

# WaveLens: A New View onto Internet Search Results

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## ABSTRACT

Internet search results are typically displayed as a list conforming to a static style sheet. The difficulty of perusing this list can be exacerbated when screen real estate is limited. When space is limited, either, few results are seen, or result descriptions are abbreviated, making it difficult to know whether to follow a particular web link. In this paper, we describe “WaveLens,” a dynamic layout technique for displaying search results, which addresses these issues by combining a fisheye lens with progressive exposure of page content. Results from a usability study showed that participants performed faster and more accurately on a search task with one of two distinct parameter settings of WaveLens as compared to the typical static list. In a post-hoc questionnaire, participants favored that setting over both the static list and another setting which involved animated zoom. We discuss design implications for the retrieval and display of search results.

## Author Keywords

Information retrieval, information visualization, user interface

## ACM Classification Keywords

Database access/Information Retrieval, World Wide Web and Hypermedia, Visualization, User Studies

## INTRODUCTION

Internet search results are typically displayed as a list conforming to a static style sheet. The difficulty of perusing this list can be exacerbated when screen real estate is limited, in which case, few results are seen and scrolling may be required to find relevant results. Or, alternatively, result descriptions are abbreviated, making it difficult to know whether to follow a particular web link. With a static style sheet, there is a tradeoff between showing more text in the description and losing search results below the window

frame. To address this tradeoff, we introduce a dynamic layout technique for displaying search results called “WaveLens.” WaveLens combines a fisheye lens, to compact the search result list, with progressive exposure of page content, to show more text as desired by a user.

This paper is divided into two contributions. First, we elaborate on the WaveLens technique and its parameter space. Second, we describe the results of a usability study in which participants engaged in a search task with two distinct parameter settings of WaveLens as compared to the typical static list. We report both quantitative and qualitative measures, and discuss design implications for the retrieval and display of search results.

## WAVELENS

The WaveLens technique is motivated by the tradeoff between showing more description text in the search results and losing a greater number of results below the window frame. The WaveLens technique utilizes a fisheye lens to compact the number of search results that can be seen without scrolling. In order to show more description text as desired, additional page content is progressively exposed based on mouse activity, such as hover and click. By integrating a fisheye lens with text insertion, the WaveLens technique allows the layout of the search result list to be dynamically adapted to user interaction.

## Fisheye zooming

In the WaveLens technique, a fisheye lens is applied vertically, not horizontally, around the focal center [15]. In the case of a search result list, the focal center is a single result item comprising the title, description, and URL of a web page, as shown in Figure 1. Since the description, title and URL are typically shown in the same font size, the focal center is flat, similar to the Perspective Wall [16]. The peripheral context, which, in this case, comprises results below and above the focal center, is decreased in a piecewise fashion. As such, the WaveLens technique constitutes a type of piecewise fisheye view [15]. Parameter settings allow designers to change the magnification factor above and below the focal center independently, and also to fix a minimum font size so as to maintain readability of the text. Again, a tradeoff prevails between the readability of search results, and fitting more results into the window frame. Figure 1 demonstrates how the parameters can be adjusted to generate a traditional

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fish-eye view around a search result, where items above and below are gradually smaller so as to display more items in the window frame. The minimum font size in Figure 1 is 8 point San-Serif.

Along with the magnification factor, the rate of magnification can be controlled by incrementally adjusting the zoom until the target level is reached. In a web browser, the effect is animated text that enlarges and settles into its maximum size. While the magnification rate controls the speed at which zooming occurs, another parameter, based on the shape of the magnification function [15], controls the size of the zoom increments. With a step function, the text immediately jumps to the maximum magnification factor upon mouse action. Other geometric and exponential functions allow the text to grow and settle in at varying acceleration.

Finally, a delay parameter controls the onset of the zoom. If the delay is set to zero and magnification is tied to the mouse hover event, as the cursor moves over each search result, a wave, with the result focused at the crest, appears to follow the direction of the mouse. The WaveLens technique derives its name from this effect. In conducting the usability study, we decided not to set the zoom delay parameter to zero since users found the constant motion distracting, if not disorienting.

