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The notion of overview in information visualization

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Abstract

Overview is a frequently used notion and design goal in information-visualization research and practice. However, it is difficult to find a consensus on what an overview is and to appreciate its relation to how users understand and navigate an information space. We review papers that use the notion of overview and develop a model. The model highlights the awareness that makes up an overview, the process by which users acquire it, the usefulness of overviews, and the role of user-interface components in developing an overview. We discuss the model in relation to classic readings in information visualization and use it to generate recommendations for future research.

Keywords: Information visualization; Overview; Awareness; Overview+detail

1. Introduction

The field of information visualization is concerned with generating interactive, visual representations of information spaces to amplify users' cognition (Card et al., 1999). Since the 1980s, the field has expanded by establishing its own conferences (e.g., the IEEE Symposium on Information Visualization), its own journals (e.g., Information Visualization), and a lively theoretical and empirical research literature (e.g., Bederson and Shneiderman, 2003; Chen and Czerwinski, 2000; Spence, 2007; Ware, 2000).

A key goal of many information visualizations is to provide a compact representation of the information space so as to assist users in thinking about and navigating the space. The notion of overview has consequently been focal to information-visualization research. Overviews of information spaces offer many benefits to the user. Greene et al. (2000) argued that a good overview "provides users with an immediate appreciation for the size and extent of the collection of objects the overview represents, how objects in the collection relate to each other, and, importantly, what kinds of objects are not in the collection" (p. 381). In addition to supporting interaction with information spaces in general, overviews may support specific tasks like monitoring, exploring, refinding, and browsing.

However, at least two uses of the term overview are found in the literature. Many authors write about users gaining an overview of the information space, which we will refer to as overviewing. Spence (2007) noted that the term overview "implies a *qualitative awareness* of *one aspect* of some data, preferably acquired *rapidly* and, even better, pre-attentively: that is, without cognitive effort" (p. 19, emphasis in original). Other authors speak about overviews mainly as a user-interface component, which we will refer to as overviews. Greene et al. (2000) wrote that "an overview is constructed from, and represents, a collection of objects of interest" (p. 381). The widespread interest in overview+detail visualizations (e.g., Cockburn et al., 2008; Hornbæk et al., 2002; Plaisant et al., 1995) provides examples of authors who use one important understanding of overview in the sense of a technical, user-interface component.

The relation between overviewing and overviews is rarely discussed. While Shneiderman (1996) focused on overviewing in the beginning of his now-famous paper, his subsequent examples are exclusively about overviews. Moreover, papers that deal with overview+detail interfaces appear to

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discuss with surprising infrequency the extent to which the overview component of the interface supports users in overviewing the information space. An implicit assumption appears to be that if an overview is provided, successful overviewing ensues. Thus, while the goal of overview in information visualization is easy to value, its more specific meaning and its referents are less clear.

On this background, the present paper reviews how the notion of overview is used in the information-visualization literature. We analyze how overview is used to discuss both psychological and technical issues in information visualization. We also review how such issues have been studied empirically. From these studies of the literature, we present a model of overview. We discuss it in relation to classic papers and books on information visualization. This discussion is mainly aimed at research, attempting to refine our understanding of overviews and overviewing, as well as to raise new challenges for design and research.

2. Review method

To investigate the meanings and uses of the notion of overview in information visualization, we conducted a literature review. We chose a literature review as our method because we want to systematically describe existing meanings and uses of overview. Previous elaboration of the notion of overview (e.g., Shneiderman, 1996) is too scarce and fragmented to substitute for such description.

2.1. Selection of outlets

In selecting journals and conference proceedings for inclusion in our review we considered outlets dedicated to information visualization as well as prominent outlets within human–computer interaction. Candidate outlets were identified by looking through the reference lists of Bederson and Shneiderman (2003), Card et al. (1999), and Spence (2007), as well as by informal searching of the information-visualization literature. This process resulted in the selection of three journals and two conference proceedings:

- ACM Transactions on Computer–Human Interaction;
- Human–Computer Interaction;
- Information Visualization;
- ACM Conference on Human Factors in Computing Systems (CHI); and
- IEEE Symposium on Information Visualization (InfoVis).

The main criteria in the selection of these outlets were frequency of papers about information visualization and prominence of the outlets. We excluded outlets predominantly about the technical aspects of information visualization because they were unlikely to discuss the notion of overview. Thus, we for example excluded IEEE Transactions on Visualization and Computer Graphics (the proceedings of recent InfoVis symposia have appeared as special issues of this journal; these issues were included in our review through the inclusion of InfoVis). Our review covers the nine-year period 2000–2008 for a total of 3945 papers (see Table 1).

