A Dynamic User Adaptable Menu System:
Linking it All Together

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Abstract

Creation and traversal of links in a user adaptable menu was examined for syntagmatically and
paradigmatically related targets. One group searched for paradigmatic related targets within the
same intermediate category under different superordinate categories, while another searched for
syntagmatic related targets belonging to different intermediate categories under the same
superordinate. Users with syntagmatic targets created and traversed more superordinate category
links, while users with paradigmatic targets traversed more intermediate category links. As
predicted, more horizontal links at the same hierarchical level were created and traversed than
diagonal links joining different levels. Overall, users tended to create links forming hierarchical
networks.
Introduction

Dynamic menus, user adaptable and self-adapting, are more flexible than traditional fixed menus. In a user adaptable menu, the user could customize a menu structure to facilitate patterns of menu selection [2]. User created paths may facilitate navigation through the menu system by making them more distinctive, memorable and comprehensible. Alternatively, a self-adapting menu system could rearrange its structure based on previous user interactions so that frequently selected items are more accessible [1,4]. However, self-adapting menus may become maladaptive, since repositioning of the menu items by the system can confuse user [8]. The present paper examines the creation and traversal of links in a user adaptable menu in terms of patterns of menu selection.

Searching for Menu Items

A Syntagmatic-Paradigmatic model specifies two relation types among objects: syntagmatic and paradigmatic [6]. Syntagmatic relations involve items belonging to different categories. For example, the selection of a Yankee seafood dinner:

You'd like a traditional Yankee seafood dinner. A nice ice cold alcoholic beverage which isn't a mixed drink or wine. You want something before the entree that's not fried, baked or stuffed. You want to order Draft Beer, Steamed Shrimp, Alaskan King Crab, and Cole Slaw.

The targets belong to different intermediate categories (drink, appetizer, seafood & vegetable) under the same superordinate *American Fare*. Frequent syntagmatic menu selections may favor placing new links either between different intermediate categories within a superordinate category or between superordinate categories in a user adaptable menu.
Paradigmatic relations describe the relationship between two objects belonging to the same category. For example, a script directing a menu selection task emphasizing paradigmatic relations involving four drinks:

At a small reunion, four friends decided to buy some alcoholic beverages. They don't like wine or mixed drinks. Since you are buying this round, you order Draft Beer, Raffo™ Beer, Carta Blanca™ Beer and Tsingtao™ Beer.

All targets belong to the same intermediate category, but fall under different superordinate categories, American, Italian, Chinese, and Mexican cuisine. Frequent paradigmatically related selections may result in the creation of links between drinks together across superordinate categories in a user adaptable menu. Essentially, syntagmatic relations are involve relationships between items under different categories, while paradigmatic relations describe relationships between items within the same category.

**Menu Structure**

Categorical organization may be described by a hierarchical tree. Suppose there were three different levels in the tree: the superordinate categorical level at the "root" node, the intermediate categorical levels and the exemplar level at the terminal nodes [7]. Paradigmatic relations in fixed hierarchical menu trees requires a vertical traversal of these levels of categories from superordinate categories to exemplars. When the user of a paradigmatic structure needs to select two items that are related syntagmatically across different categories, the user must pop-up one or more categorical levels to the parent node and go down toward the target node in order to traverse to an adjacent sibling node. If the users' task emphasizes syntagmatic relations, while the menu reflects a designer's paradigmatic relations among items, the users' navigation through the system may be cumbersome.