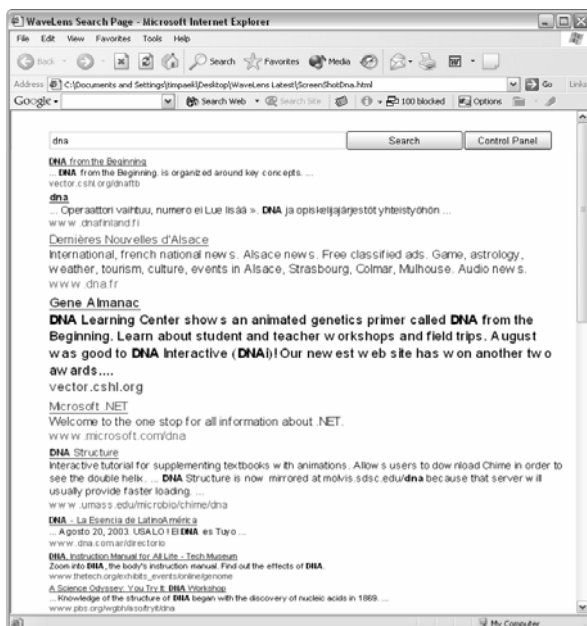


Figure 1. WaveLens technique with parameter settings to generate a traditional fisheye view.

### Text insertion

In addition to being able to control the number of results visible without scrolling using a fisheye lens, the WaveLens technique addresses the need for more description text by managing the progressive insertion of additional content

based on mouse activity. Just as zooming can be initiated by a mouse hover or click event, so can the onset of text insertion. As such, it is incumbent upon the designer to decide how best to couple text insertion with the gradual zooming of a focused result.

Similar to zooming, text insertion can be adjusted according to the rate of insertion, as well as the size of the chunks (i.e., whether the increments should be in words or phrases). A delay parameter directs the onset of the insertion.

The flip side of text insertion is text deletion, which can be keyed off either a mouse hover or click event. Deletion never extends beyond the original text of the search result. When text deletion is tied to a mouse hover event, it can commence when the cursor enters a different search result item or when the current focus is lost. This flexibility allows a user to simply move the cursor outside of the window frame to initiate deletion. When text deletion is tied to a mouse click event, it can begin when the user either clicks on the description or on another result. Like text insertion, text deletion can occur all at once or proceed at a specified rate with a specified onset delay. We found the delay to be extremely useful when the user zooms in on another item and de-magnification shrinks the focus too quickly. One final parameter allows the inserted text to persist and continue to augment with further mouse activity instead of being deleted.

### Implementation

The WaveLens technique has been implemented in DHTML using the DOM for IE5 and above. All client-side code is written in JavaScript and a server-side ASP.NET C# web application pre-fetches web pages and extracts text for insertion. A control panel allows designers to adjust the many flexible parameters in WaveLens. For the purposes of the experiment, we fixed the parameters as summarized in Table 1, which we describe in more detail in the Experiment section.

### RELATED RESEARCH

The WaveLens technique is designed to help users assess and interpret lists of search results. One aspect of design concerns what information to present (e.g., what text or other page attributes to show). Another aspect of design concerns how to present the additional information (e.g., what interaction control to use and the dynamics of presentation).

The cognitive demands associated with choosing whether or not to follow a link have long been noted in the context of general hypertext research [1]. Landow's work on rhetoric of departure [14] and Furnas' more recent work on information scent or residue [7] highlight the importance of showing readers cues about information that will be found at the destination. Early hypertext systems like Hyperties provided short summaries or glosses of each link at the bottom of the page [17]. Microsoft Internet Explorer uses

“tool tips” or “hover text” to show additional content as a pop-up window [18]. Zellweger and colleagues have explored the use of “fluid links”, and more generally fluid documents, to show additional information about hyperlinks using a variety of different presentation techniques (e.g., inline, inline in smaller font, in the margin, as a textual overlay, etc.) [22]. Kopetzky and Muhlhauser [12] and Stanyer and Proctor [19] have also explored link previews in the context of general web browsing using ideas motivated by research on magic lens filters. Much of this work on link previews focuses on system architecture and not on usability of the resulting systems. In addition, the work does not specifically address information presentation for search results.

