Static and Personalized User Interface

Kai Wu
Electrical and Computer Engineering Department
imkaywu@gmail.com

ABSTRACT
This report discusses three key research issues regarding static and personalized user interface: 1). can personalized interface be better than the static counterpart; 2). what kind of personalization is better: adaptable or adaptive; 3). what factors contribute to a successful Adaptive User Interface (AUI). In order to answer these three issues, we first make a theoretical and empirical comparison between static and personalized user interfaces. Then we compare adaptable and adaptive interfaces using an empirical study and a debate. Lastly, the factors that make a successful AUI is investigated. This is an detailed report discussing the pros and cons of static and two kinds of personalized interfaces, and design factors and choices to a successful interface.

Author Keywords
Personalization; Adaptive User Interface; Adaptable User Interface; Static User Interface; Split Menu

INTRODUCTION
The user interface is considered as one of the key components of software applications since it connects the end-users to the functionality. Some interfaces intend to fit as many people as possible, such as ”design for all” [8] technique. This ”one design fits all” approach is unable to accomodate individual differences and the variability in the context of use. Therefore, people turned to personalized/customizable interfaces.

There are generally three issues that needed to be answered in order to design and implement a successful personalized user interface: 1). Is it possible to design a personalized/customizable user interface that is better than the static one. 2). which personalization is preferred - adaptive (system-driven adaptation) or adaptable (user-driven adaptation). 3). what factors contribute to the success of the adaptive user interface.

STATIC VS. PERSONALIZED INTERFACE
Just because personalized interface can accomodate individual differences and is generally desired by people doesn’t necessarily indicate that it’s superior or preferred. It’s simplistic to assume that personalized interfaces will necessarily cure more ills rather than introducing new ones. The theoretical arguments and empirical studies are compared and discussed to determine the pros and cons of each interface.

Arguments for Static Interface
1. The user will be familiar with a fixed interaction style [4].
2. A static interface makes users skills portable across systems [4].
3. Reduce learning time [4].
4. Easier to implement and costs less [4].

Arguments for Personalized Interface
1. One interface cannot possibly meet every user’s needs. Users tend to use different functions from one another, user interface should be personalized [4].
2. Only a small fraction of functions are used. A personalized interface makes the access easier [1].

Arguments for Adaptable Interface
1. Users probably know more about what the interface should look like [4].
2. Users can have appropriate control of the system [7].
3. Users don’t have time or skill sets to configure their own interfaces. Naive and casual users may find it difficult to learn how to modify their environment. There is a trade-off between the setup overhead the user is willing to accept and the work he/she wishes to accomplish [3].

Arguments for Adaptive Interface
1. Can increase user performance by reducing a user’s mental and physical workload [4].
2. The user may not be able to develop a coherent model of the system if the system changes frequently [5].
3. The users may experience a loss of control or the feeling of loss of control when using a dynamic adptive user interface [5].
4. Dynamics of user-system concurrent modelling [3].
5. Difficulty in implementation, inaccuracies of model construction [3].

The above are the theoretical arguments for the two kinds of interfaces. But theoretical arguments alone aren’t strong enough to support any statement because there is a gap between the perceived and measured benefits and costs [2]. Here are three empirical studies investigating the user performance of the two kinds of interfaces, which can give us some insights of which interface is actually preferred by users.

Study 1: Static vs. Frequency-based Adaptive Interface
This work done by Mitchell and Shneiderman investigated user performance using static and frequency-based adaptive

menu system [4]. In the static menu, menu items are organized in traditional alphabetical way whereas in the adaptive menu, items are dynamically reordered based on the frequency of selection. The researchers conducted a **2** (Interface type: static or adaptive) by **2** (order: static first or adaptive first) factorial experiment with interface type as within group IV and presentation order as between groups IV. User productivity was used to assess the effect of dynamic menu which was measured by elapsed time to complete each task and number of errors made and corrected during each task. The result showed that menu ordering didn't have a significant impact on the average number of operations required. Nor were subjects more or less likely to make errors using one of the menu ordering styles.

Study 2: Static vs. Frequency-based Adaptive Interface vs. Split Menu

Sears and Shneiderman developed a new adaptive menu called split menu [6], as is shown in Figure 1. It was created by splitting a menu into two sections. The system places frequently selected items in the top section and infrequently selected items in bottom section. The menu items in each section are organized in the traditional order (e.g. alphabetical, chronological ordering etc.).

