

A Comparison of Children's and Adults' Retrieval Performances and Affective Reactions When Using a Conventional Interface and an Information Visualization Interface

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Abstract. Reports on an exploratory study of the performance and affective responses of children compared with adults when using a conventional tree-structured interface and an information visualization interface to identify subject terms embedded in a hierarchical subject taxonomy. It is part of a larger project to investigate the efficacy of information visualization as a means to enhance web-based subject taxonomies. The study found that adults were more successful at locating terms than children, but that there was no significant difference in the times taken to complete a successful search by children and adults. It also found that the affective reactions to the conventional interface versus the information visualization interface were very similar among the children and the adults.

1 Introduction

This paper presents an exploratory comparison of children and adults when faced with an identical retrieval task: to locate four terms from a hierarchically structured taxonomy that has been embedded into two different interface designs. The first interface adopts a conventional approach by presenting at each hierarchical level of the taxonomy an alphabetical list of terms that are the children of the parent term. The second interface employs an information visualization based on a radial design to present exactly the same taxonomy. The objective of the study, part of a wider investigation into information visualization, was to find out whether the children performed in a similar or a different way from the adults when undertaking the task and whether their affective responses likewise were comparable or otherwise. Relatively few studies have tried to compare adult with children's behavior when faced with a retrieval task, a notable exception being that of Bilal and Kirby in their study of web-based information seeking [1]. Slone [2] did observe and interview 11 children or teenagers of various ages and 20 adults who were users of a web-based online catalog in a public library, but did not sharply identify the responses from the children, teens and adults respectively, although reporting that motivation and experience influenced specific information-seeking behavior.

2 The Interfaces

Two interfaces were designed for this study. The conventional interface, "Lists", displayed on the first screen terms that are at the top level of the structure (see Figure 1); clicking on any term took the user to the screen displaying all terms at the next (second) level of the taxonomy related to this term, and so on (see Figure 2).



Fig. 1. List Interface, Top Level

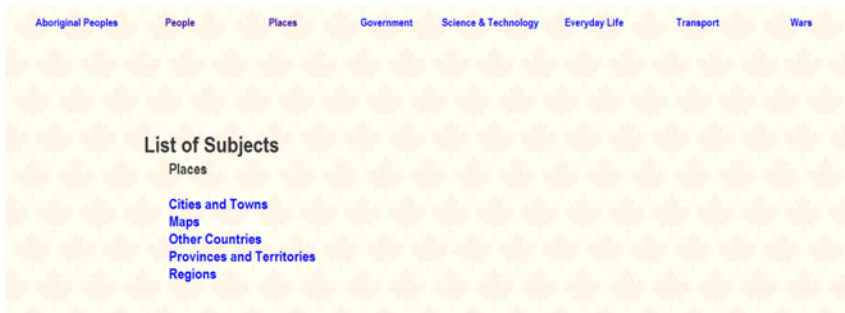


Fig. 2. Second level of "Places" hierarchy in List

The information visualization, called "Circles", was based on a 2-D radial layout technique [3] in which the position of a node relative to the center of the circle is based on the depth within the underlying tree structure. Terms at the first level of the taxonomy were displayed as a series of circles (see Figure 3). The second level was accessed by clicking on one of the circles, thereby revealing a new set of terms, grouped within the circle's circumference (see Figure 4). Terms at the third and fourth levels of the taxonomy were successively revealed in excentric clusters [4] as the user swept the cursor around the circumference (see Figure 5): as the cursor continued its sweep, earlier terms disappeared as new ones were revealed.

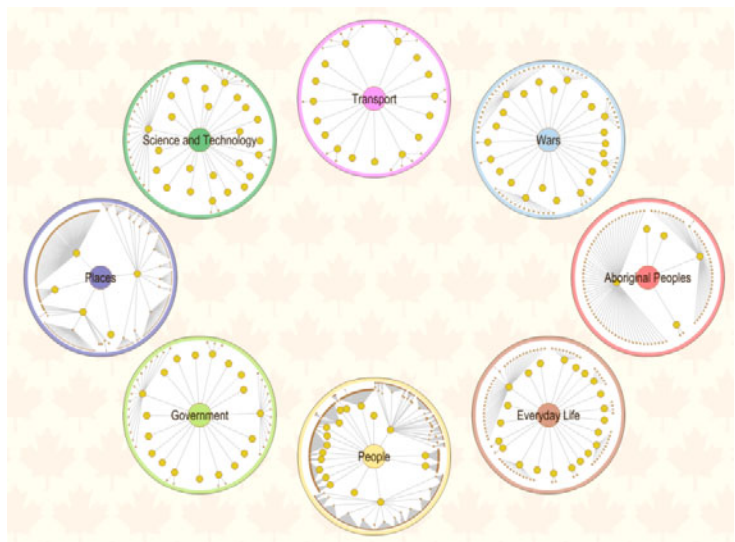


Fig. 3. Starting point of visualization navigation in Circle: the eight main topics