The most common presentation technique for displaying web search results is to show the title, URL and a short summary or gloss of each result. The summaries are sometimes the first few lines of the destination web page. More recently, query-biased summaries, which show sentence fragments that match one or more query terms, have become popular. The query-biased or contextual summaries highlight the query words in context, and such highlighting has been found to be useful in information access interfaces in general [13]. There is also experimental evidence to support the use of contextual summaries as a means of helping people decide which search results to follow [2], although very few queries were used in the experiments. The use of key sentences extracted from the text on destination pages has also been tried recently with encouraging results for improving web searching [20], although again few queries were used. Thumbnails of web pages have also been examined as a technique for providing additional information about the content of destination pages [4,21].

The above mentioned techniques for enhanced content presentation of search results are static, in the sense that they appear for all search results and independent of user interactions. Golovchinsky and Chignell’s VOIR system [8] allowed users to control the number of search results displayed, although not the nature of that content. Dumais et al. [3] explored the use of hover text to present additional details about search results based on user interaction. Searching was slower with hover text. The authors posit that this is because hover text required explicit decisions about when to seek additional information, and the hover text itself covered some of the search results.

Web search engines are experimenting with richer presentation techniques that allow users to control the presentation of additional details. Fizzle shows web pages inline in a scrollable pane [5], and Google Labs shows web pages in slide-show mode [9]. To our knowledge, there are no controlled experiments comparing these enriched control and presentation techniques with standard list views of search results.

The WaveLens technique allows for highly interactive progressive exposure of additional content for search results. We now describe an experimental comparison of two points in the WaveLens design space as well as the standard search results list to explore the use of dynamic presentation techniques in web searching.

## EXPERIMENT

To assess the usability of the WaveLens technique, we conducted a controlled experiment in which participants engaged in a search task using a list of Internet search results. All questions had answers that could be found in one search result on the list. We controlled the location of the answer with two binary variables: *Require Scrolling*, indicating whether or not the result containing the answer required scrolling to be found, and *Answer Location*, indicating whether or not the answer was readily available in the usual description text or required examining additional content invoked by mouse action.

Since the WaveLens technique is guided by a number of flexible parameters, part of the purpose of the experiment was to consider points in the parameter space we considered to be both functional as real designs and theoretically interesting to compare and contrast. We chose two points that varied along two dimensions: first, the amount of text that was inserted into the description, and second, the interaction style, which couples the type of mouse action that triggers the insertion with the magnification factor. We refer to these two points as the WaveLens *Instant* and *Dynamic* views. (We describe how additional text was selected in the Stimuli section below).

In the Dynamic view, the interaction style is coordinated with the amount of text so as to progressively insert text into the description the longer the mouse hovers over a particular result. When the mouse moves to another result and hovers, the new focus increases in magnification and content, and the old focus shrinks back to its original state.

	Normal	Instant	Dynamic
Magnification factor	1	1	1.7
Minimum font size	10	10	8
Additional text	Actual web page	Query-relevant phrases	Query-relevant phrases
Trigger for additional text	Mouse click	Mouse click	Mouse hover
Delay for additional text	0	0	1500 msec
Rate of additional text	All at once	All at once	750 msec / phrase
Trigger for loss of text	Mouse click	Mouse click	Mouse hover
Delay for text loss	0	0	3 sec
Rate of text loss	All at once	All at once	100 msec / phrase

