In Search of Salience: A Response-Time and Eye-Movement Analysis of Bookmark Recognition

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Bookmarks are a valuable webpage-revisitation technique, but it is often difficult to find desired items in extensive bookmark collections. This experiment used response-time measures and eye-movement tracking to investigate how different information structures within bookmarks influence their salience and recognisability. Participants were presented with a series of news websites. The task following presentation of each site was to find the bookmark indexing the previously-seen page as quickly as possible. The Informational Structure of bookmarks was manipulated (top-down vs. bottom-up verbal organisations), together with the Number of Informational Cues present (one, two or three). Only this latter factor affected gross search times: Two cues were optimal, one cue was highly sub-optimal. However, more detailed eye-movement analyses of fixation behaviour on target items revealed interactive effects of both experimental factors, suggesting that the efficacy of bookmark recognition is crucially dependent on having an optimal combination of information quantity and information organisation.

Keywords: Bookmark recognition, Eye-movements, Search time, Information salience, Information revisitation, World Wide Web.

1 Introduction

1.1 Keeping Found Things Found

Although the World Wide Web serves as the primary information resource for many people, its massively increasing size and complexity has made information overload one of the biggest and most obvious drawbacks of the technological age. In recent years finding resources on the web has been made easier with modern search engines, together with more refined search functions found within websites themselves. But managing successfully to find a webpage invites a secondary problem: How do you 'keep found things found'? (Jones et al., 2001). Users have many different methods for maintaining resources that have been accessed on the web, such as saving whole pages to their hard drives or printing them out. Alternatively, users may send URLs to themselves in an email, write them down on pieces of paper, or add them to the 'bookmarks' list in their web browser (Cockburn & McKenzie, 2000; Jones et al., 2001; Tauscher & Greenberg, 1997). The last method, bookmarking, is the focus of the present research.

1.2 Bookmark Basics and Good Housekeeping

Bookmarks have been in existence since the creation of the first web browser (Cailliau, 2002). They have since been adopted by most browsers as a standard navigation and revisitation tool, but tend to be referred to by different names for reasons of marketing. The term bookmark is used in the Netscape Navigator™ browser whilst the term 'favorites' is used in Internet Explorer™. Throughout this paper we employ the term bookmark simply as a convenient shorthand for the generic concept of a stored web-link in a browser menu. The text in a bookmark emanates directly from the title of a webpage as found in the <title> tag in the html code used to build the page. However, the text in the <title> tag may not actually appear on the webpage itself, and is also not necessarily the same as the 'title' appearing within the webpage, which has to be defined separately by the author.

Notwithstanding these latter observations, it is generally accepted that there are a few basic things that web authors should do in order to write acceptable bookmarks, based on the complaints of web users (Cockburn et al., 2003; Kaasten et al., 2002). First, they should remember actually to define the <title> tag. If the <title> tag is empty or even missing from the HTML code, then the filename and directory path of the page will be shown, instead of a meaningful title. If authors are using web-publishing software (e.g., Macromedia Dreamweaver™), the programme's default text will be displayed if the <title> is left undefined. This can be recognised frequently on the web by pages marked 'Untitled'. Second, authors should ideally ensure that the <title> tag and the title within the page actually match. Differences between the two have been cited by web users as a major annoyance during their efforts to locate a bookmark (Kaasten et al., 2002). Third, authors should ensure that each page on their website has a unique title to aid multiple bookmarking of pages from the same site. Finally, authors should make the title fit within the bookmark character length limit. In Microsoft Windows™, the maximum length for a bookmark is 255 characters (including spaces), but, on average, only the first 65 characters will be visible in the favorites menu in Internet Explorer™ (although all 255 characters should appear in the tool tip).