2.2. Selection of papers

Papers were selected in two steps. The first step consisted of selecting all papers with "overview" in the title or abstract. We chose "overview" as a search term because we are interested in the meanings and uses of the overview notion; as the number of papers containing "overview" was manageable there was no need to combine it with additional search terms. Papers were selected if their title or abstract contained the word "overview" or any word or phrase with "overview" as a part, such as "overviews" and "Overview+Detail". In the second step, we read the titles and abstracts to filter away papers that were obviously off target. For example, we excluded the paper "E-mail research: Targeting the enterprise" (Wattenberg et al., 2005), in which the only occurrence of "overview" in the abstract is in the sentence "Finally, we illustrate these lessons with an overview of CUE research strategies in the context of an extended case study of one specific new technology: Thread Arcs." This resulted in the selection of 60 papers for detailed review (see Table 1 and Appendix 1).

2.3. Analysis of papers

Based on reading the abstracts and skimming the full papers we developed a coding scheme, which served as the basis for our analysis. For each of the 60 papers we recorded the main references used in defining overview, some characteristics of the system and data investigated in the paper, and the type of evaluation reported, if any. When an evaluation was reported we further recorded

Table 1
Number of reviewed papers.

	HCI	TOCHI	IV	CHI	InfoVis	Total
Total number of papers 2000–2008	135	162	210	3438	224	3945
Papers with "overview" in title or abstract	2	4	13	62	18	99
Papers about overview	0	3	11	29	17	60

Note: HCI—Human–Computer Interaction, TOCHI—ACM Transactions on Computer–Human Interaction, IV—Information Visualization, CHI—ACM Conference on Human Factors in Computing Systems, and InfoVis—IEEE Symposium on Information Visualization.

characteristics of the test participants, the test tasks, the dependent measures used for assessing overview, and summarized the conclusions of the evaluation. For each of the 1391 occurrences of "overview" in the papers we recorded whether it had a technical meaning by referring to an element of a user interface (e.g., "an overview display") or it referred to the user's mental process of obtaining or maintaining an overview (e.g., "users always have a complete overview of the document"). We also assigned a descriptive keyword to each occurrence of "overview". The keywords grouped the occurrences into categories and resembled a process of affinity diagraming. Finally, we recorded the phrases that were used in the papers as near synonyms for overview. To identify these phrases we read the title, abstract, keywords, and introduction of each paper and, for each occurrence of "overview", the sentence containing "overview" as well as the sentence before and after this sentence. If near synonyms are present, we believe they will be mentioned in one of these places.

The analysis resulted in the creation of a taxonomic model of overview to be presented below. The 20 categories of this model were derived from the coding scheme and descriptive keywords through an iterative process of aggregation, structuring, and description.

2.4. Crosschecking of analysis

To validate our model of overview both authors independently coded all the data with the set of categories that constitutes the final model. The validation was performed in two steps. First, the authors coded a randomly selected subset of 20% of the data, followed by comparison of their codings. Discrepancies were discussed and a consensus was reached. Second, the authors coded the remaining 80% of the data. The Kappa value for the level of agreement between the authors in this second step was 0.82, for the classification of sentences into user-centered, technical, or other. For the classification of each sentence into the taxonomic model, the overall Kappa value was 0.79, with a value of 0.77 for classification of user-centered uses and a value of 0.80 for technical uses. According to Landis and Koch (1977), Kappa values in the range 0.6–0.8 represent "substantial" agreement and values above 0.8 represent "almost perfect" agreement.

3. Review results

Rather than proposing one conceptualization as the single best definition of overview, we have developed a model of overview that incorporates the most important aspects from our review into a unified taxonomy. The short form of this model is

> Overview is an awareness of [an aspect] of an information space, acquired by [a process] [at a time], useful for [a task] with [an outcome], and provided by a [view-transformed] [visualization].

The full taxonomic model appears in Fig. 1, and explanations of its categories in Table 2. The model states that an overview is tied to an object; it is an awareness of something. The model also describes how and when an overview is acquired and what kinds of task and outcome it may support and provide. While these parts of the model emphasize overviewing, the last part characterizes the overview displays that provide users with an overview.