**Table 1. Summary of parameter settings for the Normal, Instant and Dynamic views.**

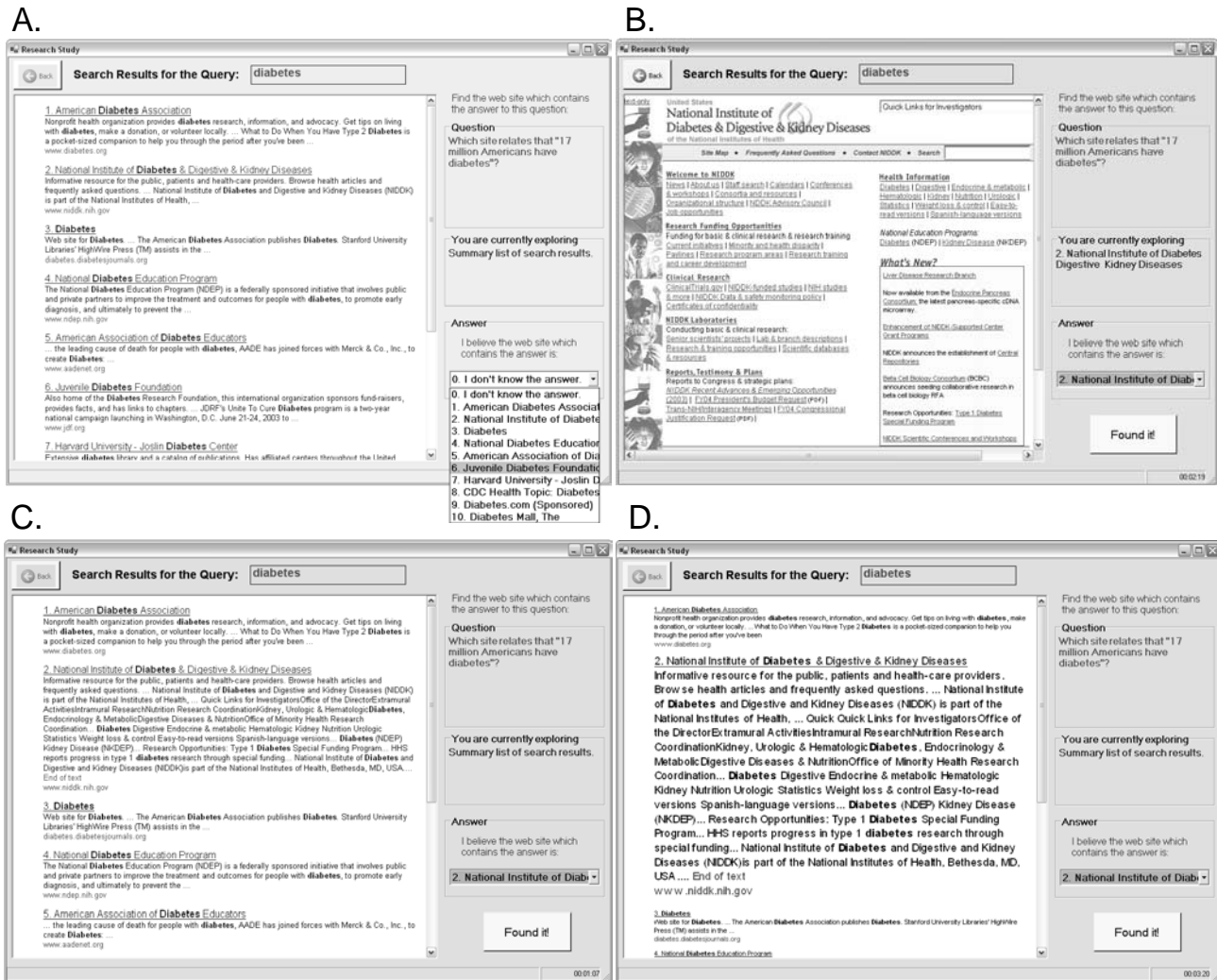


Figure 2. Experiment browser showing the Normal view in panel A and B, the Instant view in panel C and the Dynamic view in Panel D.

A minimum font size of 8 point San-Serif was used, and the magnification factor for the Dynamic view was set to 1.7. The onset of text deletion was delayed for 3 seconds and additional phrases were added at a 100 millisecond rate. In the Instant view, all of the additional text is displayed simultaneously. The interaction style is a mouse click with no zoom (i.e., a magnification factor of 1). When another search result is clicked, additional text for that item is inserted for the new focus and removed from the old focus. Table 1 summarizes the differences between the WaveLens views we studied.

The Instant and the Dynamic views were selected to examine the effect of animation as magnification and text content increased and decreased. Note that the Instant view maintains all the benefits of additional content without involving animated zoom, which characterizes the Dynamic view. We return to discuss the differences between the Instant and Dynamic views in the Discussion section.

