Evaluating the FUN Interface

Sally Lane
International Fellow
Ngee Ann Polytechnic
Singapore
Lse3@np.edu.sg

Steve Goschnick
Interaction Design Lab
University of Melbourne
Melbourne, Australia, 3010
+61 3 8344 1522
stevenbg@unimelb.edu.au

Wally Smith
Interaction Design Lab
University of Melbourne
Melbourne, Australia, 3010
+61 3 8344 1494
wsmith@unimelb.edu.au

ABSTRACT
Over recent years there has been a substantial increase in computing processing power, memory and interconnectedness, available to the general user. This volume of information accessed and accrued, often leads users to create complex information hierarchies to attempt to store it in a logical and easy to access way. However, there have been relatively few improvements in the amount of screen space available to users - decreases for many, as they move from desktop to mobile. The creation of large information (and other) hierarchies and static or decreasing screen space has led several designers to develop new ways of displaying and accessing hierarchies on the screen. One such approach is the Friendly User Navigation (FUN) interface - first deployed in a multi-agent personal assistant system called the DigitalFriend, where FUN is used to represent three types of hierarchy: a sub-agent hierarchy, a role-base information lens, and as a deep Knowledge Tree. As all of FUN's design principles could not be tested in the one study, two were evaluated in this research. The first focus was on the *speed* that the interface allows the user to navigate an information hierarchy. The second focus was on whether the FUN interface increases the *recall* ability of its users, through restricting the file structure to have no more than eight folders at any level. In addition, a usability study was conducted on it. We conclude with improvements to FUN and to the experiment design, for ongoing developments to this generic tree browing interface.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Evaluation/methodology, User-centred design, Graphical user interfaces (GUI).*

General Terms
Design, Experimentation, Human Factors, GUI

Keywords
Intelligent Interfaces, Personalization, User Studies, Knowledge Tree, Role-oriented Interface, Personal Assistant Agent

1. INTRODUCTION -
With the recent history of ever-increasing computer memory and power, and the ever-present connection of our computing devices to the internet, there has been a corresponding need for users to be able to search and access greater amounts of information quickly and effectively on computer in general. However, there have been relatively few improvements in the amount of screen space available for users to view this information - often less, with the proliferation of handheld devices. These issues of volume of information and lack of screen space have led designers to create complex information structures to store data. For users of these interfaces, finding information poses a challenge especially if they are unfamiliar with the structure. Many user interfaces have been developed to display these information structures in a way that is easy to use and navigate. Many interfaces have been developed to amplify human cognition, which is an important aim of information visualization research [22], with each interface using different techniques. One example of such a browser is the Hyperbolic Browser [16, 22], which was expected to accelerate users' browsing performance over conventional tree browsers. However, while it was found that it did allow users to search the structure at a faster rate, other factors had a large impact on the study, such as how well the lower levels of the structure related

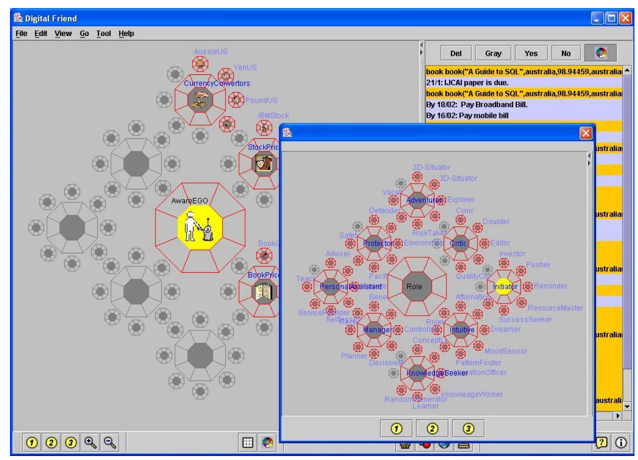

Figure 1. The DigitalFriend's Role Hierarchy and Sub-agent configuration, all using FUN.

back to their respective higher levels. The Friendly User Navigation (FUN) interface is another tree browser designed to increase the speed that a user navigates the space, as well as improve the user's memory of the structure that they are navigating.

2. BACKGROUND
The focus on the storing, retrieving and viewing of the information has sparked many theories about the best way to: structure the hierarchical taxonomies holding the information, the best way to display the information on screen, and how well people remember the information structure that they are using, during sessions, or between them.