Using the categories in the model, previous definitions and descriptions of overview can be transcribed. For example, Spence's (2007, p. 19, emphasis in original) definition of overview as "a *qualitative awareness* of *one aspect* of some data, preferably acquired *rapidly* and, even better, pre-attentively: that is, without cognitive effort" would be translated to "overview is an awareness of an aspect of an information space, acquired by pre-attentive cues or information reception when initiating a task". Similarly, the "overview first" part of Shneiderman's

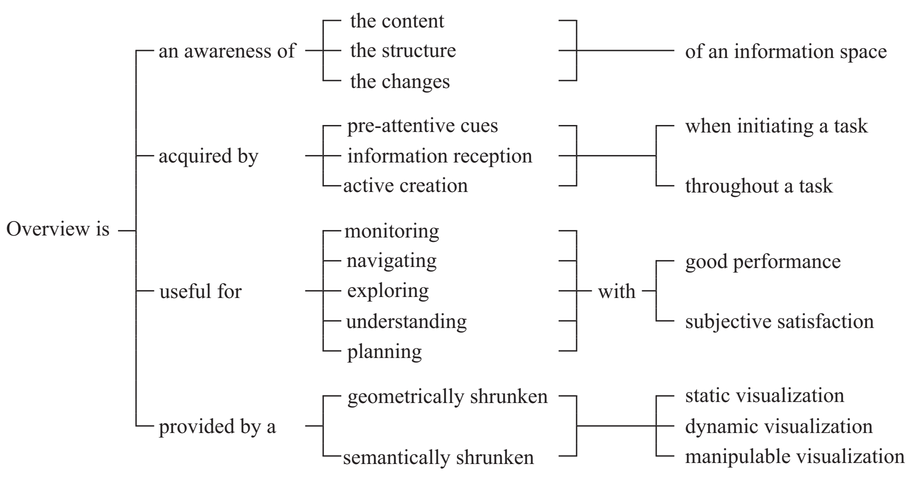

Fig. 1. Taxonomic model of overview.

Table 2
Descriptions of the categories in the model, and the frequency with which each category occurs.

Category	Description	Frequency
Aspect		93
Content	Information about the subject matter of the information space, that is (a subset of) the detail information	27
Structure	Information about patterns, relations, and other aspects of the structure of the information space, possibly relative to a specified focal point	31
Changes	Evolution of the information space in terms of changes in its content and/or structure.	4
Process		126
Pre-attentive cues	Grouping, color coding, and other means of visual popout pre-attentively direct the user's perception of the information space	9
Information reception	An overview is transferred to the user who receives it effortlessly and merely by attending to the information in the overview display	67
Active creation	User makes sense of the information space through active involvement with the overview display	52
At a time		63
When initiating a task	An overview is established at the beginning of a task as a first or early step in solving the task	32
Throughout a task	An overview is maintained throughout a task as a continuous or periodic aspect of solving the task	31
Task		47
Monitoring	User observes the information space and how it evolves, possibly with a focus on anomalies	2
Navigating	User moves through the information space by querying or other navigational means, typically to reach a specific focal point	5
Exploring	User investigates the information space looking for specific information or to discover new information	10
Understanding	User seeks to learn and understand the content of the information space, or part of it	9
Planning	User devises a course of action to achieve a goal related to the evolving content of the information space	2
An outcome		39
Good performance	Users perform tasks efficiently and maintain low rates of error, oversight, and misunderstanding	24
Subjective satisfaction	Users experience satisfaction in their performance of tasks, for example, through feelings of confidence or control	16
View-transformed		100
Geometrically shrunken	A scaling down of the information space by decreasing the magnification of all its elements by the same factor	12
Semantically shrunken	A selective downsizing of the information space by maintaining some features (e.g., structure or landmarks) and discarding others	35
Visualization		378
Static visualization	An unchanging "picture" of the information space, possibly with an indication of the current focus for which details are available in other parts of the interface	310
Dynamic visualization	A visualization that is dynamically updated when the information space is changed through user interactions in other parts of the interface	25
Manipulable visualization	A visualization that enables changes in the information space through user interactions in the overview display	29

Note: The frequency column gives the number of sentences in which the term overview occurs in a sense representing that category, $N=1391$ sentences. The category frequencies in most of the groups sum to less than the group frequency because each group also contained an "other" category, not shown in the table.