In addition to the two WaveLens views, we included a view that is typical of the current practice of using static style

sheets to display search results, which we call the *Normal* view. In the Normal view, the full web page (including both text and graphics) is shown when the title hyperlink is selected. The full web page replaces the list of search results, and a back button is used to return to the search results list.

With respect to style sheet, the Instant view utilized the same style sheet for the title, description, and URL as the Normal view. The Dynamic view starts off looking very similar to the Normal view, but changes as the user interacts with results to show more of some and less of others. The top two panels, A and B, of Figure 2 display the Normal view. Panel C shows a fully expanded Instant view with the same style sheet as the Normal view. Finally, panel D displays a fully expanded Dynamic view, which features the same additional text as the Instant view, but magnified. Note also that in the Dynamic view, the text of surrounding results is reduced in size. For the magnified result shown in Panel D, the full expansion took less than 4 seconds to complete (at a magnification rate of 50

milliseconds with a 1 second delay, and an insertion rate of 750 milliseconds with a 1.5 second delay).

## Method

### *Procedure*

We compared the Instant and Dynamic WaveLens views against the Normal view in a search task. Participants were asked to find a web page that contained the answer to a question, from among a list of ten search results. The task was performed on a standalone WinForm application written in C# using a WebBrowser Control to display the search result list. Figure 2 displays the application as participants saw it for the test question, “Which site relates that 17 million Americans have diabetes?” and the web query “diabetes.” The query keywords (in this case, “diabetes”) were highlighted in bold wherever they appeared in the search results. In the Instant and Dynamic views, they were also highlighted in the additional text content. In the Normal view, the presentation of the full web page was not altered. Since the experiment sought to compare task completion time due solely to the different presentation views, participants were not allowed to change or resubmit the specified web query. Test questions for each query were selected to make sure there was always a unique answer. Participants were told that the answer was either in the result list or one click away. They were reminded of this during the task if they happened to pursue web pages more than one click from the result list.

Once participants found the answer, they selected it using a drop down box, as shown in panel A. Participants always had the option of selecting “0. I don’t know.” In order to remind participants of what search result they were exploring, a section labeled “You are currently exploring” on the right hand side of the result list specified which item number they were investigating, as shown in panel B.

Participants were asked to complete each question as quickly as possible but not at the cost of accuracy. To prevent participants from spending too long on any given question, a dialog box appeared after 3 minutes notifying them they could select the “I don’t know” option, if they felt they could not find the answer.

### *Stimuli*

In creating the search result lists for the experiment, web queries were selected from logs of the MSN search engine. Queries were selected from a broad range of topics, including celebrities, science, literature, current events, etc. Queries did not exceed more than a few words. All queries selected occurred at least 1500 times in a given day and were ranked among the top 1000 search queries for that day.

After retrieving several pages of results for the selected queries, the list was pruned to ten using the following criteria: All results had to be in English with page content that could be extracted and successfully cached from the anchor tags. Results were discarded if they contained

offensive material, or embedded script that posed problems for our experiment browser. All results were locally cached on the machine used for the experiment. There were 24 test queries and 3 practice queries.

After pruning the result list, questions were constructed with a unique answer that could be found in only one of the ten results. The location of the answer varied based on the two variables of interest discussed previously, Require Scrolling and Answer Location. If the answer required scrolling, the answer was placed so that it was not visible in the window frame of the experiment browser in Figure 2. If the answer was located in the description text, it was visible in the description text of one of the ten results. If the answer was located in the additional content, additional interaction was needed to expose it – clicking on the link in the Normal view, clicking on the result in the Instant view, or hovering over the result in the Dynamic view.

To select additional text from the extracted page content, regular expressions were used to cull text phrases in the HTML body of the web page that contained any of the query keywords. These keywords were highlighted just as they are typically in the result list. By extracting keyword phrases, the additional text provides users with a more complete contextual summary than is given in the limited screen space typically devoted to summaries.