2.1 Working Memory

There has been much debate about the nature of memory with most psychologists preferring to think of it as a set of sub-systems that work together to form the overall system [6]. The more traditional memory models suggest that memory consists of a sensory store, a short-term memory and a long-term memory. This was revised to include working memory which comprises both long-term and short-term memory stores [26]. Other potential models include the Levels-of-Processing model proposed by Craik and Lockhart [5], the Multiple Memory Systems model proposed by Tulving [27], a Connectionist Perspective which models Hebb's work on cell assemblies, as well as varying theories about memory in the real world [6]. For the purposes of this paper the traditional memory model will be used with an emphasis on working memory.

Working memory has been defined as a system for holding and manipulating information while completing a range of cognitive tasks such as comprehension, learning and reasoning [1]. Much research has gone into exploring the capacity of working memory as it has a large effect on learning as well as everyday life. A pivotal paper on short-term memory (also applicable to working memory) is a paper written by Miller [20] which states that the capacity of working memory is seven items or chunks of information, plus or minus two chunks. More recent research which expanded on his work by Huguenard et al, determined that this number is highly accurate for the average person [13].

In dealing with interfaces that have custom hierarchies such as the DigitalFriend, remembering is important. The two types of recall - intentional and unintentional - are also known as explicit memory and implicit memory. Explicit memory is when the person was intentionally trying to remember something that they have previously seen and implicit memory is gained from previous experiences that the person does not consciously and purposely try to recollect [12, 6].

2.2 Structuring a Hierarchy

There has also been much research into the depth verses breath arguments of information and menu structuring. When depth is focused upon the number of choices at each level of the structure are minimised, but the number of levels a user must visit increases. When breadth is emphasized there are fewer levels that a user must visit, but there are more options at each level. Some argue that a tree will be faster for navigation if it is broader and more shallow, while others argue that a tree that has fewer options at each level but is quite deep will be more accurate for people navigating the structure with a specific object in mind. Most studies have found that structures with more breadth were better for *speed* than those with depth, although there have been differing interpretations of what constitutes a broad structure [18]. Most of the studies mentioned by Larson and Czerwinski [18] include experiments where the optimum number of folders per level was found to be eight.

2.3 Displaying a Hierarchy

The way that the information is displayed is highly important when trying to navigate information spaces in general, including hierarchies such as those in the DigitalFriend. An important aim of information visualisation research is to develop ways of amplifying human cognition [22], that is, memory as well as decision making processes. Some browsers have been developed with this in mind, one example being the aforementioned Hyperbolic Browser [16, 22] (see Figure 2). It was found to allow users to search the structure at a faster rate, but had uncontrolled variables that had a high impact on the experiment such as how

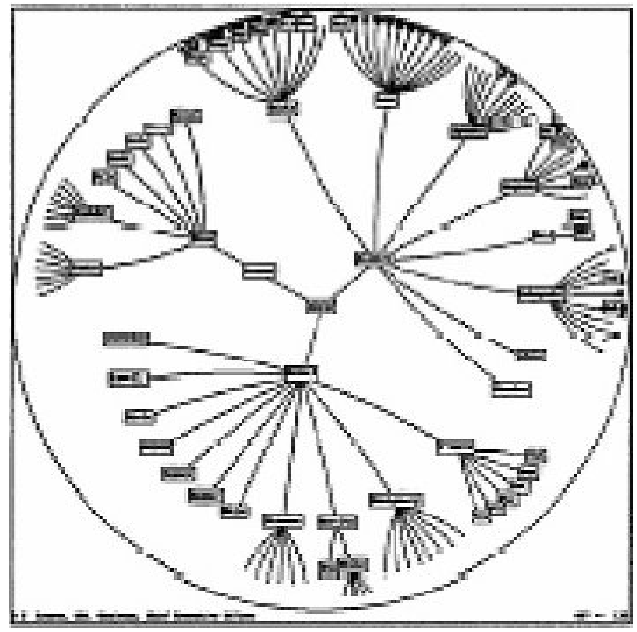

Figure 2. The Hyperbolic Tree Browser [16]

well the lower levels of the structure related back to their respective higher levels. Several other hierarchy displaying interfaces, which explore various useful and novel approaches, include: the SpaceTree [23], and the PDQ Tree Browser Kumar et al. [95].

