturb by a general preference for wide list items over narrow. For both time and preference the largest differences between means is attributable to

the item justification by scroll bar orientation interaction. In general, subjects preferred wide over narrow list items.

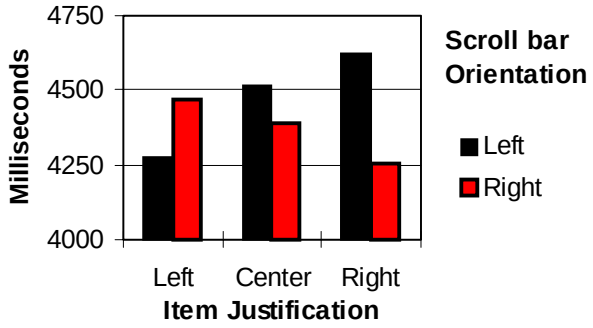

Figure 2.

Item justification by scroll bar orientation -- Times

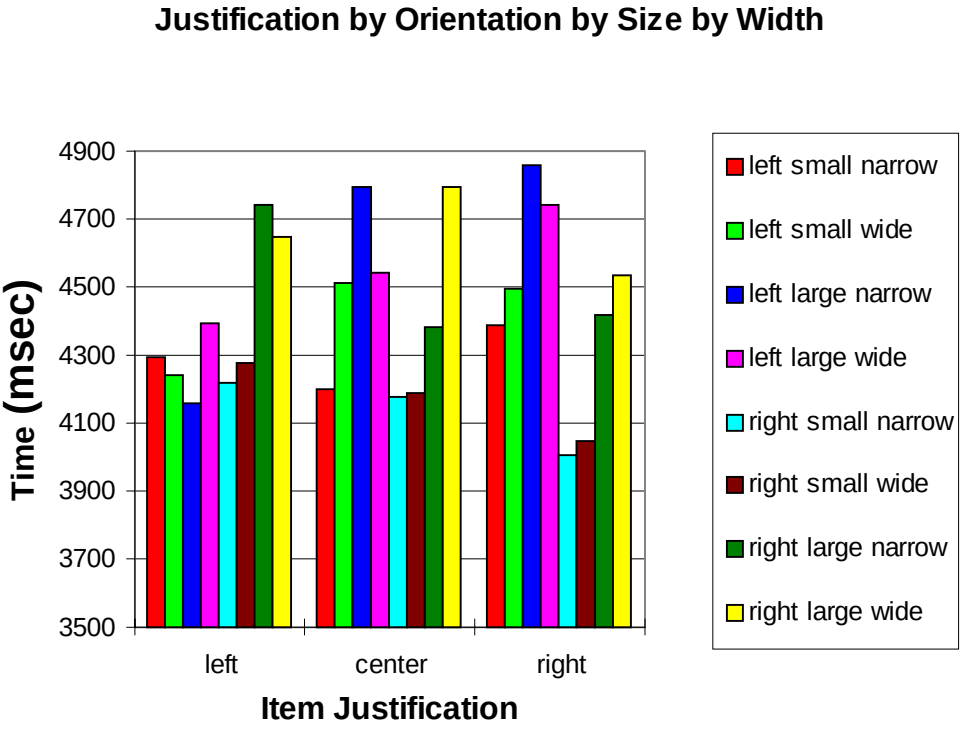

Figure 4

Four Way Interaction for item selection time

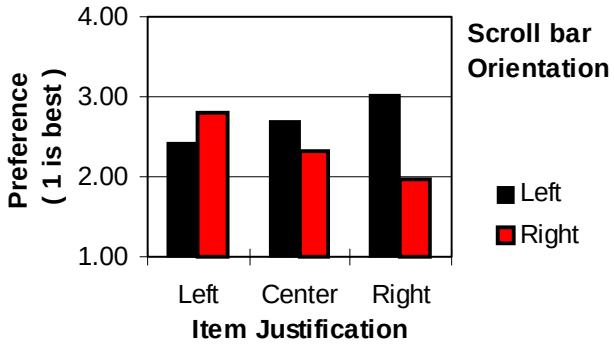

Figure 3.

