A COMPARISON OF SYMBOLIC AND SPATIAL FILING

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Abstract

The traditional and still dominant form of object reference in computing systems is symbolic - data files, programs, etc. are initially labeled and subsequently referred to by name. This approach is being supplemented on some systems by a spatial alternative which is often driven by an office or desktop metaphor (e.g. Apple's Lisa and MacIntosh systems, or Bolt's 1979 Spatial Data Management System). In such systems, an object is placed in a simulated two- or three-dimensional space, and can later be retrieved by pointing to its location. In order to begin to understand the relative merits of spatial and symbolic filing schemes for representing and organizing information, we compared four ways of filing computer objects. We found location information to be of limited utility, either by itself or in combination with symbolic information. This calls into question the generality and efficacy of the desktop metaphor for information retrieval.

Introduction

The long dominance of paper as the medium for storing information is increasingly challenged by electronic storage. Advantages associated with the on-line storage of information derive, in part, from the speed and malleability of the electronic medium and, in part, from the application of the computer's processing power. An electronically-based object can be readily modified, formatted, and quickly transmitted from one place to the next. As computing software increases in its sophistication and range of applicability, and as hardware costs decline, we can anticipate a substantial increase in the number of objects users will want to store electronically.

However, before paper takes its place beside clay tablets and parchments in a museum of historical artifacts, it is important to consider some of the advantages paper may yet hold over the medium of electronic storage. In particular, we note that a paper-based information object possesses a corporeality absent from its electronically-based counterpart. A paper-based object has attributes of size, shape, and color which may provide important cues to its access and usage. Perhaps most importantly, a paper-based object has an attribute of spatiality, i.e. it and its contents occupy a definite point in three-dimensional space.

By speaking of the crucial role which location or spatial information plays in our interactions with objects in the environment, we run the risk of emphasizing the obvious. Clearly, in searching for an object it is not enough to know *what* we are looking for - we must also know *where* it is located. Psychological research has shown that memory for an object's spatial location is often a consequence of simply interacting with that object. Under many circumstances, location information is automatically coded into memory, and can be used in subsequent recall (see Mandler, Seegmiller & Day, 1977, for example). This holds true even for comparatively abstract objects such as information on a page of text (Christie & Just, 1976; Rothkopf, 1971; Zechmeister & McKillip, 1972).

This spatial facility is largely unutilized on the symbolically-oriented systems commonly used on today's computers. Recently, however, several authors have suggested that an office or desktop metaphor could be employed to better utilize spatial information in electronically-based office systems (e.g. Bolt, 1979; Cole, 1982; Malone, 1983). A partial mimicry of a desktop can be found in Apple's commercially available Lisa and MacIntosh computers, and this approach has been taken considerably further in the experimental Spatial Database Management System developed at M.I.T. (Bolt, 1979).

Although these systems demonstrate the technological feasibility of using some form of spatiality in an electronically-based information system, psychological questions regarding the role and utility of the spatial modality, vis-a-vis the more traditional symbolic modality, remain unanswered (and largely unasked). In this regard,

we motivate the experiment of this paper by specifically asking the following questions: (1) How do spatial and symbolic representations compare with respect to various measures (e.g. ease of initial selection, subsequent memorability)? (2) What are the comparative effects of "crowding" (e.g. increases in the number of objects) in the spatial and symbolic modalities? (3) To what extent can the two modalities be usefully combined? That is, what are the limits on a person's ability to integrate spatial and symbolic information for storing and retrieving objects?

Experiment

Procedure. In order to address these issues experimentally, we compared four different ways of filing computer objects. The objects we used were AP news articles. Each article was printed on a separate sheet of paper and given a two-digit identifying number. The four methods of filing are illustrated in Figure 1, and will be referred to as Location-Only; Name-Only; Name+Location-Combined; and Name+Location-Separate, respectively.