2 Purpose of the Experiment

2.1 Rationale for Studying Text-Only Bookmarks

Bookmarks are a convenient way to revisit webpages until a bookmark list grows so large that the target item can no longer be found with ease or efficiency. The search task is likely to become even more difficult when returning to a list after a long time, with a fragmented memory of what the bookmark text actually was. To address such problems various research efforts have focused on making bookmarks easier to find and organise (Abrams et al., 1998; Cockburn & Greenberg, 1999; Cockburn et al., 2003; Kaasten et al., 2002; Tauscher & Greenberg, 1997). Custom icons can make bookmark references stand out, as can thumbnail images of the websites themselves positioned next to the text bookmarks (Cockburn et al., 2003). The latter method, however, has yet to be adopted as a standard revisitation mechanism in contemporary browsers. Furthermore, the advantages of icons and thumbnails may be short lived if their use becomes widespread as their 'pop out' value would be greatly reduced.

Thumbnails also have their own recognisability problems. Text-based pages are hard to recognise at any resolution and pages from web sites that are consistently designed are hard to differentiate (Cockburn & Greenberg, 1999). Thumbnails also consume a high proportion of screen real-estate. Each bookmark on the favorites menu in Internet Explorer™ occupies 20 pixels of vertical space, however, to achieve just a 60% chance of recognising a particular webpage, a thumbnail 144 pixels high is required (Kaasten et al., 2002). Accessibility and usability may also be problematic for visual recognition aids. Icons and thumbnails are of little benefit for visually impaired users, but plain text can always be interpreted by voice web-browsers. Similarly, other systems such as file organisers, search engines and databases may not be able to interpret graphical representations. For example, it may be difficult to implement automatic and meaningful bookmark sorting based on graphical properties. In terms of usability, it is not clear if icons and thumbnails will transpose well to PDAs and mobile phones. These devices have extremely limited screen real-estate, and thumbnails, in particular, may have to fill most of the screen to be recognised.

In general, then, whilst studies have shown that visual and graphical aids can make bookmarks stand out, research does not propose how to make webpages easier to recognise when they are represented by standard text-only bookmarks. It is clear that text-based referencing remains a major force on the web and, as such, warrants continued research and improvement. This study specifically investigates factors that affect the salience and recognisability of text-based bookmarks.

2.2 Types of Bookmark: Top-Down and Bottom-Up Informational Structures

Many web producers model the <title> tag text on how information is organised on the site. This can help users while they navigate, because their navigation trail is built up in a logical way, thereby providing feedback on where they are and how they got there (Preece et al., 2002). Two common ways of describing these information structures are 'top-down' and 'bottom-up' (Rosenfeld & Morville, 2002). A top-down structure may list the name of the site, followed by one or more sections, and finally the title of the page. Conversely, a bottom-up structure starts with the title of the page and ends with the name of the site (see Table 1). Both top-down and bottom-up bookmark structures could reasonably identify a page, but which format might be more recognisable to users when they are searching a large bookmark list, with imperfect memory? We set out to address this issue in the present study.

Top-down structure:
site name → section name → page or article title
Example:
Nifty News -- Middle East -- Senior Official Surrenders
Bottom-up structure:
page or article title → section name → site name
Example:
Senior Official Surrenders -- Middle East – Nifty News

Table 1: Examples of bookmarks relating to a fictitious news website, possessing "top-down" and "bottom-up" informational structures.

On a priori grounds, bottom-up structures might be expected to be more salient than top-down structures for three key reasons. First, users' actions are driven by goals and tasks (Preece et al., 2002). Visually searching the bookmark menu is an example of goal-driven behaviour as the user is examining the menu specifically to find a target bookmark with a particular purpose in mind (e.g., to review some information). Bookmark structures that are tailored to the user's task would be predicted to improve usability (Nielsen, 1992). Since a page title describes what the user has read, whilst the site name may be completely unconnected to the page's subject matter, it is likely that the page title may fit the user's task more than the site name, improving relevance and, potentially, recognition. Second, the fuller descriptions afforded by page titles may be more likely to evoke stronger mental imagery, which is known to aid memory and recognition (Clark & Paivio, 1987). Third, bottom-up structures may map optimally on to schema-based knowledge structures, thereby aiding subsequent recognition (Alba & Hasher, 1983).