The information visualization interface emerged from a low-tech prototype designed over a number of sessions by an intergenerational design team of adults and children [5-6].

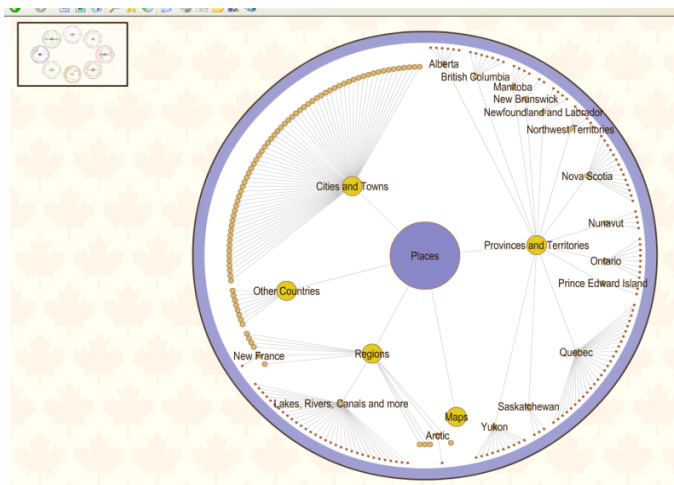


Fig. 4. Radial layout of the “Places” branch of Circles

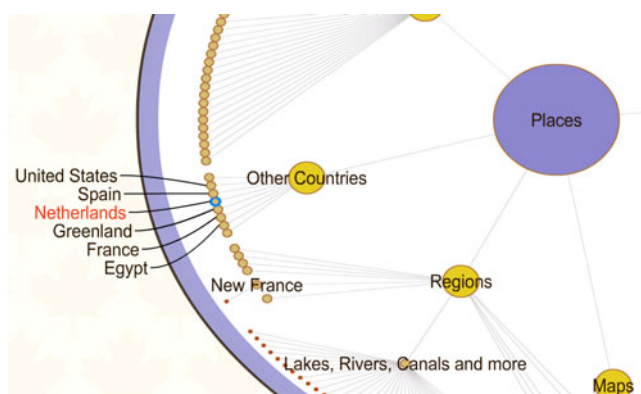


Fig. 5. Excentric Labeling (the cursor is selecting “Netherlands”)

3 Methodology

3.1 The Students and Task

The participants were 13 child volunteers (7 boys and 6 girls) aged 10 to 12 years from an elementary school and 17 volunteer graduate students. They were asked individually to locate in both Lists and in Circles four individual terms, two at the third level and two at the fourth level of the taxonomy which in total comprised 1397 terms. The four individual terms – Canoes, Vaccines, Eastern Townships and Mike Myers - were chosen for this test because they were likely to be familiar to any participant, child or adult, undertaking the test. Each term was printed on a plain card, along with the following brief description:

- Search 1: Canoes – a way to travel by water
- Search 2: Vaccines – also called “shots”, a way to prevent you from catching diseases
- Search 3: Eastern Townships – about one hour’s drive from Montreal
- Search 4: Mike Myers – a Canadian film star

The terms were located in the hierarchical structure of the taxonomy as follows:

- Transport – Boats – *Canoes*
- Science and Technology – Medicine – *Vaccines* (or alternatively Science and Technology – Inventions – *Vaccines*)
- Places – Provinces and Territories – Quebec – *Eastern Townships*
- People – Jobs and Occupations – Actors – *Mike Myers*

3.2 The Procedure

The procedure was pre-tested with five graduate students, as a result of which minor adjustments were made to the pre- and post- questionnaires as well as the observation checklist. Detailed instructions for the research assistants were prepared and the research assistants were given a short training session to ensure that the procedure would be executed smoothly and consistently in the evaluation.