There are three possible links in the matrix describing a hierarchial organization of categories: vertical, horizontal, and diagonal. Vertical links joins hierarchically related items and categories from different levels of the hierarchy. A user adaptable menu allows the user to the create horizontal links to traverse to adjacent sibling nodes. A horizontal link across vertical boundaries of the hierarchical tree would facilitate the search for items under different superordinate categories. Horizontal links between related nodes creates a structure resembling a hierarchical network. Nodes may also be linked diagonally so that hierarchically unrelated exemplars or categories may be connected.
Horizontal Links

Horizontal linkages may reduce the number of vertical traversals (See Figure 1). Horizontal superordinate links, linkages between a small number of superordinates (eg. American & Italian), bypass most nodes (a & b). Horizontal intermediate links, connections between intermediate categories (eg. American and Italian drinks), may facilitate paradigmatic menu searches (c & d). Horizontal exemplar links, connections among exemplars (eg. draft beer and Raffo™ beer), increase access to a group of frequently selected items (g & h). If all the horizontal links between similar superordinate and intermediate categories were created, the resulting structure would resemble a hierarchical tree with the terminal nodes linked to their adjacent node. These linkages would serve to reduce the number of intervening nodes that must be traversed between the source and destination nodes.

Figure 1. A Linear structure menu with horizontal and diagonal links.

Diagonal Links

There are three types of diagonal links (See Figure 1). Diagonal superordinate-exemplar links (a & l) connect superordinates to exemplars that are not encompassed by that superordinate category. Diagonal intermediate-exemplar links (e & m) links an intermediate category to an instance belonging to another category. Diagonal superordinate-intermediate links (b & f) connect superordinate and intermediate categories that are not hierarchically related.

In the present study, a hierarchical organization is flattened into the format of a linear sequential menu structure (See Figure 1). Connections between the superordinate categories
(a & b), intermediate categories (c thru f) and exemplars (g thru n) are not present since they are presented all on the same menu frame contiguously (See Figures 1 & 2). The levels of the hierarchy are presented as indentures of text like that of an index. Traversal in this linear menu structure is like turning pages in a book. When links between superordinates, intermediates and exemplars are allowed in a link adaptable menu, both horizontal and diagonal linkages result in a hierarchical network. Creating only the horizontal links between similar superordinate and intermediate categories would result in chains of links to form a hierarchical tree with the terminal nodes linked to their adjacent node. Overall, these links shorten the number of nodes traversed, thereby pruning the structure.

The initial menu structure contains preexisting horizontal links (left and right arrows) connecting different adjacent intermediate categories (e.g. drink & appetizer) on different nodes under the same superordinate, which facilitate search for those given syntagmatic related targets. Consequently, users given paradigmatically related menu targets were expected to create more horizontal links than users given syntagmatically related targets. Although diagonal links could effectively link the same nodes (e.g. pages 1 & 2 to 5 & 6), the proportion of horizontal links were predicted to greater than the proportion of diagonal links, since horizontal links would create a more hierarchical structure which would facilitate search for both paradigmatically and syntagmatically related items. Horizontal links would allow traversal of the linear menu structure by categories or exemplars at the same level of the hierarchy. Horizontal intermediate categories were expected to be the most frequently created and traversed compared to horizontal superordinate and horizontal exemplar links. The paradigmatic group was expected to create horizontal links joining categories with the same names at the intermediate category level across different superordinate categories. For example, drinks under American fare were predicted to be connected to another category also called drinks under a different cuisine such as Mexican fare. The syntagmatic group was expected to create horizontal links between categories of different names within the same superordinate category and between different superordinate categories. Lastly, altered menu structures were expected to resemble a hierarchical network with chains of horizontal superordinate links and horizontal intermediate links.
Method

Subjects
Psychology students, 18 males and 30 females, participated for extra credit. Each subject was tested individually.

Materials
The computerized restaurant menu system, implemented on a Macintosh II™ in Hypercard™, had four superordinates: American, Italian, Mexican, and Chinese fares. Each cuisine had eight intermediate categories: drinks, soups, appetizers, beef, fowl, seafood, vegetables and desserts. Each category contained eight items for a total of 256 items. This 3 level hierarchical tree (4x8x8) was presented in a book format where superordinates, intermediate categories and exemplars appeared on the same page (See Figure 2). Each of the 16 screens had 2 pages. Each page listed an intermediate category and eight items. A superordinate category appeared every eight pages. For example, American Fare appeared on the first line of page one followed by, the category, drinks, and eight American drinks. On the opposite page, the American soups were listed with soups appearing on the first line. Successive pages had two intermediate categories appearing on opposite pages: appetizers and beef (pages 3 & 4); fowl and seafood (pages 5 & 6); vegetables and desserts (pages 7 & 8). This same pattern holds true for all superordinate categories.
### Procedure