In the light of this previous theoretical analysis, a key prediction was that bottom-up information structures would facilitate bookmark salience (and, thereby, target bookmark recognition) relative to top-down information structures. A second key prediction related to the way in which the number of distinct information cues in the bookmark (i.e., one, two or three cues) might affect bookmark recognition. We predicted that the greater the distinct number of recognition cues displayed, the more the user should be able to infer meaning to facilitate identification of the target bookmark. In other words, the possible interpretations of bookmark information were expected to be constrained or augmented by the context afforded by extra information (cf. Rumelhart & Norman, 1985). Of course, there may well be an optimal amount of information content above which no added value for bookmark recognition would obtain. We were alert to this possibility in our data analysis. In addition, we sought to examine any potential additive or interactive effects that might derive from the combination of the 'informational structure' and 'number of informational cues' factors that were independently manipulated in our study.

In terms of dependent measures, bookmark recognition was assessed by measuring the overall time taken to find a target bookmark embedded within a menu containing distracter bookmarks. It was assumed that shorter overall search times would be indicative of more effective bookmark recognition. Eye-movement measures were also employed as a means to provide a deeper understanding of information salience within a bookmark-search context. More specifically, the frequency and mean duration of eye fixations on a bookmark component were taken as indices of relative information salience. The use of eye movements in the present study was based on the assumption that they provide a fairly pure, on-line measure of the processing demands associated with items of information, such that more processing (i.e., more fixations and longer fixation times) would reflect decreased salience and interpretational uncertainty, whereas less processing would reflect increased salience and ease of recognition (Cowen et al., 2002; Goldberg & Kotval, 1999; Jacob & Karn, 2003; Just & Carpenter, 1976). We believed that making use of eye-movement measures in the present study would enable detection of potentially more subtle information-salience effects than might obtain from the rather gross (and inherently noisy) measure of the overall search time taken to find a target bookmark (cf. Zelinsky & Sheinberg, 1995). Thus, we anticipated that the eye-movement findings would serve to clarify and extend effects that might be less extreme in the search-time data.

3 The Experiment

3.1 Participants

Thirty postgraduate students (12 female and 18 male) took part in the experiment (mean age: 32 years; age range: 15 to 65 years). Participants received payment for their contribution to the research. All participants had normal or corrected-to-normal vision and were regular users of the web, with an average of seven years experience. All but one participant reported that Internet Explorer™ was their main web browser. A majority of participants reported that they had never seen the websites used in the study, although six stated that they were familiar with a few of the websites, but did not use them regularly.

3.2 Design and Materials

A 2 x 3 within-participants design was used (see Table 2). The first factor was the 'Informational Structure' of bookmarks (top-down vs. bottom-up), and the second factor was the 'Number of Informational Cues' (one, two or three). Participants were presented with a series of websites, and the task following presentation of each site was to find the bookmark indexing the previously-seen page as quickly as possible. Twenty-four webpages containing articles on international news and current affairs were collected and saved as static screenshots. These pages had clear site names, article titles and section names, ensuring equal opportunity for encoding and later recognition. The original title-bar text was deleted from each screenshot to enable systematic manipulation of the bookmark text. For each website, a set of six screenshots (i.e., one for each experimental condition) was created of Internet Explorer™ with the favorites menu displayed. This enabled webpages to be rotated across all experimental conditions to ensure maximum experimental control. The bookmark associated with a webpage was randomly located in the favorites menu. The presentation order of experimental conditions was counterbalanced across participants to eliminate fatigue and practice effects.

Informational Structure	**Number of Informational Cues**		
	1	2	3
Top-down (i.e., site name first)	Site name	Site name - Article title	Site name - Section name - Article title
Bottom-up (i.e., article title first)	Article title	Article title - Site name	Article title - Section name - Site name

Table 2: Experimental conditions arising from the manipulation of Information Structure (top-down vs. bottom up) and Number of Informational Cues (one, two or three).