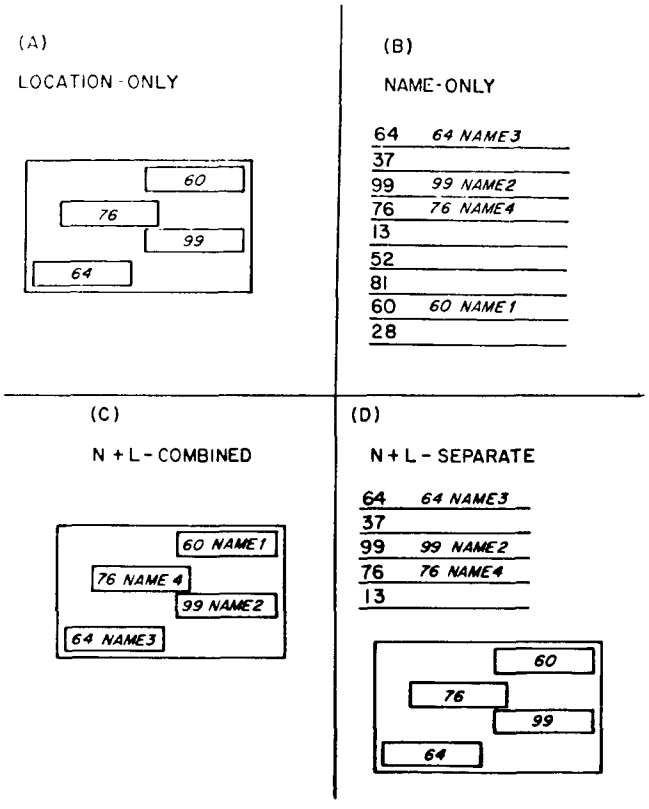

Figure 1

The Location-Only condition depicted in panel (A) was intended to mimic a pure spatial filing scheme in which the primary way of storing or retrieving an object is by its spatial position. Subjects were given a "desk sheet" and told that filing in this condition was like putting things away on a desk in unlabeled groups. The Name-Only condition, panel (B), is similar to current computer systems in which a filename is assigned to each object and serves as the primary route to its subsequent retrieval. Subjects used the "name sheet" to store and retrieve objects by symbolic means. Pilot data showed near perfect performance when 10-letter names were allowed. To eliminate this problem in the present experiment, we limited names to 2 characters in length. Panels (C) and (D) depict two combinations of both symbolic and spatial information. In one, a labeled object is placed on a "desk sheet". This filing system combines symbolic and spatial information in an integral fashion - there are labeled objects on the desktop. In the other combination, two separate filing schemes (a "desk sheet" and a "name sheet") are maintained for symbolic and spatial information. While both kinds of information are available, they are not integrated in a single filing system.

Subjects were 71 area homemakers (17 Location-Only; 20 Name-Only; 17 Name+Location-Separate; 17 Name+Location-Combined). Each subject was given a looseleaf notebook of stimulus materials, plus a filing sheet (a desk sheet and/or name sheet, depending on condition). The news articles were organized into one practice block and three experimental blocks of 10 articles each. After reading each article, subjects were asked to file it according to the scheme outlined for their condition. A retrieval test was administered after each group of 10 articles. The retrieval test consisted of a set of brief statements about the previously filed articles. Subjects were told to use their filing sheets to decide to which article the statement referred. They were given three guesses for each retrieval statement. Subjects in all filing conditions responded exactly the same way to the retrieval statements (three two-digit numbers), although their responses were based on information from quite different object representations.

Subjects completed a practice block of 10 articles and three retrieval statements during which they were introduced to the filing and retrieval tasks. This practice block was intended to familiarize subjects with the general procedure, the range of articles, and their particular filing scheme. The practice filing sheets were then set aside, and the three experimental blocks of articles and retrieval statements began. After the first block of 10 articles, there were 3 statements; after the second block, 6 statements (3 about articles from each of the first two blocks); and after the third block, 9 statements (3 about articles from each block). Note that during the experimental phase, each block of 10 articles resulted in more items being filed on the name or desk sheet. This allowed us to study the effects of crowding in the various filing schemes.

At several points during the experiment (e.g. before reading a block of articles), subjects were asked to record the time. These values were used to estimate the time required to initially file and subsequently retrieve objects.

About two weeks later, subjects were asked to return. Subjects used their original filing sheets to answer 30 retrieval statements without reviewing any of the previously read articles.

Results. The data reported in this paper are based on the first guess for each retrieval statement. A comparison of retrieval accuracy for the four naming conditions reveals a significant main effect ($F(3,67) = 10.0$, $p < .001$), with means: .57 (Location-Only); .80 (Name-Only); .82 (Name+Location-Separate); and .88 (Name+Location-Combined). Only the Location-Only condition is reliably different from the others. Although there is a tendency for subjects to be more successful at retrieving objects when both name and location information are available, this effect is not reliable. Thus, location is neither an effective filing dimension in and of itself, nor does it appear to add much (if anything) to the symbolic name dimension.

There is also a reliable effect of block. Not surprisingly, it is harder for subjects to retrieve articles as the number of them increases from 10 to 30; accuracy decreases from .88 to .77 to .66 over the three blocks ($F(2,134) = 30.0$, $p < .001$). In addition, the time required to read a statement and retrieve the relevant article increases as a function of block (.47, .51, .65; $F(2,134) = 8.4$, $p < .001$). There are many possible accounts for the observed effects: (1) there are more items on the name or desk sheet - the filing space becomes crowded; (2) more items have been read, so the association between a retrieval statement and a story may be more difficult; and (3) on the average, the delay between the time an article was read and the time it was tested is longer. We can attempt to sort out these various sources of interference by separately examining performance for statements about articles from the three different blocks. There is a sizable block effect for statements about articles from the most recent block (.88, .78, .69; $F(2,134) = 12.2$, $p < .001$), suggesting that crowding of the filing space per se leads to decrements in performance. The effect is also reliable, and somewhat larger, for statements about articles from the first block (.88, .77, .61; $F(2,134) = 31.2$, $p < .001$), indicating that delay between filing and retrieving is also important.