The first experiment was two **in situ usability studies** conducted at UMD and NASA. The purpose of this study was to demonstrate the potential advantages of split menus applied to daily tasks. The result showed that split menus resulted in faster mean selection times for each menu and several individual fonts. Besides, subjects consistently rated split menus better than the traditional alphabetic menus.

The second experiment was a controlled lab experiment asking subjects to perform menu selection as quickly and accurately as possible. Three interfaces, alphabetical, frequency-based and split menu, were used to validate that split menus can result in faster selections. Three frequency distribution were explored, as shown in Figure 2: Distribution One had the frequently selected items near the bottom of the alphabetic menu; Distribution Two had the frequently selected items near the middle of the alphabetic menu; Distribution Three had the frequently selected items near the top of the alphabetic menu. A **3** (Interface Type) by **3** (Frequency Distribution) within subject experiment was conducted. The result of mean selection times showed that there was a significant main effects for interface type and frequency distribution as well as a significant interaction between interface type and frequency distribution. Subjects consistently rated split menus the best, alphabetic second best and frequency-based menus worst. Even though alphabetic menus were slower than frequency menus for two of the three frequency distributions, users didn't like the unpredicatability of the frequency-based menus.

Study 3: Personalized vs. Non-personalized Phone Number Directory

This work done by Greenberg et al. was conducted in a hope of providing strong and quantitative evidence to support either AUI or the objections [3]. The interface of interest, a telephone number directory, exhibits a repetitive pattern of access which can be modelled as Zipf distribution, as shown in Figure 3. Such a distribution seems to encourage adaptive interface because there is an opportunity to give preference to items that have higher frequencies.

The menu system comprises a list of ranges of names. Upon selected, the range is further divided into subranges and the process repeats until the user selects a name. The access/selection frequencies are used to divide the probabilty distribution into approximately equal portions. So higher frequency names, appear on the higher-level menu while less frequently names appear on the lower-level menu, as shown in Figure 4.

The researchers conducted a **2** (adaptation type) by **2**(order) foctoral design as shown in Figrue 5. The dependent measures are scanning time per trial/menu and error rate per trial/menu. Scanning time per trial is the time between the appearance of the first menu and the successful location of the name in the final menu. Scanning time per menu is the time between the appearance of a menu and the successful location of the range containing the name in that menu. Error per trial/menu is the percentage of selection errors made during a given trial/menu. The result showed that adaptive directory has a significantly faster trial completion time and fewer errors per trial than the static directory. At menu level, subjects made fewer errors per menu in the adaptive system than in the static one. Most subjects preferred the adaptive directory scheme because it required shorter search paths.

Discussion

From the three empirical studies above, We can come to the conclusion that the personalized interface is better than the static one if correct adaptation techniques are utilized. The disparity between the results from Study 1 and 2 indicates that frequency information alone is not sufficient, which explains why the frequency-based AUI performed worse than static interface in the Study 1. The reasons of failure are "lack of consistency" and "a sense of loss of control" [5] which will eventually lead to loss of confidence of the system.

ADAPTABLE VS. ADAPTIVE INTERFACE

We are clear now that personalized interfaces are preferred by users and it's possible to come up with successful and useful ones if reasonable strategies are utilized. The next issue is what kind of personalized interface works better?

There are generally three ways to personalize the user interface. First, a system designer or administrator listens to feedback from the user and adjust the system to fit the current needs. Secondly, there is adaptable interface (user-driven customization) in which users can modify the environment themselves. Unfortunately, there is a trade-off between the setup overhead the user is willing to accept and the work he/she wishes to accomplish. Naive and casual users may also find it difficult to learn how to modify their environment. Thirdly, there is adaptive interface (system-driven customization) in which the system monitors the user's activity and tries to adapt dynamically and automatically to the user. Though accurate prediction can increase user's productivity and decrease mental and physical workload, the system's "random" behavior and spatial instability may confuse users and leave a sense of loss of control [3]. The first approach works well for certain applications and user group, the latter two approaches are likely the only scalable ones to personalization [10].

Empirical Study: Static vs. Adaptable vs. Adaptive

This is the first empirical study comparing the adaptable and adaptive interaction techniques done by Findlater and McGrenere [1]. The measured and perceived efficiency of three menu systems: static, adaptable and adaptive are compared in a controlled lab study. The interface was split menu, in which the top four items were static, adaptable by the subject or adapted according to the subject's frequently and recently used items, as shown in Figure 6. Specifically, two items in the top section were frequency items and two are recency items.