3.3 Apparatus

The website screen shots were presented on a 15" flat-screen monitor, with a resolution of 1024 x 768 pixels. Eye movements were recorded with an LC Technologies Eyegaze™ development system which determines gaze direction by means of the pupil-centre/corneal-reflection method. The tracker consists of a standard desktop computer running Windows NT/2000™, an infrared camera mounted beneath the monitor, and software to process the eye-movement data. An additional, smaller monitor was used to ensure that the eye was in the centre of the camera's field of view. The eye tracker is accurate to within 0.45 degrees of visual angle, which, at 51cm from the screen, covers approximately 3.8cm. This corresponds to 12.8 pixels on the monitor used, which had a dot pitch of 0.297mm. Eye movements were sampled 60 times per second, with tracking errors not exceeding 6.3mm. Although the tracker can tolerate head motion of around 3cm in all directions, participants used a chin-rest to minimise loss of data. Fixations were detected at 100ms or above, an appropriate cut-off point for tracking eye movements in reading tasks (Hyönä et al., 1989; Inhoff & Radach, 1998).

3.4 Procedure

Participants completed 24 trials, one for each website and bookmark-menu combination. On arrival participants were shown the tracker and given a brief explanation of how it worked. Adjustments were made to the chinrest and the monitor to accommodate individual variations in seated head position. At all times the same viewing angle between the face and the screen was maintained. Participants were seated at approximately 51cm from the screen. Once the camera's focus and aperture were set the participant was calibrated with the tracker. This procedure lasted 15 seconds and consisted of the participant following a series of 9 dots around the screen. Following calibration, custom software was launched which presented participants with on-screen instructions and which took them through the experiment itself. After reading the instructions participants completed four practice trials while the experimenter sat beside them to answer queries. Care was taken to check that participants understood the study requirements before they proceeded to the main session (e.g., that they had to read each news page for a fixed time and that their ability to recognise a bookmark for that page would then be tested). Each news page appeared for 18 seconds, with each bookmark screen then appearing for up to 30 seconds. Participants pressed the spacebar on the keyboard to indicate that they had found the target bookmark. If they could not find the target within 30 seconds, the trial ended and the next trial began.

3.5 Data Processing

Once the eye movements had been measured, logged and error corrected, the data were filtered to enable examination of participants' processing of specific regions of the screen. The main areas of interest were the site name, section name and article title on the website itself and on the associated bookmark screens. Once areas of interest had been defined, parsing software was used to extract the corresponding eye-movement data and format it for statistical analysis.

4 Results

4.1 Overall Search Times

Mean response times per condition were derived for each participant and reflected the time taken between the appearance of a bookmark menu and the participant registering that the target bookmark had been detected. Faster response times were taken to be indicative of superior recognition. To retain as much data as possible, response times were scored even if participants failed to find the target bookmark (such failure was actually extremely rare). If a bookmark was not found, a maximum response time of 30 seconds was scored (again, almost all target items were found within the permitted timeframe).

Mean response times are presented in Table 3. Descriptive analyses indicated that these data (and all subsequent data that we report) met assumptions of normality and were suitable for parametric analysis. A two-way repeated measures analysis of variance (ANOVA) revealed that there was no main effect of Informational Structure (top-down vs. bottom-up), $F(1,29) = .155$, $p = .697$, but there was a main effect of Number of Informational Cues (one, two or three), $F(2,58) = 8.443$, $p = .001$. The interaction effect was also unreliable, $F(2,58) = .963$, $p = .388$. Employing the Bonferroni post-hoc test, significant differences were found between the one-cue and two-cue conditions ($p = .001$) and between the one-cue and three-cue conditions ($p = .004$). No significant differences were found between the two-cue and three-cue conditions. These results fail to support our stated prediction that the informational structure of bookmarks would impact upon overall search times. The data do, however, indicate that the number of information cues that are present in a bookmark affect search behaviour: Two cues were seen to be optimal, one cue was highly sub-optimal, and a third cue added no value to the two-cue condition (indeed three cues promoted marginally slower bookmark search than the two-cue condition).