(1996) visual information-seeking mantra "Overview first, zoom and filter, then details on demand" suggests a definition like: "Overview is an awareness of an aspect of an information space, acquired when initiating a task". Nine (15%) of the reviewed papers refer to Shneiderman's (1996) information-seeking mantra as their definition of overview; none refer to Spence's (2007) definition. The majority of the papers speak about overview without references and without explicitly defining what it means. We proceed to show how our model of overview is derived from the sample of papers.

3.1. Uses of the term overview in a sample of papers

A total of 1391 sentences were extracted from the sample of papers and each sentence was placed into one of the following groups. Technical uses of overview in a sentence refer to an overview as a user-interface element, for example part of an overview+detail visualization. We found 1126 (81%) such sentences. User-centered *uses* of the term overview include references to the user getting or forming an overview and similar cases, where the user experiences the overview. We found 190 (14%) such cases.

Other uses include cases that were unclear, lacked context (e.g., keywords), or which did not reflect the intended sense of overview (e.g., "to give an overview of the literature"). We found 75 (5%) such cases.

3.1.1. Aspects: content, structure, and changes

User-centered uses of overview concern how overviews are acquired, what it means to have an overview, and what overviews may be useful for. These 190 sentences form the main concern of this review. About half of these sentences mention what aspects of an information space an overview is about, that is, the nature of the information that one is aware of when having an overview. They relate to the topmost row of the taxonomic model in Fig. 1. In many cases, these sentences simply mention that overviews help provide overview information, for instance as in "[t]he latter provides overview information without the need for an additional window" (Zhao et al., 2005). Similar remarks are made in 28 sentences. It is rarely made clear what overview information might be, except perhaps a view of the information space at a more abstract level. Metaphoric phrases like "bird's eye view" (three papers), "broad overview" (two papers), "global overview" (two papers), and "big picture" (two papers) appear to describe a similar understanding of overviewing. Thirteen sentences, however, suggest that the overview is of large sets of data, as in "It provides a good overview for large data sets" (Wang et al., 2006) and "The system provides an overview of the current state and history of large source files" (Gehlenborg et al., 2005). Three sentences speak specifically about getting an overview of "complex data" and six sentences suggest that the awareness is about the entire document collection, for instance by mentioning "collection overview" or that an important activity is "gathering general information about the data set (metadata)".

Some of the 190 sentences are more specific about the nature of an overview. One such group of sentences concerns the content of which the user is aware. Mostly, this is specific to a particular domain or application type, being about "search results", "numerical data sets", "hierarchies", "documents", and "photos". While the awareness that makes up overviewing is mainly about information spaces, two papers speak about the awareness of collaborators and co-workers (Ellis et al., 2007; Gross et al., 2003).

Another group of sentences that characterize awareness concerns structure or relations in the data. For instance, 11 sentences speak of an overview about the structure of a data set. In a paper on supporting collaborators' awareness of each other, one visualization is characterized as providing a good overview of the structure of a shared workspace (Gross et al., 2003). Other sentences similarly highlight how the awareness may be about relations among data, for instance among variables or within a set of information objects. Being aware of the distribution of query terms across documents is also mentioned in three sentences. Eight sentences speak of an overview concerning the context of a data set or more likely the context of a part of the data or of individual data points, for instance by mentioning that "he should maintain an overview and understand the context of the data focused on" (van Wijk and Nuij, 2003).

In four papers having an overview is seen as an awareness of the normal state of affairs or, conversely, an awareness of changes in the information space. For instance, one paper discussing intrusion detection offers as one advantage of a visual interface the following: "Providing an overview of the state of the network and a baseline comparison for normal activity" (Wang et al., 2006).

3.1.2. Process: pre-attentive cues, information reception, and active creation

Many of the 190 sentences speak about the process by which users acquire an overview from visualizations (126 sentences). Surprisingly, only nine sentences emphasize on pre-attentive or very fast acquisition of overviews, as in "Overview displays can support a variety of cognitive functions by providing a common frame of reference for team problem-solving, supporting quick assessment of a system state, enabling rapid shifting between views, and providing pre-attentive cues about where one should focus next" (Cushing et al., 2006, p. 2). Three of these sentences specifically mention that an overview should be glanceable, that is, offering information that can be decoded by a mere glance.