Subjects were randomly assigned to either the paradigmatic or syntagmatic groups. Both groups first used a fixed menu followed by a user adaptable menu. Subjects learned to use a mouse to select menu items in a practice problem. Then, subjects searched for 32 items specified in 8 randomly presented scripts in the fixed menu system. These search tasks served to give users: experience performing paradigmatic or syntagmatic menu selections and familiarity with the menu. Next, they learned how to reorganize the menu structure with links in the user adaptable system. They then were instructed to reorganize the menu by creating additional links to facilitate menu searches. They had as much time as needed to create as many as they wanted. However, they were not allowed to delete any links. Subjects again searched for 32 menu items in 8 randomly presented scripts in the link adaptable menu.

The paradigmatic group read scripts specifying four targets within the same intermediate
category belonging to different superordinate categories, while the syntagmatic group read scripts specifying four targets belonging to different intermediate categories in the same superordinate category. Scripts were presented before each search and appeared in a window continuously during the search task. Subjects selected items by clicking on the box to place a checkmark next to the item. They completed each problem by clicking on the order button. At the bottom of the screen, a left arrow flipped to the previous node, while a right arrow flipped to the next node. Double arrows next to menu items, created by the user, allowed traversal across several nodes. All menu selections times were recorded, but will not be discussed.

**Results**

Link creation and traversal was examined in terms of proportions of horizontal (superordinate-superordinate, intermediate-intermediate, exemplar-exemplar) and diagonal link (superordinate-intermediate, intermediate-exemplar, exemplar-superordinate) types with respect to two types of menu search tasks: syntagmatic and paradigmatic. An arcsin transformation normalized the distribution of all proportion data for all analyses of variance.

**Link Creation**

A repeated measures analysis of variance was performed to determine if there were differences in the proportion of the types of links of horizontal and diagonal links created in paradigmatic and syntagmatic groups (See Figure 3). As predicted, there were proportionately more horizontal links (90%) than diagonal (10%), $F(1,46)=193.15, p<.05$. Unexpectedly, the paradigmatic group, (95% horizontal, 5% diagonal) did not create more horizontal links than the syntagmatic group (84% horizontal, 16% diagonal), $F(1,46)=2.75, p>.05$. The simple main effects of types of horizontal links were examined. Syntagmatic users created more horizontal superordinate links than paradigmatic users, $F(1,46)=4.98, p<.05$. Syntagmatic and paradigmatic users' creation of horizontal intermediate and horizontal exemplar links did not differ, $F(1,46)=0.83, p>.05$ and $F(1,46)=3.07, p>.05$, respectively. Horizontal intermediate links linked more categories with the same name (93%) than different names (7%), $F(1,44)=277.93, p<.05$. Unexpectedly, paradigmatic users did not create more horizontal intermediate links with the same category names than syntagmatic users, $F(1,44)=2.27, p>.05$. 
Figure 3. Paradigmatic and syntagmatic groups' mean percentage of creating horizontal and diagonal links.

Almost half of the links created (paradigmatic=47% and syntagmatic=50%) were part of chain links (2 to 8 links in length). The proportionate distribution of chain links created by syntagmatic and paradigmatic groups did not differ, $F(1,46)=0.10$, $p>.05$. There was a greater proportion of horizontal chain links (41%) than diagonal chain links (0%), $F(1,46)=41.29$, $p<.05$ (See Figure 4). A significant simple main effect revealed differences among horizontal links: superordinate, intermediate and exemplar, $F(2,92)=9.31$, $p<.05$. A post hoc comparison using Newman-Keuls revealed that there was a greater proportion of horizontal intermediate chains than horizontal exemplar chains.
Mean Percentage of Links Chains Created

![Bar chart showing mean percentage of links chains created for Paradigmatic and Syntagmatic groups.](chart.png)

Figure 4. Paradigmatic and syntagmatic groups' mean percentage of horizontal chain links (2 to 4 links in length).