Alternative two-dimensional tree-like displays include: Cheops [2] where the display is similar in concept to the tree-like displays but is compacted into a triangle-like display and the Pad and Pad++ interfaces [4]; [3, 21] that create links between information accessed at similar times and remembers this for future use. Others are designed to display the whole structure, with much less emphasis on ease of interaction or usability, which are less relevant to this work, including Treemaps by Schneiderman [24] and Visualisation to the Million [7].

3. THE RESEARCH PROBLEM

The Friendly User Navigation (FUN) interface was designed with several criteria in mind:

- It needed to be the interface to several different structures within the multi-agent application tool, the *DigitalFriend* [10,8]. Firstly a hierarchy of sub-agents (see lefthand side of figure 1) that make up a user's *digital friend* (a many-functioned personal assistant agent), secondly to display a role-hierarchy (see righthand foreground of figure 1) used to both categorise sub-agents and also as a user-selectable filter upon *alerts* and *notifications* that flow from the whole group of sub-agents making up a person's *digital friend*, and thirdly a Knowledge Tree (see figure 3) representing an individual user's personal ontology for managing their information store within the DigitalFriend tool. See Goschnick et al [10, 9, 11].

- To display flashing visual-alerts from the various sub-agents in an agent hierarchy.
- To navigate larges amounts of information, faster and be recalled more easily, than the mainstream tree-display controls, most frequently in Windows Explorer, and also Finder in in Mac OSX - both of these mainstream interfaces are seen as *desktop metaphor* artifacts, not well suited to the 24 hour, 7 day a week (24x7) of ubiquitous systems such as

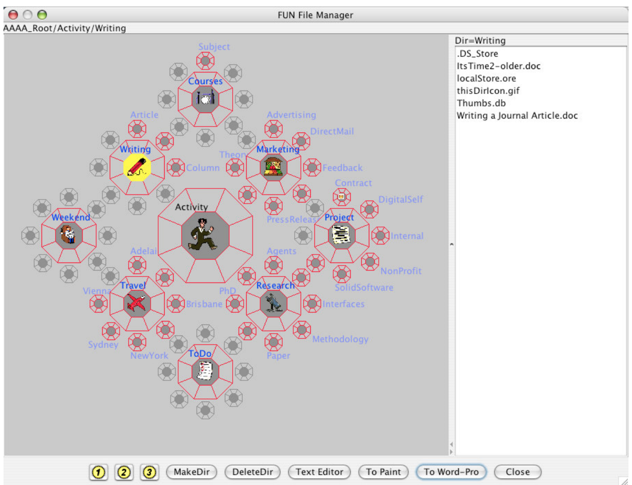

Figure 3. A third use of the FUN interface within the Digital-Friend is the Knowledge Tree, with built-in File Manager

the DigitalFriend.

- Multi-form-factor goal: To be able to visually scale down to screen-sizes as little as 160x160 pixels, and up to large flat screen displays, and be uniformly useful across those screen-size ranges.

The FUN interface was initially developed by Goschnick for use with agent oriented software for web based services [9]. Referred to originally as ShadowFaces, the interface to the Shadowboard multi-agent architecture, it has been increasingly referred to as the Friendly User Navigation (FUN) interface. Its display consists of 73 octagons placed in a diamond like pattern on the screen, all of which are selectable, though only one at any time is selected. In the case of the Knowledge Tree depicted in Figure 3, these octagons represent the different folders in the information hierarchy. The central octagon is the largest which suggests that it is the focus of the information and the highest level folder displayed on the screen. However, the current folder can be any of the 73 octagons, and is highlighted with a yellow centre. Around the central octagon are eight additional octagons placed at the focus octagon's eight compass points (north, north-east, east, south-east, south, south-west, west and north-west). These are smaller in size which emphasises that they are sub-levels of the central octagon. Each of these eight octagons has an additional eight smaller octagons placed along their own compass points.