The researchers first simulated a real-world task using real menus and selection data. But considering real task scenario might help subjects achieve higher performance. In order to eliminate the effect of task scenario, the task was set as a sequence of menu selections. Menus were masked using different labels to avoid transfer effects. Three schemes were created by permuting the order of the menu and assigning different mask. Both quantitative and qualitative measures including speed, error rate and a poll-style questionnaire.

A **3** (menu type) by **3** (scheme) within-subject factorial experiment was conducted. The result showed that there was no significant main, interaction, or ordering effects of scheme. The adaptive menu was slower than the static menu but the adaptable was not slower than the static one except when subjects used the adaptable menu first. Subjects preferred the adaptable menu to the static one, but not to the adaptive menu.

This study showed that users can customize the interface efficiently once the customization mechanism is easy to use, or the value of customization is recognized. Though the measured performance is highest when using the static menus, subjects perceived themselves to be most efficient using the adaptable interface and showed higher overall satisfaction.

A debate: Direct Manipulation vs. Interface Agents

There has been some debate in the HCI community as to which of these two approaches is better [7]. One side argues that the goal of interface design is to create environments where users comprehend the display, where they feel in control, where the system is predictable, and where they are willing to take responsibility for their actions. The other side believes that due to the open, dynamic nature of this networked and unstructured information and the fact that we are dealing with untrained instead of professional users, the right adaptive algorithm can be utilized to help users focus on their tasks, rather than on managing their tools.

Discussion

Even Professor Shneiderman, a hard-core propnent of direct manipulation conceded that *increased automation is desired as long as it can increase user's productivity* which showed that the automatic adaptation is a goal worth pursuing. Professor Maes emphasized that the reason why there was disagreement was that the two sides actually focused on different problem domains: what Professor Shneiderman was interested in was well-structured information domain with professional users whereas what Professor Maes was interested in was dynamically chaning, unstructured information domains with untrained user. This statement can be interpreted as these two adaptation strategies are better suited for different applications and domains.

Therefore, instead of debating which interface triumphed, it's more important to consider which interface would be better suited for a specific application or under a certain circumstance. Since performance enhancement is the ultimate goal of interface design, we shouldn't champion one interface while disregarding the other's merits completely.

FACTORS MAKE A SUCCESSFUL AUI

Now we've seen both successful and unsuccessful adaptive interfaces which inevitably leads to the final issue: what factors contribute to the success of the AUI.

Study 1

This study done by Gajos et al. tried to understand those aspects of adative interfaces which make some of them successful and others not [2]. The researchers designed three adaptive interfaces: Split Interface which copies important functions onto a designated toolbar in a spatially stable manner, Moving Interface which moves promoted functionality from inside popup panes onto the main toobar, Visual Popup Interface which highlights promoted buttons in magenta, as seen in Figure 7. They used two adaptation algorithms: frequency-based and recenty-based algorithm.

In the first experiment, the subject were asked to complete tasks mimic real-world activities. The study was a **4** (user interface type: no adaptation, Split, Moving, or Visual Popup) by **2** (adaptation algorithm: frequency or recency-based algorithm) by **3** (task) design, with user interface type and task as within-subject factors and adaptation as a between-subjects factor. Participant satisfaction ratings, overall preferences and task times are collected to evaluate the interfaces. The result showed that task times were not sensitive enough due to the heavy cognitive decision making. The analysis of satisfaction ratings showed there was a significant main effect for UI type which was caused by significantly higher ratings for the Split Interface when compared to either no adaptation or the Visual Popout condition. Users' perceived costs and benefits showed that the Split Interface was most beneficial and least costly whereas the Visual Popup Interface led to little benefit and higher cost.

In the second experiment, the tasks were changed to simply press buttons to reduce the cognitive complexity. Since no difference was found between two adaptation algorithms and Visual Popup Interface's inability to achieve high performance, these conditions were dropped in this experiment. Instead, prediction accuracy (30% and 70%) was added. The study was a **3** (user interface type: no adaptation, Split, and

Moving) by **2** (accuracy: 30% and 70%) within-subject design. The analysis of task times showed a significant main effect of UI type, accuracy and interfaction between accuracy and trial order (30% first or 70% first). The result of satisfaction showed that though users felt they were more efficient using both adaptive interfaces, it was easier to locate the functionality and less confusing to use in the static interface.