The overview is often described as being acquired in a passive manner, what we call information reception, for example by being provided (35 sentences), given (9 sentences), or offered (2 sentences) to the user. For instance, one paper notes that "the visual interface provided the users with an overview of the state of the network" (Thompson et al., 2007); another that "the purpose of this visualization is to give users an overview of the keywords and co-authorships in the database" (Elmqvist and Tsigas, 2007). Ten sentences suggest that users get an overview, as in "How can a user easily and intuitively alternate between walking around an environment, getting an overview, and examining objects?" (Tan et al., 2001). Other descriptions of acquiring an overview are more active, suggesting active creation of the overview on part of the user. For instance, 13 sentences describe users as gaining an overview of data (e.g., "This allows the user to gain an overview of the area"), and five sentences speak about the user constructing or extracting an overview of the data, for instance (Kildal and Brewster, 2007):

> In particular, information is accessed sequentially and in full detail, providing poor contextual information, which rapidly saturates working memory before an overview of the complete set of information is constructed.

Twenty-two sentences imply that users obtain an overview, as in "Each participant had to obtain an overview of 24 tables" (Kildal and Brewster, 2006), and 12 sentences use some verb form of overview. These counts of sentences suggest that a small majority of the studies reviewed focus on passive reception of overview information (56% of the sentences coded for process) in contrast to the active creation of overview information.

3.1.3. Time: initially or throughout a task

The timing of the process of overviewing is mentioned in 63 sentences. These sentences in part describe the role of overviews when the user first gets in contact with an information space. This may be done by stating that ''most analysts start with an overview of the data'' (Stolte et al., 2002) or ''obtaining overview information is the first task that needs to be completed'' (Cui and Yang, 2006). The initial overview appears to reflect well the earlier quote that overviews should help users ''with an immediate appreciation for the size and extent of the collection of objects the overview represents, how objects in the collection relate to each other, and, importantly, what kinds of objects are not in the collection'' (Greene et al., 2000). Several papers discussing initial overviewing do so by citing the information-seeking mantra (eight sentences), which emphasizes that overviews should be presented first. Most of the sentences do not specify what should or could be part of an initial overview, though one mentions metadata (''A natural way of approaching a set of information previously unknown to a user starts with gathering general information about the data set (metadata)''; Kildal and Brewster, 2006).

Another aspect of the process of overviewing is the need for maintaining or keeping an overview. Five sentences discuss this as in ''overviews to maintain (literally) an overview'' (van Wijk and Nuij, 2003) or as in the following example (Hornbæk et al., 2002):

> The differences observed might be one indication that the overview helped both navigation and keeping an overview: a function that subjects in the no-overview condition had to substitute for more zooming.

Other sentences suggest that the use of auditory information changes the nature of acquiring the overview from something that may be done quickly (following Spence's definition) to a longer process.

Two sentences about the timing of overviewing are particularly interesting in speaking about implicit overviews, for instance as in ''A multilevel map might also be more effective because it provides an implicit overview of the space that users memorize as they navigate the detail view'' (Hornbæk et al., 2002). This quote suggests that navigation and overview creation are intertwined. In contrast, many sentences presuppose that overview tasks and extracting overview information is a conscious, explicit activity separate from navigation and other tasks for which the overview may be useful.

3.1.4. Tasks for which an overview is useful

A large group of sentences focused on the tasks or activities that overviews support. In contrast to the sentences about the nature of the awareness of an information space, these sentences are about the tasks that may be supported by this awareness. Several sentences speak about overview as a task in itself. Sixteen sentences refer to the ability to answer ''overview questions''. For example, one paper mentions that ''Participants performed various overview and detail tasks on geospatially-referenced multidimensional time-series data'' (Yost and North, 2006). Eleven sentences speak about overviewing collections of information. However, these sentences do not help much in understanding what the overview task is about; we return to them in the Discussion section.

Other sentences are more specifically about tasks. The tasks mentioned include the monitoring of an information space, looking for changes or anomalies, as in the following quote:

> We found that the textual interface allows users to better control the analysis of details of the data through the use of rich, powerful, and flexible commands while the visual interface allows better discovery of new attacks by offering an overview of the current state of the network (Thompson et al., 2007).

Five sentences specifically mention navigation, as in ''six subjects mention that the overview+detail interface supports easy navigation'' (Hornbæk and Frøkjær, 2001). Exploring an information space is also mentioned (10 sentences), for instance, when looking for outliers or prominent clusters of data. Six sentences describe high-level analysis tasks, what we call understanding, for instance as in ''high-level tasks relating to influence and overviews'' (Elmqvist and Tsigas, 2007). Finally, planning is mentioned in a few papers. One paper on a naval warfare visualization for decision support describes the planning tasks as follows: ''Our hypothesis was that an effective overview would support users in planning the order in which to make asset assignments, so as to avoid making an arbitrary assignment that would make infeasible a future assignment'' (Cushing et al., 2006).