### *Design*

The experiment was a 3 (Interfaces) x 2 (Require Scrolling) x 2 (Answer Location) within-participant factorial design. Search task completion time was the main dependent variable. In addition, we looked at search accuracy, mouse movements, and qualitative questionnaire ratings. We used an equal number of test questions which had both an answer that required scrolling and did not, as well as one that could be found in the usual text description or required exploration. Presentation of search tasks was blocked by Interface. Participants completed 1 practice task and 8 experimental tasks in each interface condition. Order of presentation of the interface conditions was also counter-balanced across participants.

### *Participants*

Participants were 18 adults from the Seattle metropolitan area. They were mostly of intermediate web ability with some familiarity with web searching, and represented a wide range of ages, backgrounds, jobs, and education levels. In a follow-up questionnaire, all participants reported using the Internet at least every week, with half of the participants using a search engine every day.

## RESULTS

After participants finished the study, they filled out a questionnaire in which they rated each view along a Likert scale and selected their preferred view. They also received open ended questions in which they wrote what they thought were the best and worst aspects of each view. Before relating the qualitative results from these open-

ended questions, we report how the views compared on quantitative measures.

## Quantitative

### Search completion time

Search completion time was defined as the total amount of time from receiving a test question to clicking the “Found It” button after having selected an answer in the drop down box. We performed a one-way ANOVA on the correct and completed questions (i.e., those questions to which participants did not answer “I don’t know”) and found main effects for Interface ( $F_{2,304}=3.92$ ,  $p<.05$ ), Require Scrolling ( $F_{1,304}=4.93$ ,  $p<.05$ ), and Answer Location ( $F_{1,304}=15.47$ ,  $p<.001$ ). We did not find any significant interaction effects.

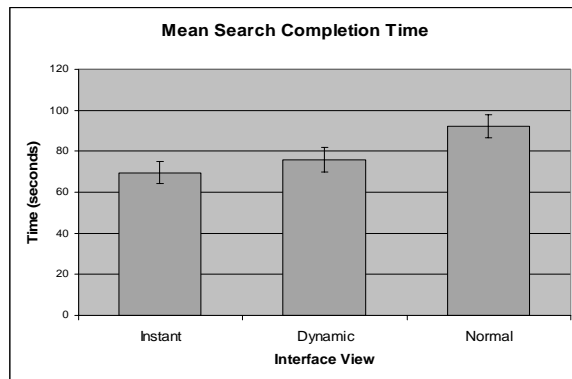


Figure 3. Mean search completion time for Interface.

Figure 3 shows the mean search completion times for the three views. Participants completed the search tasks in an average of 69.6, 75.8, and 92.0 seconds for the Instant, Dynamic and Normal conditions, respectively. Both WaveLens conditions were faster than the Normal condition in spite of the fact that participants were familiar with the Normal view. Post-hoc multiple comparisons using the Tukey test revealed a significant difference between only the Normal and Instant views ( $p<.05$ ). The difference between the means of the Normal and Instant conditions is 22.4 seconds, which represents a roughly 25% advantage.

Even though all web pages and additional summary text were cached locally, load times differed slightly across conditions. In the case of the Normal view, graphics such as images just take longer to load than text. In the case of the Dynamic view, additional text was not shown for 1.5 seconds after hover and then it was shown progressively, both of which require additional time. Average Normal view downloads were less than 2 seconds and full expansion took less than 3 seconds in the Dynamic view. Since the mean number of clicked items in the Normal view was 2.2, load time differences were not enough to account for the difference of 22.4 seconds between Normal and Instant views. Load time differences could, however, account for the lack of a significant effect between the

Dynamic and the Instant views, given the parameter settings we used for the experiment.

Figure 4 shows the mean search completion time for Require Scrolling, and Figure 5 shows the same for Answer Location. The difference between means is 14.6 and 25.8 seconds respectively. The main effect for Require Scrolling reflects that it takes longer to find items down the list. The main effect for Answer Location reflects that additional content is only exposed on direct user actions (hover or click, depending on the condition). This requires additional time.