From this study, several factors that impact the success of AUI can be identified:

- **spatial stability**: the familiar parts of the interface was not altered.
- **predictive accuracy**: the more useful the resulting adaptations, the more likely it is that users will take advantage of the adaptations.
- **frequency of adaptation**: high frequency effectively reduces the system's predictabilty.

Study 2

This work done by Tsandilas et al. was an empirical study that examined two adaptative interfaces/adaptation techniques in isolation from any particular adaptation mechanism [9]. The researchers controlled the accuracy of the suggestions and examine the performance of the adaptative interfaces with respect to that accuracy. The interfaces of interest were shown in Figure 8: the first technique simply highlights suggested items by changing the background color, the second one shrinks non-suggested items in addition to highlighting items.

For each task, subjects were asked to select the goal item from a list of 50 items. Four or eight items are highlited using either the NORMAL or SHRINK technique. The goal item was either included or not included in the highlighted items with respect to adaptation accuracy.

A **3** (adaptation accuracy: 100%, 80% and 60%) by **2** (adaptation technique: NORMAL or SHRINK) by **2** (number of system suggestions: 4 or 8) within-subject design was conducted. The dependent variables included: 1) time *BlockTime* to complete a block, 2) time *SuggestedTime* to complete a task when the goal item had been highlighted, 3) time *NonSuggestedTime* to complete a task when the goal item had not been highlighted. The result showed that accuracy had a significant effect on *BlockTime* and *SuggestedTime*. There was a significant interaction effect between accuracy and adaptation techniques - SHRINK technique was slightly faster when accuracy was 100%, but degraded faster than that of NORMAL when accuracy decreased. Besides, SHRINK technique resulted in a large number of errors when the accuracy was imperfect.

From this study, we concluded that the effectiveness of the adaptation techniques are affected by the accuracy of the prediction, which aligned with the conclusion from Study 1.

Discussion

From the two studies, we can conclude that spatial stability, predictability (accuracy of the suggestion), frequency of adaptation are the key factors to design a successful AUI.

CONCLUSION

From the three issues of interest and the detailed paper review, we come to the conclusion that personalized interface is a better solution to accomodate individual differences when suitable adaptation techniques can be implemented. As the most promising and scalable ways of personalization, both adaptable and adaptive interfaces have their own advantages and specific domain of application, therefore should be investigated seperately or hopefully combined together to come up with more novel interfaces. Lastly, there are some general guidelines, like spatial stability and predictability, to follow in order to design a useful AUI.

FUTURE WORK

More research should be done to bring together the advantages of both adaptable and adaptive interfaces to design a user-customizable and system-adaptive interface to better enhance user's performance. The aforementioned studies of adaptive user interface and design factors mainly focus on menu system. This dynamic and adaptive nature of AUI should be introduced to broader range of interfaces' design. In order to achieve this goal, more research has to be done to discover user reaction to more general adaptive interfaces and develop more sophisticated adaptation algorithms.

REFERENCES

1. Leah Findlater and Joanna McGrenere. A comparison of static, adaptive, and adaptable menus. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 89–96. ACM, 2004.

   This paper conducted empirical studies to examine whether an adaptable approach to personalization is better than a system-controlled adaptive approach or not. Three menu conditions (static, adaptable and adaptive) were implemented as a split menu and compared. The result showed that static and adaptable interfaces were significantly faster than the adaptive one and the majority of users preferred the adaptable menus overall.

2. Krzysztof Z Gajos, Mary Czerwinski, Desney S Tan, and Daniel S Weld. Exploring the design space for adaptive graphical user interfaces. In *Proceedings of the working conference on Advanced visual interfaces*, pages 201–208. ACM, 2006.

   This paper tried to isolate and understand the factors that made an AUI successful. Three adaptive interfaces were implemented and evaluated in two experiments along with a non-adaptive baseline. The results were synthesized with previous work and design factors and choices that affect the success of AUI were discussed.

3. Saul Greenberg and Ian H Witten. Adaptive personalized interfacesa question of viability. *Behaviour & Information Technology*, 4(1):31–45, 1985.