Item justification by scroll bar orientation -- Preference

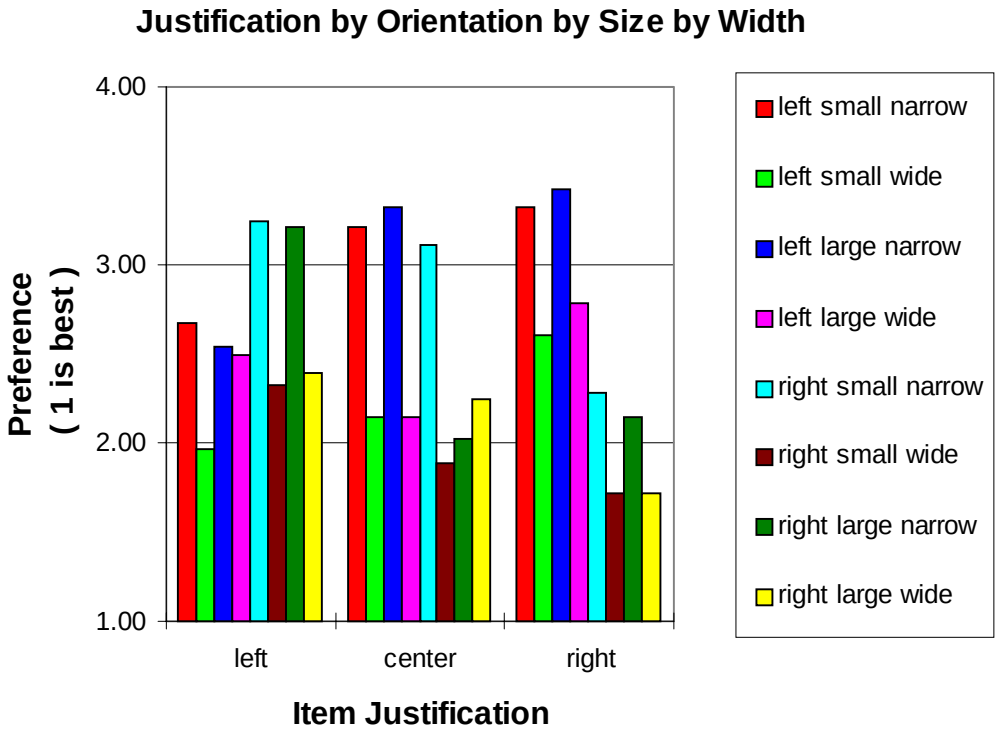

Figure 5

Four way interaction for preference judgment.

Discussion

List box designs have been implemented fairly consistently. In the past, there have been slight variations on a list box's implementation, for example, the advent of storing non-textual data in a list box widget (i.e. graphics, hierarchy trees, etc.) has grown in popularity. However, for the most part, the purpose of the list box has not changed, nor has it's control mechanisms (scroll bars). Traditionally, the list box is implemented with the scroll bars affixed to the right-side of the list box (right-oriented). Most data stored in a list box widget is textual and by convention, textual data is left-justified. This right-oriented scroll bar, left-justified list box item design has been widely adopted throughout the GUI community. Our research indicates users actually perform better with a different list box design than is commonly practiced.

Both user response time and user preference results indicate a significant bias towards like scroll bar orientation and list item justification (i.e., left-justification, left-orientation and right-justification, right-orientation). Conversely, users did not perform as well with opposite orientation and justification (i.e., left-justification, right-orientation and right-justification, left-orientation). These results suggest that a list box designed with a right-oriented scroll bar and left-justified data set are not configured optimally.

This research shows that list boxes are ambidextrous. Yet, list boxes in today's GUIs are not designed to accommodate this ambidextrous property. The results show that both right-oriented, right-justified and left-oriented, left-justified designs are preferable for a list box. One possible area for future research is to build an ambidextrous list box widget that changes its scroll bar configuration based on item content or a user's preference. Research on the ambidexterity of other GUI widgets (.e.g, combo boxes) should also be done. Today, the ongoing list box design debate about Apple's forthcoming Rhapsody system plays a commercial role in driving future directions of this research.

Given our results we suggest the following design guidelines for list box widgets:

- Consider using left-oriented scroll bars with left-justified items.
- Consider using right-oriented scroll bars with right-justified items.
- As list item size increases in length and variability we strongly suggest you consider using left-oriented scroll bars with left-justified items. This should increase speed and user satisfaction and reduce errors.
- Try to keep the list item size as small as the semantics of your application allows.

Conclusion

From this research, we have found that users interact with a list box in an ambidextrous manner. They respond faster and prefer a list box with like orientation and justification (i.e., left-oriented, left-justified and right-oriented, right-justified). The results indicate users respond similarly regardless of data types (e.g., color bars or text) stored in the list box. Interestingly, we've identified that most GUIs today implement a list box with a design that is not effective, given our results. Surprisingly most GUIs implement a list box with a left-justified data set (i.e., standard text justification) and a right-oriented scroll bar. Our research has a particular relevancy to the GUI design process for Apple's upcoming new operating system Rhapsody. If future research with the ambidextrous properties of GUI widgets can uncover a stronger tie between user performance and preference, then all users could benefit from a more flexible, satisfying GUI.

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