The first difference is that the FUN interface forces the information structure to have a maximum of eight objects at any one level with an unlimited number of files (i.e. equivalent to 8 sub-directories in a file manager, but a directory can hold any number of files). This restriction does not occur in most other tree browsing interfaces as they commonly don't affect the way the information is hierarchy structured. This is inspired by the aforementioned findings of Miller and others [20,19,25], and the octagonal tile pattern that it allows, also helps to facilitate the multi-form factor goal, i.e. given that all lines in the graphic representation are either at 90 or 45 degrees - which very much suits square-pixel display modes of modern devices. The second difference is that due to the design of the FUN interface users are able to see two levels down into the tree at any stage, aiding them in making correct choices as to where they are likely to find certain items/files. The tree can be of unlimited depth so the three levels within the FUN interface are like a *lens* that can be moved through the directory structure. This is different to most tree browsing interfaces where the user can only see the subfolders directly below the area that they are currently in.

The research reported here, is based on an experiment to see it the FUN interface did rival or surpass a standard tree browsing interface (Windows Explorer was chosen) in terms of *speed*, measured by the time a user took to locate things placed in the hierarchy, and in term of users ability to *recall* where items were located.

The experiment and usability evaluation was the subject of an honours student research project by Lane [17], and it encompassed the following hypotheses:

Hypothesis 1: A deep-and-narrow file structure will produce slower searches for items than a broad-and-shallow structure.

Hypothesis 2: The FUN interface will produce faster searches for items than a standard tree-browsing interface.

Hypothesis 3: Search behaviour using an information structure with eight folders at each level will produce better learning then a broad-and-shallow file structure.

Hypothesis 4: Search behaviour using the FUN interface will produce better learning than a standard tree-browsing interface.

Each of these hypotheses required different experimental designs and different data to be gathered.

This first hypothesis was designed to test/verify results reported elsewhere, is outside of the scope of this paper but is reported elsewhere [17]

4. THE EVALUATION

4.1 Experiment

The study was qualitive rather than quantitive. Thirty participants were recruited aged between 18 and 35. Sixty percent were female. Seventy-six percent attended a tertiary educational facility. Thirty-six percent rated their computer ability as 7 or below, while twenty percent self-rated as 10 out of 10 - ten is high, zero is low.

These were then broken into three groups of 10 participants each. The first group used the FUN interface with a deep and narrow file structure, hereafter called FUN Deep, with target documents/files located on different levels within the tree. The second group used Windows Explorer with the same file structure as group one, hereafter called Windows Deep. The third group used Windows Explorer as the interface to a different file structure which was broad and shallow, heraeafter called Windows Shallow.

The Knowledge Tree part of the DigitalFriend also functions as a file manager, but only for that sub-section of the disk that the Knowledge Tree occupies, so that part of the program was compared with Windows Explorer. Most of the users were very familiar with Windows Explorer, but none of them were familiar with the FUN interface (it was a prototype only, at the time of the experiment).

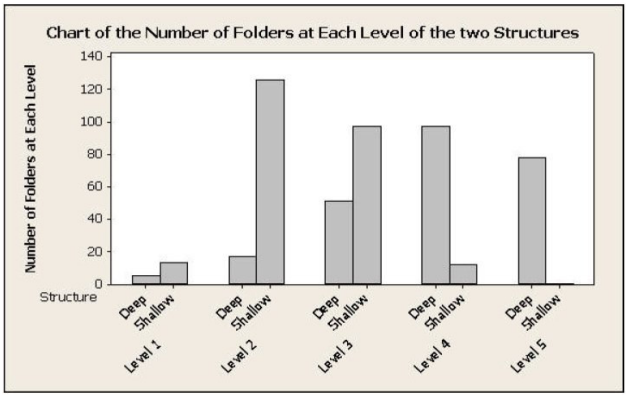

Figure 4. The number of folders at each level in the structures

The two file structures (Deep and Shallow) used in the experiment both contained 248 directories - not reproducible here, for space reasons. The Deep structure had a maximum of five levels with 39% of its folders placed at level four and 31% at level five, while the Shallow structure had only four levels with 50% of its folders at level 2 - with majority of choices in the first two levels (See figure 4).

Each participant was asked to complete a set of 35 tasks. Each task involved locating a file in a particular directory - which were simply written in text format on individual cards and given to the participant one at a time - like the following:

`AAAA_Root/World/Countries/Oceania/Australia`

In order to test the participants speed in locating a task, the users were simply timed. In order to assess their ability to recall elements of the structure, participants were given 11 prompted recall sheets, away from the screen, after the 35 tasks were completed. For example, under the path *AAAA_Root/World/Countries/Oceania* the set of folders they would try to recall were: *Australia, Fiji, New Zealand, Papua New Guinea* and *Vanuatu*.