In order to provide strong and quantitative evidence to support either AUI or the objections, this paper conducted an empirical study using the task of entires retrieval from a large ordered telephone directory. An 2 by 2 mixed factorial study was designed and the result supported the use of AUI. Though it didn't necessarily generalize to other interfaces, the result supplies evidence to refute the objections to AUI in general.

4. Jeffrey Mitchell and Ben Shneiderman. Dynamic versus static menus: an exploratory comparison. *ACM SIGCHI Bulletin*, 20(4):33–37, 1989.

   This paper compared user performance of static and frequency-based adaptive menu systems using the task of menu selection. The subjects in the adaptive menus first condition was significantly slower than did subjects in the static menus first condition. Menu ordering style did not have any significant effect on the average number of operations required. Nor were subjects more or less likely to make errors using one of the menu ordering styles.

5. AF Norcio and J Stanley. Adaptive human-computer interfaces. Technical report, DTIC Document, 1988.

   This report presented a survey of recent research in adaptive interface computer software as well as a discussion of factors that require consideration in designing this software. An adaptive interface needs to include a knowledge base that encompasses four domains. These four domains are knowledge of the current user, knowledge of the interaction scheme, knowledge of the problem task, and knowledge of the underlying system. This report reviewed and discussed these knowledge bases along with the positive and negative aspects of adaptive interfaces.

6. Andrew Sears and Ben Shneiderman. Split menus: effectively using selection frequency to organize menus. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 1(1):27–51, 1994.

   This paper developed and applied a new adaptive interface called Split Menu, which was implemented and tested in two in situ usability studies and a controlled experiment. In the usability studies performance times were reduced by 17 to 58% depending on the site the menus. In the controlled experiment, Split Menu was significantly faster than alphabetic menus and yielded significantly higher subjective preferences.

7. Ben Shneiderman and Pattie Maes. Direct manipulation vs. interface agents. *interactions*, 4(6):42–61, 1997.

   This is a transcript of a debate between Professor Shneiderman who was a hard-core proponent of direct manipulation of user interface and Professor Maes who was a believer of software agents, which was adaptive and could act according to the user's preference and behavior. Professor Shneiderman thought though it was important to accomodate individual differences, it was more important to create a predictable interface that maked users feel in control and take responsibilty of their action. Professor Maes's point was that due to the dynamicly changing and unstructure information domain we were facing (WWW), direct manipulation would have to give way to softwar agents one day.

8. Constantine Stephanidis. Towards the next generation of uist: Developing for all users. *Advances in human factors/ergonomics*, pages 473–476, 1997.

   This paper discussed design requirements and criteria for developing interactive computer-based applications and telematic services accessible by different user groups, including disabled and elderly people, in the context of the emerging Information Society. To this effect, recent contributions towards user interfaces for all are reviewed and an HCI research and practice agenda is discussed.

9. Theophanis Tsandilas et al. An empirical assessment of adaptation techniques. In *CHI'05 Extended Abstracts on Human Factors in Computing Systems*, pages 2009–2012. ACM, 2005.

   This paper presented an empirical study that examined two adaptation techniques (NORMAL or SHRINK) applied on a menu system. User performance was measured controlling the accuracy of the suggestions made by the adaptive user interface. The result indicated that different adaptation techniques were affected differently by the accuracy of the adaptation.

10. Daniel S Weld, Corin Anderson, Pedro Domingos, Oren Etzioni, Krzysztof Gajos, Tessa Lau, and Steve Wolfman. Automatically personalizing user interfaces. In *IJCAI*, volume 3, pages 1613–1619, 2003.

    This paper surveys a decade's work on customization and adaptation at the University of Washington. Automatic personalization may greatly enhance user productivity, but it requires advances in user-initiated customization and interface-initiated adaptation. In order to improve customization, we must make it easier for users to direct these changes. In order to improve adaptation, we

must better predict user behavior and navigate the inherent tension between the dynamism of automatic adaptation and the stability required in order for the user to predict the computers behavior and main- tain control.