3.1.5. Outcome: performance and subjective satisfaction

The sentences in the sampled papers suggest various outcomes of using overviews; 39 sentences give examples of such outcomes. A total of 15 sentences speak about overviews that are ''effective'', ''meaningful'', or ''good''. For instance, ''It provides a good overview for large data sets'' (Wang et al., 2006) or ''we show how presentation software can structure a meaningful overview of the underlying content'' (Holman et al., 2006). Unfortunately, these sentences help little in understanding why and how the overview is appropriate.

A group of 24 sentences lists specific performance benefits of overviews. One frequent benefit mentioned is the ability of an overview to quickly convey information (mentioned in nine sentences), for instance as in ''We propose this technique to obtain quick overviews of tabular numerical data'' (Kildal and Brewster, 2006).

Two sentences speak more broadly about overview information being easy to acquire. Another group of 16 sentences discusses subjective satisfaction resulting from overviews. These sentences speak in particular about reducing workload (e.g., "requiring lower subjective workload" or "low overall workload") and about a preference for an interface that provided an overview.

3.1.6. A view-transformed visualization

The 1126 sentences that contain technical uses of overview describe properties of overviews. A total of 100 of these sentences describe the view transformation employed to shrink the information space to the size of the overview display. Twelve sentences mention geometric shrinking. For example Cushing et al. (2006, p. 2) write that "use of zoom factors and thumbnails in the design of overview+detail displays is most appropriate in domains where the data set can be represented literally as a 'big picture' (in a graphical sense)". Different kinds of semantic shrinking are mentioned in 35 sentences, which include phrases such as "abstract overviews", "structural overviews", and "semantic zooming". Semantic shrinking is applied for information spaces as different as fund managers' stock portfolios (Dwyer and Gallagher, 2004), individual documents (Hornbæk and Frøkjær, 2003), networks of metabolic pathways (Dwyer et al., 2008), and wikis to support group communication (Ullman and Kay, 2007).

A variety of information-visualization techniques are used for overviews, including overview+detail (213 sentences), fisheyes (63 sentences), thumbnail overviews (24 sentences), graph overviews (23 sentences), focus+context (21 sentences), treemaps (16 sentences), time-line overviews (7 sentences), heatmaps (6 sentences), cascading overviews (4 sentences), linked overviews (2 sentences), and tag clouds (2 sentences). While these techniques in principle provide for interaction through the overview display, it appears that interaction with the information space is mainly accomplished through detail displays. In 310 sentences the overviews are static, possibly with an indication of the current focus for which a detail display provides additional information (e.g., "a field-of-view box"). Only 29 sentences mention that changes in the information space can be performed through the overviews. Mostly, the possible changes consist of moving or resizing the field-of-view box, effectively using the overview as a scrollbar. However, a couple of sentences mention more extensive manipulations, for example "the ability for a user to make mission assignments from the overview" (Cushing et al., 2006, p. 2). This suggests differences in how tightly overviews are linked to the tasks they aim to support.

3.2. Evaluations of overviews and support for overviewing

Of the 60 reviewed papers, 24 present laboratory experiments, 13 present more informal evaluations, 1 presents a field study, and 22 papers contain no evaluation. We analyze the 24 (40%) papers presenting laboratory experiments to see which kinds of task and dependent measure they use, and what they conclude from the experiments. We only look at laboratory experiments because the two other groups of evaluation have mostly no set tasks (7 papers) or no information about tasks (2 papers).

3.2.1. Tasks used in experiments

Table 3 shows the tasks used in the laboratory experiments. The distribution of the experimental tasks across the task categories is similar to the distribution for the full set of all 60 reviewed papers (cf. Tables 2 and 3). The most frequent category of tasks concerns exploring the information space (13 papers). This category comprises six papers about open-ended search that involves finding a concrete, but ill-defined, object in the information space (e.g., the most influential paper in a citation database), four papers about visual scanning of an area for a well-defined object, and three papers about the identification of trends. As an example of trend-identification tasks, Ellis et al. (2007) asked participants to solve a task that "focused on discerning historical patterns in change tracking data that earlier work suggested were potentially important but hard to detect". While the identification of trends is a rather complex task, visual scanning is a simple task.