4.2 Usability Study

The experiment took place in a usability lab [14] at the University of Melbourne. Two video camera captured both visual and audio data, with a facilitator present who asked post-test questions.

To gain an understanding of the skill level, attitude and general demographics including age, frequency of computer usage, attitude towards computers (see [17] for survey form). Their opinions about the interfaces and the file structures were also captured.

So, in addition to being an experiment, the whole process had elements of a usability test of the prototype FUN interface, from which useful feedback was gleened.

5. FINDINGS

5.1 Experiment

5.1.1 Hypothesis 1

Figure 5 represents the results that test hypothesis 1. This indicates that the trend for the data was for Windows Deep to always be faster than Windows Shallow, which is supported by the low probability of the null hypothesis in both of the lines. This, however, only indicates the trend of the data and does not indicate whether this is actually the case at each level. To see which structure is faster an analysis was taken at each directory level in the two structures.

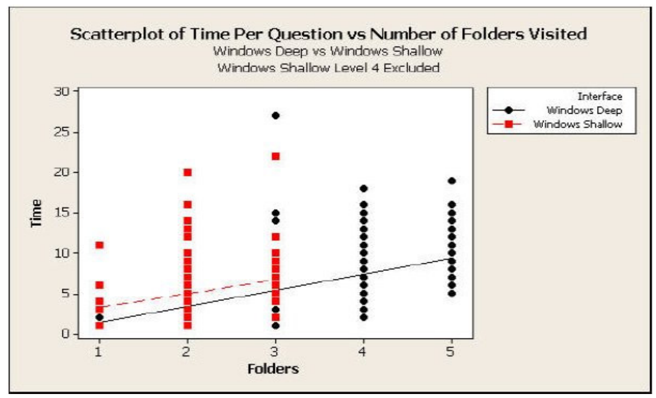

Figure 5. Regression Lines for Comparing Windows Deep and Windows Shallow: Time Taken per Question vs Different Levels Navigated.

At level one the difference between the two means is 2 with Windows Deep being faster than Windows Shallow, however it is not significant. At level 2 Windows Deep is again faster with a mean of 2.9 compared with Windows Shallow's 4.4. The probability of this is 0.2% (P=0.002) which is statistically significant. At level 3 Windows Deep again had the smaller mean (7.3 compared with 10.8) however was again not statistically significant.

Therefore the validity of this hypothesis depends on the level of the structure that was being navigated to. At level 1 there is no evidence suggesting either of the two structures is faster. At level 2, Windows Deep is definitely faster than Windows Shallow. At level 3 there is no evidence as to which is faster.

5.1.2 Hypothesis 2

Figure 6 represents the results that test hypothesis 2. The regression lines shown in Figure 6 indicate that the trend for the two interfaces is quite similar in terms of time spent at the first level, however as more levels are added FUN Deep appears to slow at a faster rate than Windows Deep does. The regression line for the FUN interface fit 30.4% of the data with the probability of the null hypothesis being 0.00% indicating a significant result. The regression line for the Windows Deep data fit a similar percentage of the data (31.2%) and also had the probability of the null hypothesis being 0.00% (P=0.000) indicating that a comparison of these two trends could be quite accurate.

To fully assess which interface is faster, analysis was conducted at each level of the structure comparing the means of the data sets. At level 1 FUN Deep had a mean of 5.8 while Windows Deep had a mean of 1.2. The probability of the null hypothesis for this data set is 0.07% (P=0.07) which is not significant. Level two of the structure had similar results with the mean of FUN Deep being 2.39 and the mean of Windows Deep being 2.9 which was not statistically significant (P = 0.12). This indicates that there was no difference in the times of the interfaces at both level one and level two of the information structure. Levels three, four and five of the information structure did show that Windows Deep was faster than FUN Deep at each of these levels with a P-value of 0.000 at each case which is statistically significant.

5.1.2.1 Usability Feedback re Hypothesis 2

From the usability study it became clear that there were serious anomalies with the comparison, with regards to speed. The vast majority of participants were regular Windows users, while they were all trained in FUN for a brief ~5 mintues period, to familiarize themselves with it, however, given its significant difference from any other tree browser, more training/prior usage of FUN would likely narrow the gap seen in Figure 6.