APPENDIX

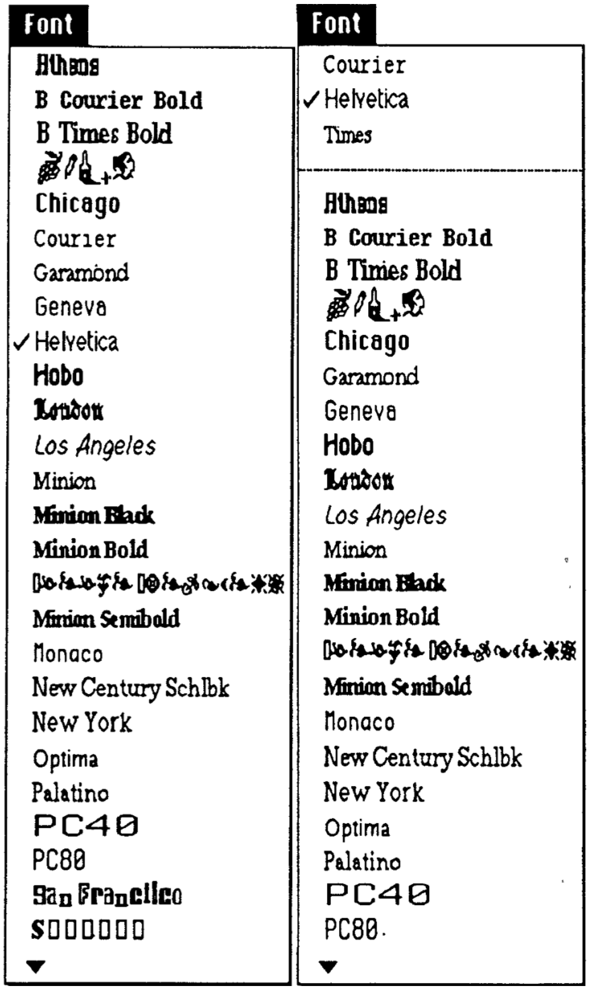

Figure 1: Left: static menu; Right: split menu.

Alphabetic		Split		Frequency	
Item	f(x)	Item	f(x)	Item	f(x)
1	2	11	24	11	24
2	4	13	20	13	20
3	0	15	16	15	16
4	8	1	2	4	8
5	2	2	4	8	8
6	2	3	0	12	6
7	4	4	8	2	4
8	8	5	2	7	4
9	0	6	2	1	2
10	2	7	4	5	2
11	24	8	8	6	2
12	6	9	0	10	2
13	20	10	2	14	2
14	2	12	6	3	0
15	16	14	2	9	0

Alphabetic		Split		Frequency	
Item	f(x)	Item	f(x)	Item	f(x)
1	2	6	24	6	24
2	4	8	20	8	20
3	0	10	16	10	16
4	8	1	2	4	8
5	2	2	4	13	8
6	24	3	0	12	6
7	4	4	8	2	4
8	20	5	2	7	4
9	0	7	4	1	2
10	16	9	0	5	2
11	2	11	2	11	2
12	6	12	6	14	2
13	8	13	8	15	2
14	2	14	2	3	0
15	2	15	2	9	0

Alphabetic		Split		Frequency	
Item	f(x)	Item	f(x)	Item	f(x)
1	24	1	24	1	24
2	4	3	20	3	20
3	20	5	16	5	16
4	8	2	4	4	8
5	16	4	8	8	8
6	2	6	2	12	6
7	4	7	4	2	4
8	8	8	8	7	4
9	0	9	0	6	2
10	2	10	2	10	2
11	2	11	2	11	2
12	6	12	6	14	2
13	0	13	0	15	2
14	2	14	2	9	0
15	2	15	2	13	0

Figure 2: Top: Distribution One; Middle: Distribution Two; Bottom: Distribution Three.

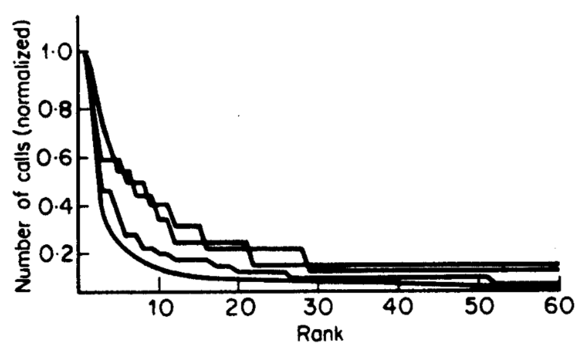

Figure 3: Sample distributions of personal telephone usage, compared with Zipf.