Informational Structure	**Number of Informational Cues**			
	1	2	3	*Mean*
Top-down (i.e., site name first)	13.70 (6.37)	9.90 (5.06)	10.58 (4.29)	11.39
Bottom-up (i.e., article title first)	12.80 (6.05)	11.10 (4.99)	11.49 (5.19)	11.80
Mean	13.25	10.50	11.03	

Table 3: Mean time taken to locate target bookmarks (seconds), with standard deviations in parentheses.

Although the failure to find a predicted effect of informational structure on overall search times runs counter to predictions, we note that there is a clear hint in the pattern of response times for an interaction effect between the Informational Structure and the Number of Informational Cues factors. This is exemplified in the relatively rapid search-time score for the top-down/two-cue bookmark condition (where the site name precedes the article title), when compared against all other conditions. We anticipated that this interaction might manifest itself more clearly in the eye-movement analysis of bookmark salience effects.

4.2 Adjusting Eye-Movement Data for Phrase Length

As the eye-movement data were analysed per area of interest, a raw count of fixations would show misleading results as they do not take into account the differing lengths of the text phrases contained within these areas (i.e., mean phrase lengths of 2.79 words for site names, 6.83 words for article titles, and 1.79 words for the section names). To adjust for these differences, the mean number of fixations per area of interest was divided by the mean number of words in the phrase. In this way, we are able to separate higher fixation frequency due to the simple fact that there were more words to read, and higher fixation frequency because an item was actually harder to recognise. Note that because the mean *duration* of fixations per area of interest is *not* contingent on the number words in the phrase, this latter measure was not adjusted. Eye movements were analysed for 24 of the 30 participants (the data of six participants was of insufficient quality to warrant inclusion in the analysis).

4.3 Eye Movements During the Encoding Task

We explored the amount of processing effort devoted to different informational cues during participants' initial inspection of the news-oriented webpages. Mean (adjusted) fixation frequencies and mean fixation durations per informational cue are presented in Table 4. A one-way repeated-measures ANOVA was used to assess mean fixation frequencies per informational cue and revealed a main effect of Cue Type, $F(2,46) = 68.962$, $p < .001$. Bonferroni post-hoc tests revealed that the element most frequently fixated was the site name, although only the difference between the site name and the section name was reliable ($p < .001$). The article title was also fixated on more frequently than the section name ($p < .001$).

Informational Cue	**Mean fixation frequency**	**Mean fixation duration (ms)**
Site name	2.41 (0.88)	241 (24)
Article title	2.09 (0.63)	225 (20)
Section name	1.08 (0.39)	227 (22)

Table 4: Mean (adjusted) fixation frequency and mean fixation duration per informational cue while browsing the websites (standard deviations in parentheses).

A one-way repeated measures ANOVA was also used to analyse mean fixation duration data. A main effect was found according to the type of informational cue being viewed $F(2,46) = 8.948$, $p = .001$. Bonferroni post-hoc tests revealed that the mean fixation duration on the site name was longer than on the article title ($p = .001$) and longer than on the section name ($p = .021$). The mean fixation durations on the article title and the section name were not reliably different.

4.4 Eye Movements During the Bookmark Search Task

4.4.1 Scanning Strategy

In the bookmark-search task, participants consistently scanned down the left-hand side of the bookmark menu, as has been found in similar studies of menu search (Altonen, 1998). Fixations were largely concentrated in the second 8th of the bookmark menu, which corresponds to the first four letters of the first word of each entry (Table 5). Saccadic movements were also concentrated towards the left of the menu (we do not present saccade data for reasons of space). These data suggest that the lead information in a bookmark has a higher psychological 'profile' than other information. For the purpose of our subsequent analyses we focus exclusively on eye movements associated with the lead cue in each bookmark. This restricted focus should enable the eye-movement analyses to augment the search-time findings described previously.