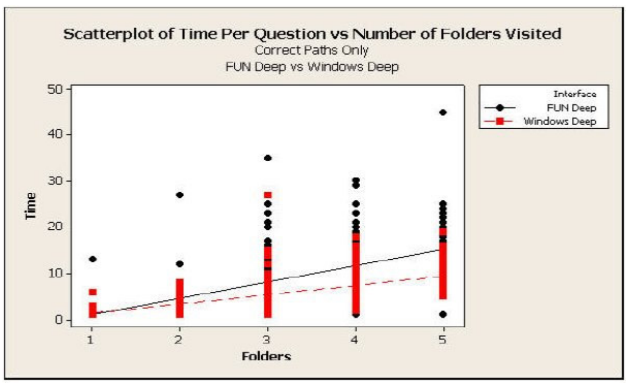

Figure 6. Regression Lines for Comparing FUN Deep and Windows Deep: Time Taken per Question vs Different Levels Navigated.

Secondly, the FUN system used was then a prototype, and there was a discernible delay between mouse-clicks and highlighted current tile, which numerous participants commented on. So the immaturity of the prototype in terms of raw execution speed, affected the result. Execution speed has been improved markedly since the experiment.

5.1.3 Hypothesis 3

The data used to test this hypothesis was the percentage of prompted recall sheets the participants got correct. The sheets included in this analysis were the ones completed by participants using Windows Deep and Windows Shallow as to eliminate any differences in the interfaces. This ensured that the data was focused on the structure of the file hierarchy as much as possible as the same interface was used. It was not tested per sheet but rather their percentage of the entire prompted recall test. These percentages were then plotted, as represented in Figure 7, to display the range within the results.

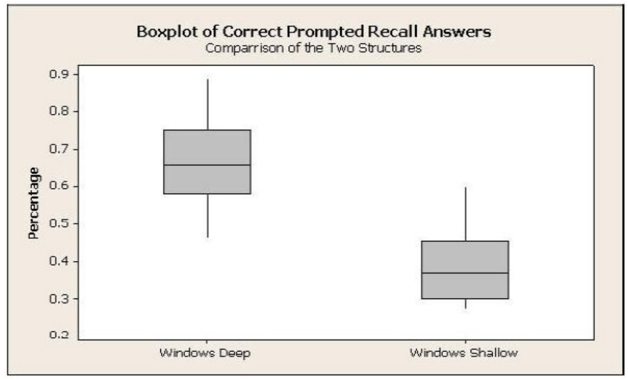

Figure 7. Comparison of Prompted Recall Results for Windows Deep and Windows Shallow

This figure suggests that there is a difference in the range of results between the two structures. A paired t-test was conducted to find out the significance of this difference. This test gave the probability of the null hypothesis as being 0.1% (P=0.001) which is significant as it is less than 5% probability. This finding supports Hypothesis 3.

5.1.4 Hypothesis 4

Similar data as that used to test Hypothesis 3 was used to gain results for this hypothesis. The data being used in this instance was generated from the participants who used FUN Deep and Windows Deep. The underlying file structure between these two tests was the same, so that the differences between the two interfaces could be assessed. The percentages were plotted as represented in Figure 8 to display the range in results.

This figure suggests that there may be some difference between the two interfaces as the FUN interface appears to perform consistently better than Windows Explorer however a paired-test was conducted and found that the probability of the null hypothesis as 50% (P=0.503) which is not significant. Figure 4.7 does show that there is one outlier in the results for both interfaces. Upon removal of this outlier the t-test was redone and returned with the probability of the null hypothesis being 11.6% (P=0.116) which is a large difference than the previous test, however it is still not classified as significant, though it does suggest that there is some correlation between these two sets of data.

5.2 Usability Study

While the experiment conducted was empirical in design, it was also a usability test of the FUN Interface, conducted in a usability laboratory, following procedures consistent with user-centred design. Usability tests are qualitive rather than quantitive in nature. And while the sample sizes are very small for an empirical test, they are not small in usability terms.

Users voiced a number of complaints about the FUN interface, which is not unusual given that only a prototype of this interface was used during these experiments. Some of their suggested improvements included the very obvious missing features from the prototype: a back button, a home button and different labelling of the navigation buttons. Most of these suggestions were only missing due to time constraints preventing them being implemented before the test. They are now implemented in the FUN interface.