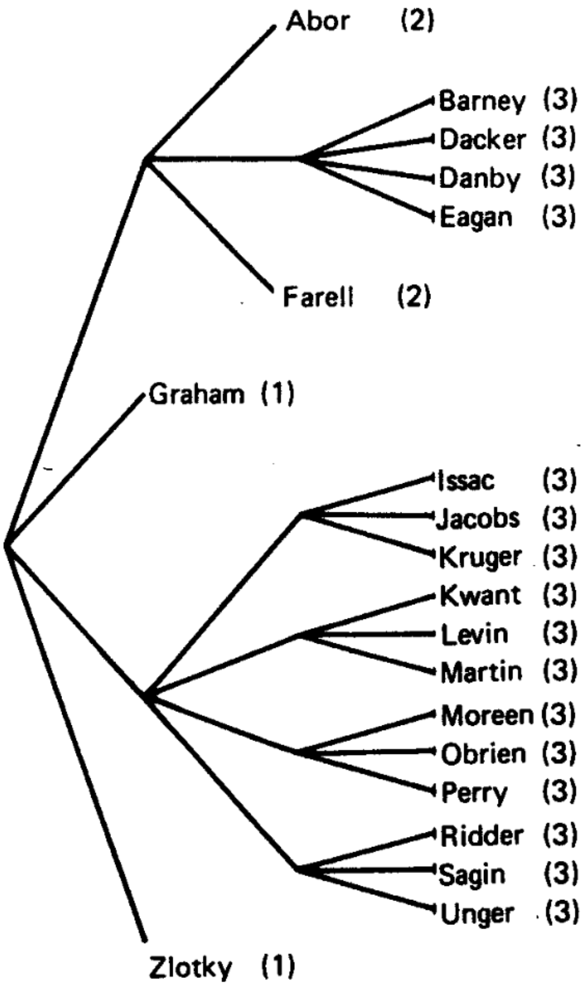

Figure 4: Menu tree reflecting popularity of items.

		Order	
		Adaptive first	Static first
Adaptation type	Adaptive	S1–13	S14–26
	Static	S1–13	S14–26

Figure 5: Mixed factor ANOVA design.

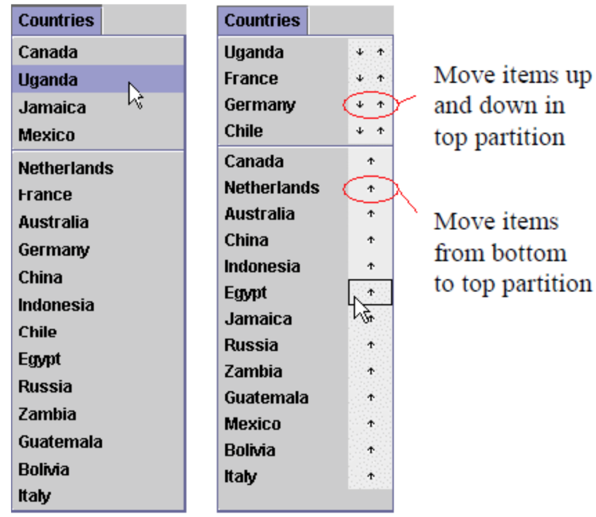

Figure 6: (a) Static split menu; (b) Adaptable split menu.

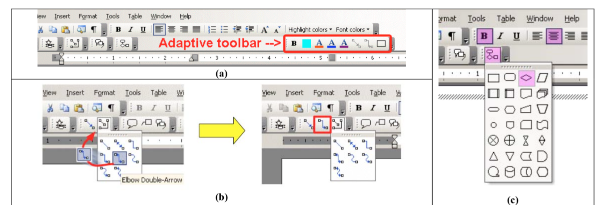

Figure 7: (a) The Split Interface; (b) The Moving Interface; (c) The Visual Popup Interface.

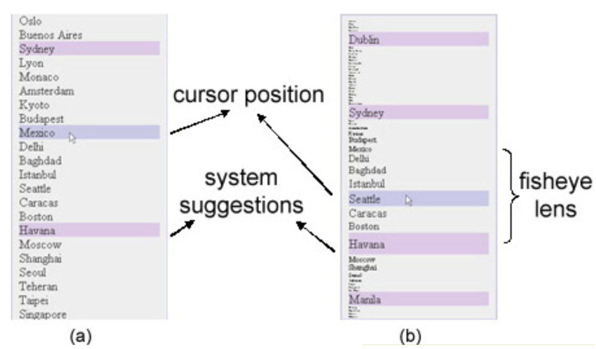

Figure 8: (a) Highlighting suggestions (NORMAL); (b) Shrinking non-suggested items (SHRINK).