Position in Bookmark	Fixation Frequency	Total Fixation Time (ms)	Mean Fixation Duration (ms)
1st	1530	492	322
2nd	13368	4180	313
3rd	5191	1199	231
4th	2906	649	223
5th	1820	404	222
6th	1136	249	219
7th	611	135	221
8th	117	24	202

Table 5: Cumulative fixation frequency, cumulative fixation time, and mean fixation duration in relation to areas (divided into eights) of the bookmark menu.

4.4.2 Mean Fixation Frequency

Data relating to the mean fixation frequency (adjusted for phrase length) on the lead cues in bookmarks are presented in Table 6. A higher fixation frequency on lead information was taken to be indicative of greater uncertainty in recognising the target. A two-way repeated-measures ANOVA revealed a main effect of Informational Structure, $F(1,23) = 73.962$, $p < .001$, with bottom-up bookmarks receiving less fixations on lead information than the top-down ones. This finding suggests that having an article title first (as arises in all bottom-up conditions) invokes superior bookmark salience compared with having a site name first (as arises in all top-down conditions). There was also a main effect of the Number of Informational Cues, $F(2,46) = 12.259$, $p < .001$, with the two-cue condition being optimal. This latter finding supports the search-time data reported earlier.

Informational Structure	**Number of Informational Cues**			
	1	2	3	*Mean*
Top-down (i.e., site name first)	1.34 (.44)	0.87 (.35)	1.00 (.46)	1.07
Bottom-up (i.e., article title first)	0.75 (.22)	0.61 (.19)	0.67 (.27)	0.67
Mean	1.05	0.74	0.84	

Table 6: Mean fixation frequency (adjusted) on the lead cues of the bookmark (standard deviations in parentheses).

Interestingly, there was also a significant interaction between Informational Structure and Number of Informational Cues, $F(2,46) = 4.620$, $p = .015$. The number of cues affected fixations differently depending on whether a site name or an article title was the lead cue. Indeed, it appears that top-down structures (which tend overall to be less salient) are much more sensitive to the presence or absence of additional information cues relative to bottom-up structures (whose recognisability seem to be essentially resistant to the presence of additional cues). This interaction effect makes sense in as much as having a site name as the lead information (as arises in top-down conditions) is problematic for bookmark recognition unless the article title appears directly alongside the site name. These fixation-frequency data therefore extend the search-time findings and indicate that users are sensitive to the informational structure of bookmarks. In particular, having bottom-up structures generally improves bookmark salience, with an article-title/site-name structure promoting optimal recognition performance.

4.4.3 Mean Fixation Duration

Data relating to the mean fixation duration on the lead cues in bookmarks are presented in Table 7. In the present study, information which required longer fixations was considered to be less meaningful than information with shorter fixations. A two-way repeated-measures ANOVA revealed a main effect of the Informational Structure, $F(1,23) = 10.437$, $p = .004$, as well as a main effect of the Number of Informational Cues, $F(2,46) = 5.742$, $p = .006$. There was also a significant interaction between Informational Structure and Number of Informational Cues, $F(2,46) = 5.948$, $p = .005$. These findings directly parallel those discussed above in relation to the mean fixation-frequency data.

5 Discussion

5.1 Are There Differences in Bookmark Salience?

In the present study we were interested in the interplay between verbal information structuring and the quantity of informational cues in promoting bookmark salience and recognisability. The study involved taking measures of the overall search time to find target bookmarks, as well as acquiring more detailed eye-movement indices of information salience. In terms of the global search-time measure, faster responses were assumed to indicate superior recognition when participants were searching for a target bookmark within a set of distracter bookmarks. The study revealed no significant difference in the overall time it took to find bookmarks structured in a top-down versus a bottom-up manner, suggesting that, in a gross sense, both structures may have appeared equally salient. On the other hand, the number of cues on display within a bookmark did emerge as a significant factor affecting search times. Two cues within a bookmark were found to be optimal, whilst one cue was clearly inadequate. Adding a third cue did not bring any significant recognition benefit, and, indeed, the three-cue condition was marginally worse than the two-cue condition. The limited benefits of having a three-cue structure may well be due to the 65 character limit associated with the bookmark menu within Internet Explorer™ (i.e., the third cue may often only have been partially visible, thereby negating its potential usefulness).