A number of users were perplexed when they could not take the currently highlighted directory deeper into the display, eg. taking it from a Level 2 position to Level 3 position with the FUN display. It happens when the current directory is a 'second level' directory, so it is impossible for the FUN interface to zoom back further than where it currently is, to make it appear at Level 3 on the display. A suggested remedy to this problem, is to render the Level 3 button inoperable whenever the current directory cannot be displayed deeper on the FUN display.

One of the most common problems that participants experienced is a lag in the run time of program itself, resulting in a noticeable delay between when they click on the screen and the appropriate response of the interface itself. This again is due to the FUN interface being a prototype containing non-optimised code, however this lag had an impact on the speed of the user using the interface.

The ability to skip a level or two during navigation in FUN was liked by many of the participants.

6. SIGNIFICANCE

As already underlined the sample size is small for an empirical test. From sample size alone, it is not surprising that statistical significance was elusive in two of the four hypothesizes. However, as a usability test we gained much from the exercise.

When tested for speed the FUN interface did not perform as expected, which is largely due to the fact that it is a prototype being tested against a heavily refined program. While it does show potential and the ability to skip a level or two during navigation was liked by many of the participants, it still needs to be further refined before it can compete with a heavily refined program.

To answer the research question of whether the FUN interface aids in the recall ability of its users it can be said that the visual display of the information did not impact on the recall ability. However, the underlying design principle of the FUN interface to restrict the structure to have no more than eight folders at each level did have a significant impact on the participants ability to recall the structure.

These findings impact on the structuring of information hierarchies especially in situations where memory of the structure is important to carrying out a desired task. Such a situation could include a working environment where the user is required to retrieve and store files from a large shared network that they cannot restructure to suit their own personal information taxonomy. It would also be applicable to tasks where the user is categorising and storing a new file in their personal file structure, choosing a directory where they should store it, where it may be most easily found later on.

7. CONCLUSIONS & FUTURE RESEARCH

A significant result from the usability study was the ability for the user to skip one or two levels of the hierarchy when they were advancing deeper into the Knowledge Tree. However, they did highlight some problems when stepping back up the tree, from where they had come. We took that result and went back to the design of the interface to extenuate the cited virtue, while minimizing the reported problem. Figure 9 below is a prototype of an enhanced FUN interface, which utilizes the four corners of the window to display up to four of the previous levels of the hierarchy, through which the user has already navigated. These smaller represetations take advantage of the existing technology to change the scale of the interface, initially designed and implemented to cope with different screen sizes of ubiquitous devices.

In the example within figure 9, the user currently has *Australia* highlighted as the current folder, in the centre of the screen. From this position they can step one level forward to a *state* of Australia, or two levels forward to some sub-folder of a chosen state. However, unlike the original FUN interface, we can currently see the *earliest* folder selection in the top lefthand corner (*AAAA_Root* was selected). Then clockwise, one corner around, in the top righthand corner, we can see the second folder chosen by the user, which was *AAAA_Root/World*. One more corner around, in the bottom righthand corner, we can see the user's third choice which was *AAAA_Root/World/Continent*. In this example their fourth choice is the current choice occupying the centre of the screen, but, if they stepped forward deeper into the hierarchy for a new current choice, then their current choice would revert to occupying the bottom lefthand corner of the screen.

So this new configuration of the FUN interface gives us the ability

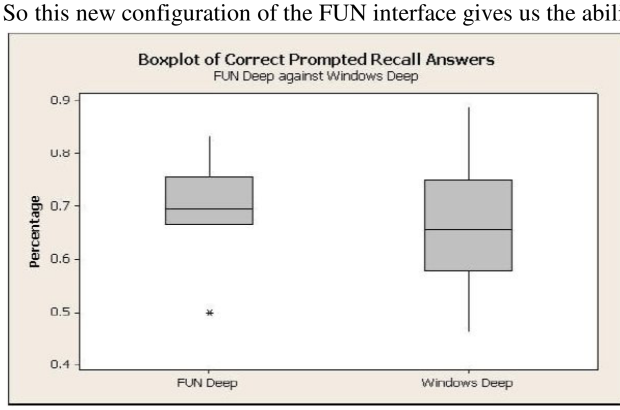

Figure 8. Comparison of Prompted Recall Results for FUN Deep and Windows Deep

to *envisage and enact stepping back* (i.e. see where we are going, before we go) either one, two, three or four levels, while retaining the ability to step one or two levels forward. In addition, on a