**Link Traversal**

The following analyses consider users who traversed new links. Overall, 87.5% of the subjects (79% paradigmatic & 96% syntagmatic) traversed newly created links. Paradigmatic and syntagmatic users were compared by using the percentage of new link traversals out of the total number of traversals. Paradigmatic users (m=41%, sd=32) traversed new links more than syntagmatic users (m=23%, sd=23), F(1,40)=7.93, p<.05. A greater mean proportion of horizontal links (90%) were used more than diagonal links (10%), F(1,40)=104.4, p<.05. Examination of the horizontal links reveal that paradigmatic users traversed horizontal intermediate links proportionately more than syntagmatic users, F(1,40)=4.47, p<.05 (See Figure 5). However, syntagmatic users traversed horizontal superordinate links more than paradigmatic users, F(1,40)=5.01, p<.05. These users did not differ in traversal of horizontal exemplar links, F(1,40)=0.59, p>.05.
**Mean Percentage of Horizontal Link Traversal**

![Bar chart showing mean percentage of horizontal link traversal for Paradigmatic and Syntagmatic groups.](chart)

**Figure 5.** Paradigmatic and syntagmatic groups' mean percentage of traversal of horizontal and diagonal links.

### Discussion

**Summary of the Results**

Overall, as predicted, there were more horizontal links created than diagonal links as single links or a chain links. Approximately half of the new links were chained together. Comparison of the horizontal chain links revealed that there are proportionately more intermediate links than exemplar links. Most horizontal intermediate links joined categories with the same name. Unexpectedly, paradigmatic users did not create more horizontal intermediate links with the same category names than syntagmatic users. Unexpectedly, paradigmatic users did not create more horizontal links than syntagmatic users. Paradigmatic users created proportionately less horizontal superordinate links than syntagmatic users. Consequentially, paradigmatic users traversed horizontal intermediate links more than syntagmatic users, while syntagmatic users traversed horizontal superordinate links. Overall, a greater percentage of the paradigmatic users' traversals, those who traversed new links, were new links compared to syntagmatic users. These results suggest that both paradigmatic and syntagmatic groups tended to create chains of horizontal links at the superordinate and intermediate levels of the hierarchy forming a hierarchical network.
Link Creation and Traversal Strategies

Menu structure and traversal strategies may explain why a greater proportion of horizontal links were not created in the paradigmatic condition. If users started in cuisine different from the targets' cuisine, users needed traverse to another cuisine or superordinate. Thus, they connected superordinates together to make large jumps from one cuisine to the next. However, this entailed traversing to the node containing the superordinate. A more efficient strategy involved creating links between horizontal intermediate links belonging to different superordinates so that one could traverse directly from current node to another node containing the superordinate. Thus, syntagmatic users could traverse either horizontal superordinate links or horizontal intermediate links, while paradigmatic users mainly traversed horizontal intermediate links. The results suggest that syntagmatic users chose to create and traverse horizontal superordinate links more than horizontal intermediate links. The search tasks appeared to have a large impact on link creation and traversal.

Conclusion

Although diagonal links may have accomplished the same exact traversal patterns as horizontal links, users, overwhelmingly, created and traversed horizontal links more than diagonal links. Since most horizontal links and horizontal chain links were at the superordinate and intermediate categorical levels, users appear to rely heavily on the hierarchical structure of the categories to create and traverse links in user adaptable menus. These results correspond to the findings of a study of a hypertext system which found that 73% of the links created connected hierarchical nodes together or hierarchical nodes to individual cards, while only 7.5% were nonhierarchical referential links [5]. This study supports the contention than hierarchical links may facilitate navigation [3]. This study also suggests that customization of user adaptable menus may facilitate search for paradigmatic and syntagmatic related items.
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