Informational Structure	**Number of Informational Cues**			
	1	2	3	*Mean*
Top-down (i.e., site name first)	335 (74)	272 (75)	292 (50)	300
Bottom-up (i.e., article title first)	274 (30)	277 (34)	266 (54)	272
Mean	305	275	279	

Table 7: Mean fixation duration (ms) on the lead cues of the bookmark (standard deviations in parentheses).

The failure to find a reliable effect of Informational Structure on overall search times challenged our a priori prediction that this factor would be associated with recognition efficacy. We note, however, that the controls implemented in our study during the encoding phase of each trial did not extend to detailed presentational and formatting aspects of the websites that participants were presented with (e.g., in terms of colour schemes, information layout, logo presence or size). Although we had assumed that such factors would add random variance to the bookmark search-time measure, they may instead have had a more systematic impact than expected, thereby weakening the emergence of Informational Structure as a determinant of the global performance metric. On a more positive note, however, closer inspection of the profile of search-time data across conditions does suggest that top-down bookmarks *were* more sensitive to the existence of extra cues than were bottom-up bookmarks. The top-down bookmark with one cue (i.e., displaying the site name alone) was associated with the slowest search time out of all conditions, but this decreased sharply to the fastest search time when a second cue (the article title) was added to the site name. These results indicate that a site name in a bookmark may be relatively less salient than an article title, that is, the site name appears to 'need' extra information to spark the same level of recognition that the article title can attract by itself. The eye-movement data permitted a more detailed exploration of such effects.

The assumption in the present study was that higher fixation frequencies and longer fixation durations in the bookmark-search task would be indicative of uncertainty in recognising targets (cf. Goldberg & Kotval, 1999; Jacob & Karn, 2003). Increased uncertainty did indeed seem to arise in the present study in the case of bookmarks with top-down structures, whose lead cues were fixated more frequently and for longer overall than was the case of the lead cues of bottom-up structures. These findings suggest that bottom-up bookmarks have more salience than top-down bookmarks, and can thereby facilitate more rapid bookmark search and recognition. In addition, and as was hinted at by the search-time data, eye-movement measures revealed that top-down bookmarks (i.e., those having the site name first) were far more sensitive to the existence of extra cues than were bottom-up bookmarks (i.e., those with the article title first). Thus, whilst bottom-up bookmarks appeared to be equally salient, regardless of the number of informational cues, top-down bookmarks involving either a single cue or three cues were linked to poor task performance, which was only ameliorated in the two-cue, top-down condition. Indeed, it seems important to emphasise that when viewed in isolation, the site name was considerably less salient than all other conditions, as it was fixated for far longer and with a greater frequency of fixations.

Interestingly, too, when we consider the encoding phase of the test (i.e., when participants read through the news websites) it was observed that site names actually received greater attention than article titles. They were fixated more frequently and for longer on average, serving as further evidence that site names may be more difficult to encode meaningfully. Moreover, despite being subjected to more scrutiny during initial encoding, site names still ended up being less salient for subsequent bookmark recognition than did article titles.