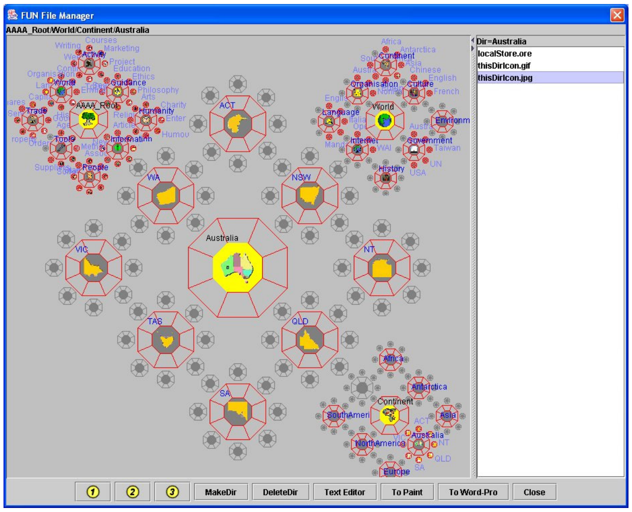

Figure 9. Proposed Modification to the FUN Interface

laptop, desktop or a larger display -on which we can see much of the detail in the corner representations - we can step side-ways across many branches of the tree, either one or two levels from anywhere on the path over seven generations of a deep hierarchy.

In addition to this innovation which was sparked by the usability testing, the experimental design can be reused, now that several of the teething problems with the original FUN prototype have been fixed, and new user-friendly features have been added.

Next time around, we will put users on a more even footing when comparing the FUN interface with industry standard tree browsers. We will source participants who are Windows users that have never used Mac OSX and compare their usage of FUN against the Mac Finder in its so-called *column-view* - which represents the navigation path thus far through the file hierarchy. They will be given equal amounts of training on both interfaces to familiarize them with both interfaces. Similarly, we will source participants who are Mac or Linux users, who have no experience with *Windows Explorer*, and put them on a Windows PC to compare their usage of FUN against Windows Explorer - as the two alternative tree browsers.

The other change to a future experiment involves getting the user familiar with the hierarchy structure (the particular ontology used, in the case of the Knowledge Tree), as all three uses of the FUN interface within general usage of the DigitalFriend - the *sub-agent hierarchy*, the *role hierarchy* and the *Knowledge Tree* - are structures the user uses over and over again, during their regular usage of the application. I.e. In daily usage they are well known structure - for example a user has and knows their own Knowledge Tree - so when they are storing new files or other information, they know where they want to navigate to, it's a question of getting there efficiently. So the *speed test* will be of primary interest, over the recall test in the next set of experiments. Although other uses of FUN outside of the DigitalFriend may well raise interest again, in recall testing.

A key component of the FUN interface was removed for the experiments reported here: that is to have each folder represented by a distinctive *icon*. The removal of icons was done to simplify the experiment design and so that the focus of the research could be done on the speed and recall ability without adding an extra level of complexity. However, this part of the FUN interface is a key design feature, and needs to be explored in more depth. Icons have been shown to aid in the memory of the information structures and the extent to which the FUN interface's icons aid this would be useful to study. Furthermore, with the additional buttons to aid navigation such as the Home button, a Back button, and a double-click action on the centre button which steps the user back one level at a time backtracking the path taken so far, further experiments could now measure the effectiveness of these smaller improvements, against the results reported here as something of a benchmark.

Most of the current day mainstream GUI interfaces have a "desktop metaphor" history and are designed for mouse-based interaction. There is a bias for on-screen components to gravitate to the edges, where mouse selection has advantages. However with the increasing popularity of mobile devices with much smaller screen spaces and direct pointing devices, the desktop metaphor designs are becoming less transferable across these devices. As the FUN interface has its information structure displayed in the middle of the screen, it would also be interesting to determine whether it is a more effective interface in some scenarios with alternative types of interaction such as pen and stylus based interfaces on mobile devices.

8. ACKNOWLEDGMENTS

The software tool *DigitalFriend V1.0*, is a product of a development effort titled *The Digital Self Project*, an open source project funded by a Telstra Broadband Fund Development Grant, provided by Telstra Ltd, Australia.

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