Perhaps the most interesting result is the interaction of condition with block ($F(6,134) = 4.9$, $p < .001$). This interaction is shown graphically in Figure 2. All filing conditions start out about equal, but the Location-Only condition drops off rapidly. This result suggests that visual space has lower resolution than symbolic name space for filing and retrieving information objects.

Fifty-two of the subjects who completed the first experimental session were able to return for the delayed test (14 Location-Only; 12 Name-Only; 13 Name+Location-Separate; 13 Name+Location-Combined). Although the overall level of performance is much lower, the trends discussed above are still evident. There is a large and reliable effect of condition ($F(3,47) = 6.7$, $p = .001$), with the Location-Only condition being the worst. The means for the four filing conditions are: .17 (Location-Only); .31 (Name-Only); .41 (Name+Location-Separate); and .45 (Name+Location-Combined). Again, while there is a tendency for combinations of name and location to improve performance, the effect is only marginally significant in one case (Name-Only vs. Name+Location-Combined).

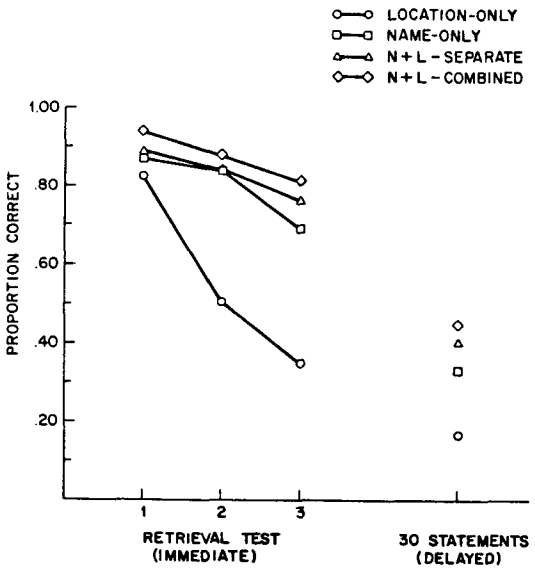

Figure 2

Summary and Conclusions

The experiment represents a first attempt to assess the utility of a two-dimensional spatial representation in a filing system. In this regard, the results do more to suggest directions for further research than they do to provide any firm conclusions. On the face of it, the relatively poor showing of the Location-Only condition and the very modest, non-significant, improvements in performance observed for the two conditions in which objects were represented both spatially and symbolically, call into question the efficacy of the desktop metaphor.

However, two caveats are immediately obvious. First, the desktop used in the present experiment was a very impoverished one (although perhaps not unlike that offered by a blank CRT terminal screen). Performance might improve if the space were enriched through the introduction of landmarks or through use of graphics providing a more credible simulation of a three-dimensional space. We have begun to explore such enhanced spaces. Second, the materials used (AP news articles) did not especially lend themselves to a spatial

organization. It is possible that the results would be radically different given another set of materials placed in another kind of space - e.g. travelogue descriptions placed on a map.

These observations clearly indicate the need for more experimentation with different kinds of materials in combination with various spatial enhancements, but they do not vitiate the results of the present experiment. While the materials of this experiment did not immediately suggest stratagems of spatial organization, they are not, in this respect, unlike a variety of other information objects (e.g. programs, datasets, memoranda, letters, etc.) which a user might want to store electronically. Furthermore, while the desktop in the present experiment was clearly an impoverished one, so too was the set of symbolic representations from which subjects could choose (i.e. names could be only two characters in length).

Although there is great interest (both theoretically and practically) in comparing the relative utility of spatial and symbolic filing systems, it is not a simple issue. Clearly, both modes can be implemented in a variety of ways some of which are decidedly better than others. A potentially more useful set of comparisons concern the relative effects of factors which are known to affect performance in both modalities. In the present experiment, we note that performance in the Location-Only condition was on par with that for other conditions in the first block but fell off rapidly thereafter. Thus, it appears that the spatial modality is especially vulnerable to crowding.

Given this observation, it might be argued that the spatial modality is best used as a holding area for the temporary representation of objects preliminary to the selection of a more permanent, perhaps symbolic, representation. Malone (1983) has suggested such a system of "deferred classification" based upon his study of the way people manage paper-based objects in an office setting. In particular, he notes that people often delay filing objects under symbolic headings and elect, instead, to place them in unlabeled "piles". Presumably the time during which objects are in such temporary piles can be used to gain a better understanding of them and the context(s) in which they occur.

We conclude by re-emphasizing the need for continued experimentation to explore possible roles for the spatial modality in electronically-based information retrieval systems. The increased sophistication and economic feasibility of computer graphics and of analog input devices (e.g. the mouse, joystick, touchscreen, etc.) create wonderful new opportunities to improve the interface between users and computers. However, to forego experimentation on the application of these new-found capabilities is to run the risk of indulging in a costly kind of technological trendiness in which new systems are implemented "because we can do it" and not as a consequence of their psychological utility.

References

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