The purpose of the evaluation was briefly explained to the participant by the research assistant, following a script to ensure consistency. It was emphasized that the interfaces and not the participants were being evaluated. The students then completed a short pre-test questionnaire to collect biographical information.

This was followed by the evaluation itself. Each student was asked to locate, one by one, all four terms in the taxonomy, two in the List interface and two in Circle. The research assistant noted the student's affective behaviour as well as any obvious problems, comments or questions raised by the student on a checklist. The four terms were rotated to ensure that they were searched by the same number of students on List and Circle, and that on each interface they were searched equally as the first and as the second term. To avoid student frustration, it was decided that the duration of any search would be limited to a maximum of five minutes, after which the student would be shown how to find the term and the search would be judged a failure. Furthermore, research assistants were instructed to propose search termination to any student who appeared to be very frustrated with the task (introduced especially with the young students in mind). Successful location of a term was confirmed by an onscreen message. The on-screen activity of the students as well as any spoken commentary by either student or research assistant was captured using Camtasia software with the audio feature enabled.

Finally, each student answered six questions on a post-questionnaire to gather affective reactions to the two interfaces:

- How did you like the way words were listed?
- How did you like the way words were shown in Circles?
- Which one was easier to use?
- Which one was more fun to use?
- Which was faster to use?
- Which would you prefer to use to find a word?

3.3 Data Analysis

Two retrieval measures were applied: success or failure in locating a term correctly in the taxonomy, and in case of success, the time taken to accomplish this. Affective responses to the interfaces were measured by participants' responses to the four questions on the post-questionnaire using a five-point Likert Scale.

The 30 elementary school and graduate students each completed four searches, for a total of 120 searches; 60 were undertaken on the List interface and 60 on the Circle interface. In the case of one search, the research assistant failed to activate Camtasia; the data analysis therefore was applied to 51 searches by children and 68 searches by adults for a total of 119 searches. Camtasia searches were analyzed to determine

whether the student successfully completed the search task and if so, the length of time taken to locate the sought term. The start time was noted by a research assistant when the student clicked on the opening menu screen to select either List or Circle. The end time was noted as the second when a screen was displayed saying "Bingo! You found the word". The responses to the six questions on the post-questionnaire as well as the research assistants' written observations were analyzed to identify the students' affective reactions to the two interfaces.

4 Results

4.1 Search Success or Failure

The major retrieval difference between children and adults was in failure/abandonment rates. Of the 51 term searches undertaken by the children, 11 (21%) were unsuccessful; none of the 68 adult searches were unsuccessful. In nine instances (82%) these failures were encountered in trying to find one or other of the level-four terms in the taxonomy rather than a level-three term. In 8 instances the child could not find the term in the 5-minute time period allotted; in the remaining 3 cases the research assistant proposed termination of the search because the child appeared very frustrated. There was no significant difference between the two interfaces as regards these failed and/or uncompleted tasks.

4.2 Search Completion Times

The situation was different when comparing all adult search completion times with those registered by the children who did successfully complete a search. As Table 1 shows, the descriptive statistics do not reveal major differences between children and adults. A two-sample T test confirms this result (List, $t=0.246$, $df=52$, $p=0.807$; Circle, $t=0.307$, $df=53$, $p=0.760$).

Table 1. Times to complete search (seconds)

Interfac	Particip	N	Mean	Median	Std. Dev.	Min.	Max.
List	Children	20	67.5	49	52.11	12	190
	Adults	34	63.9	50	52.84	10	258
Circle	Children	21	98.3	69	76.44	17	279
	Adults	34	92.4	73.5	64.10	13	329

List Interface. There is no significant difference between the mean times of adults and children when completing the searches on the List interface ($t=0.246$, $df=52$, $p=0.807$). The Mann-Whitney U Test confirms this result ($p=0.768$).

Further analysis by search shows no significant differences between children and adults in the times they spent completing the searches (Table 2). Due to small sample sizes, we are reporting the median times and we utilized the Kruskal-Wallis nonparametric tests here.