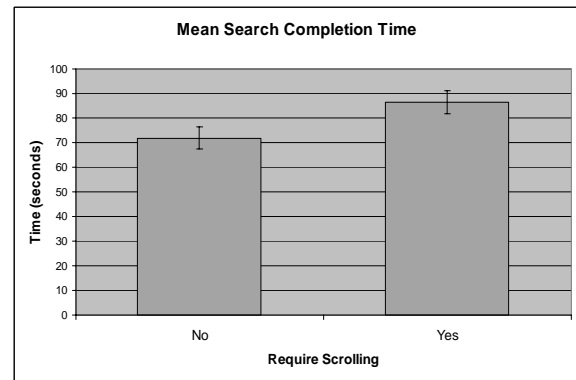


Figure 4. Mean search completion time for Require Scrolling.

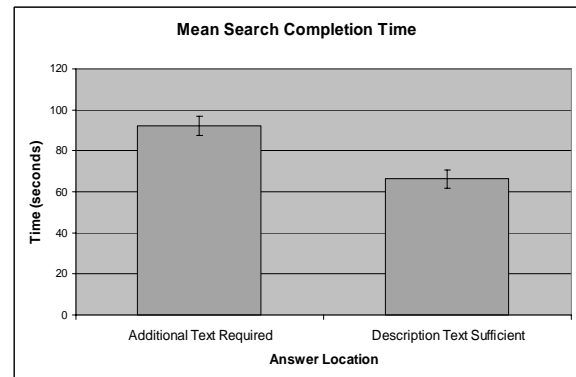


Figure 5. Mean search completion time for Answer Location.

### Don't know and error responses

Participants gave up on some questions by selecting the “I don’t know” option. They responded as such to 18.4% of the questions in the Normal view, 8.3% of the questions in the Instant view, and 6.9% of the questions in the Dynamic view. Hence, participants were not only slower with the Normal view than the other two, but they were more than twice as likely to give up. Since most of the “I don’t know” responses came after the 3 minute timer reminded participants that they could give up, the differences in search time in practice may even be larger than those noted above. For questions in which participants found an answer, we scored whether their selection of the answer

page agreed with our selection. The error rates were 18.7%, 14.4%, and 16.4% for the Normal, Instant, and Dynamic views respectively. The important point for interpreting completion time is that the error rates were comparable across conditions.

#### Mouse activity

For all questions, we recorded the amount of time the mouse was spent on each search result for the Normal, Instant, and Dynamic views. The mean dwell times were 39.6, 43.1, and 39.6 seconds respectively, with no significant differences between conditions. We observed a wide range of individual differences in the way participants used the mouse; some used their mouse to guide reading of the search results, and others simply did not. However, no differences across presentation conditions prevailed.

#### Qualitative

##### Subjective preferences

On the questionnaire, all participants preferred either the Instant or Dynamic view over the Normal view. Asked to choose their favorite, 7 of the 18 participants picked the Dynamic view, and the rest picked the Instant view. The participants were also asked to rate each of the views on a 7 point Likert scale (where 1=Dislike, 4=Neutral, 7=Like). The mean ratings were 4.2, 6.1, and 4.4 for the Normal, Instant, and Dynamic views. Only the Instant view was significantly different from the Normal view ( $t_{18}=-4.62$ ,  $p<.001$ ). Despite the fact that 38.9% of the participants preferred the Dynamic view, it did not differ in rating from the Normal view since the ratings for the Dynamic view demonstrated high variance (e.g., 5 ratings of 1 or 2, and 8 ratings of 6 or 7). The Instant view, in contrast, had 14 ratings of 6 or 7 and no ratings of 1 or 2.

To better understand participant preferences, we analyzed the most common responses to the open-ended questions about the best and worst aspects of each view. The best aspect for the Normal view was its familiarity. The worst aspect was having to actually go to the web page to look for additional content. The best aspect of the Instant view was its ability to instantly get additional text for a search result whenever desired. The worst aspect was that sometimes the length of the text retrieved was overwhelming. Finally, the best aspect of the Dynamic view was its large font size which enhanced readability. The worst aspect was focal disorientation and lack of control. As several people noted, when they hovered over a result, sometimes as it grew larger, the mouse would accidentally hover over another result, causing that item to grow and the previous item to shrink. Similar focus targeting problems have been noted by other researchers [10].