5.2 Factors Promoting the Salience of Article Titles

The improved recognition salience for bottom-up bookmark structures (i.e., those that have article titles as lead cues) raises the issue of what causal factors might promote such effects. One explanation may derive from schema theories of memory organisation (Alba & Hasher, 1983) which emphasise how existing knowledge can make new information easier to remember. 'Meaning' is essential if we are to remember something effectively (Rumelhart & Norman, 1985), and schemas can readily enable the derivation of meaning from information. So, for example, article titles typically 'tell a story' that has intrinsic meaning (e.g., about an election defeat or a terrorist incident). Site names however, at least for news websites, certainly have a lower capacity for rich meaning as they involve abstract names unconnected to the news stories they provide. It is also noteworthy that imaginable and concrete items can be easier to remember as they are represented more richly in memory (Paivio et al., 1968). Article titles tend to embody more imaginable, concrete words that site names, which can often be rather abstract, so an advantage in recognition value may be further facilitated by this difference.

5.3 Generality and Future Studies

The study could be criticised on the grounds that any real-life situation might include location memory for menu entries (Hornof & Kieras, 1999). The main counter-argument is that bookmark lists can be left for a long time or re-arranged, and menu positions can be forgotten. Another rebuttal stems from the fact that pages saved on hard drives are often left in archives for a long time and can be re-ordered in many ways, thus disrupting memory for entry location. In these cases the users would have to rely on the text content of the bookmark.

We believe that our findings should generalise most effectively to sites that share a similar information hierarchy to those that were used in the present study, although assessing such generalisability remains an empirical issue. We also acknowledge that our results do not warrant the prescription of a single universal bookmark structure that is applicable to all contexts. Instead, we take the view that optimising bookmark structures for different kinds of information-retrieval tasks is best assessed through empirical methods of the type that we have advanced here. In addition, there may be more factors affecting the salience of bookmarks than could be revealed in the present research, which tests for short-term recognition. For example, further studies could explore longer cut-off times on the bookmark search task, or introduce longer delays between the viewing of the website and the appearance of the bookmark menu. The effects of familiarity could also be investigated: Are people more likely to recognise pages that come from websites that they use regularly?

Eye-movement data on the websites themselves could be analysed to make recommendations for the bookmark text based on the pattern of eye movements while encoding. For example, the URL was looked at quite often in the present study, which indicates that it may be a significant navigational cue. Similarly, previous research on graphical bookmarks (Cockburn et al., 1999) could be replicated using eye-tracking measures for a more detailed analysis of recognition value. Finally, further studies could be performed to refine the test protocol so that companies can use the technique to find out how to organise information structures in large-scale information-retrieval tasks. Application areas include information architecture, knowledge management, database engineering and web design. Some specific proposals that can be made in relation to website developers and browser designers, respectively, might be: (1) for the former to use additional mark-up in the HTML <title> element to separate and identify the different types of informational cue; and (2) for the latter to implement a facility that allowed users to re-order these bookmark cues to show the most salient attribute first (just as can be done with file listings that can be structured by, for example, filename/type/date and the like).

6 Conclusions

The number of informational cues present within a bookmark was seen to affect overall search times to detect that bookmark when embedded in a menu of distracter items. Two informational cues were optimal, one cue was highly sub-optimal, and three cues was marginally worse than the two-cue condition. The informational structure of bookmarks (i.e., whether informational cues were organised in a top-down or bottom-up manner) appeared, perhaps somewhat paradoxically, to have no reliable impact on the basic search times to find a target item. However, more detailed eye-movement analyses of fixation behaviour on target bookmarks revealed interactive effects of both experimental factors (informational structure and number of informational cues), suggesting that the efficacy of bookmark recognition may well be dependent on having an optimal combination of information organisation and cue quantity. In particular, the eye-movement data indicated that effective recognition of top-down bookmark structures (e.g., where the site name is the lead information) may be highly context sensitive. In larger-scale information repositories than the one studied here it is possible that the informational-structure factor could be further amplified such that it could have an even more marked effect on search behaviour. Overall, we believe that our findings support the contention that web developers would do well to exercise caution in designing navigational schemes and data structures to support webpage revisitation via bookmarks. Even small changes in bookmark salience could have serious consequences for revisitation efficacy.

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