Table 2. Differences and similarities of search times between children and adults

Task	Participants	N	Mean	Std. Dev.	Median	p
Canoe	Children	7	65.6	57.04	39	0.271
	Adults	8	29.0	15.94	21.5	
Vaccine	Children	4	24.3	7.72	22.5	0.315
	Adults	9	36.6	23.21	30	
Eastern Township	Children	4	122.5	58.01	119.5	0.355
	Adults	9	100.4	68.09	75	
Myers	Children	5	60.8	22.16	52	0.242
	Adults	8	88.3	47.40	83	

Circle Interface. There is no significant difference between the mean times of adults and children when completing the searches on the Circle interface ($t=307$, $df=53$, $p=0.760$). The Mann-Whitney U Test confirms this result ($p=0.815$).

Further analysis by search shows no significant differences between children and adults in the times they spent completing the searches (Table 3). Due to small sample sizes, we are reporting the median times and we utilized the Kruskal-Wallis nonparametric tests.

Table 3. The differences and similarities of search times between children and adults

Task	Participants	N	Mean	Std. Dev.	Median	p
Canoe	Children	6	101.2	90.35	74	0.906
	Adults	9	91	57.52	75	
Vaccine	Children	7	110.2	106.21	57	0.487
	Adults	8	56.5	27.33	65	
Eastern Township	Children	4	75.3	18.84	76	0.865
	Adults	8	109.6	97.46	70	
Myers	Children	4	96	36.94	87.5	0.643
	Adults	9	110.4	52.17	94	

Noteworthy are two significant differences, one between children and adult time variances on the List interface when performing the Canoe search (Levene's Test for Equality of Variances, $F= 9.420$, $p=0.009$), and the other between children and adult time variances on the Circle interface when performing the Vaccine search (Levene's Test for Equality of Variances, $F= 12.194$, $p=0.004$). These results show that in both cases children were significantly more heterogeneous than adults in performing the tasks.

In terms of affective reactions, 71 percent of adults and 62 percent of children preferred Lists, whilst 59 percent of adults and 62 percent of children agreed that Circles was more fun to use.

5 Discussion and Conclusions

The specific task imposed in this study was deemed suitable because it seemed to be one that could equally be attempted by children and adults without a bias towards one group or another. Likewise the two interfaces, though based on ideas generated by intergenerational teams including children, were not specifically intended to be "child-appropriate" (in the Bilal and Kirby study [1] the search interface had been designed specifically for children).

The elementary school students (children) and graduate students (adults) differed significantly in one major respect: their ability to successfully complete their term searches within the allotted time period (5 minutes). All the adult searches were successful, whereas 21% of the child searches were not completed. It could be that the time limit was too short, but 5 minutes seemed a lengthy time to find a term from within a taxonomy with a breadth of 8 categories and a depth of four levels. At any rate, it is impossible to speculate as to whether any of the failed child searches might have been completed with even more time available. And outside of the experimental conditions in which this study was conducted it seems unlikely that any user would have devoted more than 5 minutes to locating a term in a taxonomy as a prelude finding information within an actual database.

Excluding failed searches, there was no significant difference in the mean search time for all participants for each interface: Lists ($t=0.246$, $df=52$, $p=0.807$); Circles ($t=0.307$, $df=53$, $p=0.760$). However, children's search times were significantly more heterogeneous than adults when using Lists ($F=9.420$, $p=0.009$) and Circles ($F=12.194$, $p=0.004$) for the two level-three tasks. For all participants, Lists performed significantly better for one of the level-three searches compared with one of the level-four searches, whereas with Circles no such significance was found between searches.

The affective reactions to the two interfaces were very similar between the children and the adults both in terms of which interface they preferred - with a majority opting for Lists in both cases - and which they thought most fun to use - this time with majorities in support of Circles.

Caution must be exercised in generalizing from one small-scale study using one conventional and one visualization interface. Nevertheless, when undertaking on these two interfaces four searches that can be considered appropriate in terms of difficulty for both children and adults, these two user groups differed in their ability to complete successfully the searches. This finding is in line with that of Bilal and Kirby [1], in their study of the similarities and differences between children (in their case from grade seven) and adults (graduate students in information science) as they looked for information on the Web using a children's portal. They found that the adults were more successful than the children in finding answers to a factual question although they identified many similarities in the behavior of these two very different age groups. Likewise, in our study when comparing the adults with just those children who were successful in their searches, no significant differences were found between adults and children in search times.

It must be emphasized that the task itself involved locating terms within a subject taxonomy, and the results cannot be indiscriminately extended to an information-seeking task such as finding information on the Web. It would be interesting to

explore further this latter point, though the problem is to identify search questions that might reasonably be tackled by children and adults alike without giving one group an inherent advantage over the other.

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