Even participants who liked the Dynamic view thought that more training would be required to get used to the interaction style. With only 8 search tasks for the Dynamic view, it might have been difficult to get the interaction technique down.

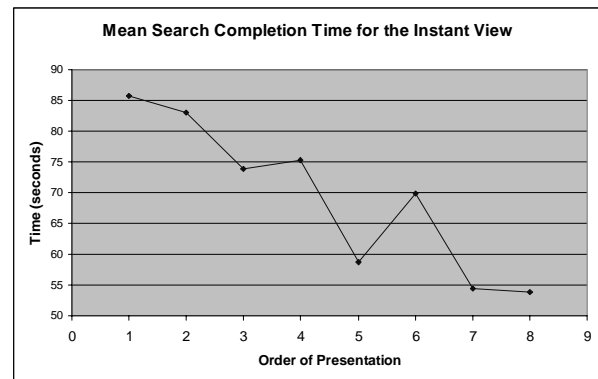


Figure 6. Improvement in search completion time for the Instant view.

It is interesting to note the effect of training on the Instant view, as revealed in a main effect for order of presentation ( $F_{7,292}=2.52$ ,  $p<.05$ ). Figure 6 displays a plot of the mean search completion time as a function of presentation order, which shows a significant downward trend towards faster completion time ( $t_{24}=11.22$ ,  $p<.001$ ). No item effect was observed, and questions were randomly generated. One possible explanation for this trend is that participants learned to be more selective about which search results to expand for additional content since oftentimes, the extracted text was lengthy.

#### DISCUSSION AND DESIGN IMPLICATIONS

We examined three different presentation views, two of which explored points in a very rich WaveLens design space of interaction techniques, distortion functions and dynamics, additional content to display, and presentation style. Our findings suggest that additional query-relevant text should be made readily available to users on demand; Both WaveLens parameter settings were preferred to the Normal view, and resulted in faster task completion times, although this effect was only reliable for the Instant condition.

It is important to note that the Dynamic view represents just one point in the parameter space for dynamic information presentation. Two aspects of its current design presented problems which can be improved for future studies. As noted above, targeting was a problem in the Dynamic view. Since search results are usually explored in a top-down manner, we believe that we can mitigate this problem. In addition, text was progressively deleted when the mouse was placed outside the focus region (e.g., when participants used the scroll bar). Several participants commented that this was unexpected. This can be addressed in several ways. We could delete text only when new text is inserted. Alternatively, we could decouple zooming from text insertion or deletion and have all the text expanded as in the Instant view. Finally, we could provide visible guides indicating where users can rest their mouse without

initiating animated zoom. In short, the Dynamic view may be more useful with additional interaction dynamics.

In comparing WaveLens to existing practice, we need to further tease apart possible confounds. In the Normal view, keywords were highlighted in the summary, but not when the full web page was displayed, since this is common practice. In the WaveLens views, content was highlighted in both the summary and in the additional content. To separate highlighting and content presentation, we would need to highlight the keywords in the web page as well.

In addition to improving the dynamics of the fisheye view and the presentation of additional content, we note several other interesting directions for presenting search results. In our experiment, zooming always displayed query-centric information. However, different types of information could be presented, including thumbnails or additional text that is independent of the query. We plan on exploring such cues. Finally, WaveLens presentation techniques can be investigated in a wider variety of web search tasks.

## CONCLUSION

In this paper, we introduced WaveLens, a dynamic layout technique for displaying search results, which combines a fisheye lens with progressive exposure of page content. WaveLens is motivated by the tradeoff between showing more description text in the search results and losing more results below the window frame. We selected two points in the WaveLens parameter space, the Instant and Dynamic views, and conducted a user study. Results showed that participants completed search tasks more quickly with the Instant view, compared with the Normal presentation of search results. The Dynamic view was also faster than the Normal view, although the effect was not reliable in our experiment. Most participants preferred the Instant view, although several preferred the Dynamic view. We plan to continue to explore the rich WaveLens parameter space to give Internet searchers more flexible control over what content they see when exploring web search results.

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