The second most frequent category of tasks is simple navigation task (11 papers). This category of tasks consists of searching the information space for a known item, for example navigating to a specified appointment in a calendar (Bederson et al., 2004) or finding a named object on a map (Hornbæk et al., 2002). Notably, Cockburn et al. (2006) had participants find and re-find information in

Table 3
Tasks in the 24 papers presenting laboratory experiments.

Task	Frequency	Sample task
Monitoring	3	Monitor an interface to receive alerts about possible attacks, determine the cause of the alerts, and decide if an attack had occurred (Thompson et al., 2007)
Navigating	11	Navigate to specific calendar appointments or monthly views (Bederson et al., 2004)
Exploring	13	Find the most influential paper(s) or author(s) in a citation database (Hornbæk et al., 2002)
Understanding	8	Write a one-page essay stating the main content of a document just read (Hornbæk and Frøkjær, 2003)
Planning	3	Plan a weekend-long trip to Stockholm considering all the necessary details of transportation, accommodation, and possible activities (Jhaveri and Räihä, 2005)
Other	1	Set parameters defining the animation of an overview display to achieve smooth and fluent animation (van Wijk and Nuij, 2003)

Note: 12 experiments involved only a single category of task, 9 experiments involved two categories of task, and 3 experiments involved three categories of task.

documents varying between 10 and 300 pages. The motivation for the re-finding task was given as "When finding a page for the first time, the participant's search is purely visual, but as they repeatedly search for the same item they are better able to exploit spatial awareness of the target's location" (p. 4). This navigation task enables the authors to reach conclusions about their overview display.

Eight papers use understanding tasks. In five papers participants are asked to make comparisons that require a sense and assessment of two separate parts of the information space. For example, one paper has participants making topological comparisons between nodes in a large hierarchy of data about evolutionary biology (Nekrasovski et al., 2006). In three papers users perform open-ended exploration of the information space and are subsequently tested on their understanding of the content of the information space. One of these papers asked participants to perform open-ended reading of documents before writing essays (Hornbæk and Frøkjær, 2003); it can then be assessed to which degree the document visualizations support understanding the overall structure and argument of a document. Open-ended exploration is particularly interesting because the awareness of the information space is, in part, developed during the task and because the task does not clearly prescribe what to look for.

In three papers participants solve planning tasks that involve decision-making in face of multiple criteria and an information space of complex, interacting information objects. For example, Cushing et al. (2006) had participants acting as military planners performing a mission-to-platform assignment to comply with the commander's intent. Among other things, they used this task to analyze whether participants got "the big picture" and could get "status at a glance", and to assess participants' level of situation awareness. This category of tasks aims to assess overview by participants' ability to perform a task that presupposes an awareness of the information space and involves acting based on this awareness rather than merely acquiring or describing it.

Finally, three papers had participants monitor an information space, stressing the need to notice changes in the structure or content of the information space. For example, the participants in the evaluation of Info-Lotus played a color-picking game while monitoring their emails; the latter being the activity that Info-Lotus aimed to support (Zhang et al., 2005).

3.2.2. Dependent measures in experiments

The dependent measures employed in the laboratory experiments show how the usability of overviews has been assessed, as well as how overviewing has been probed experimentally. Several of these measures are unsurprising. Most experiments employ dependent measures of efficiency, in particular task completion time and error rates. Users' subjective satisfaction and preference are also commonly measured, and some experiments measure mental workload, typically by NASA TLX (Hart and Staveland, 1988). Such measures are similar to those found in the experiments on human–computer interaction more broadly (Hornbæk, 2006).

Three groups of measure are of more specific interest to the aim of this review. First, six experiments measure aspects of participants' learning and memory of the information with which they have interacted, for instance about their retention of the contents of a lecture on elections (Holman et al., 2006) or their incidental learning from interacting with geographical maps (Hornbæk et al., 2002). Using a similar idea, Thompson et al. (2007) looked at whether participants in a study of intrusion detection made discoveries of other potential attacks besides the primary focus of their task. In two other experiments participants were, as a supplement to general satisfaction questions, also asked about their memory for locations (Cockburn et al., 2006; Lam et al., 2007). This group of measures is often associated with monitoring and understanding tasks, and it appears to be motivated by a hypothesis that a successful overview improves learning (or, the awareness of content).

Second, three experiments assess overview by measuring the quality of participants' solutions of understanding and planning tasks, for example by grading essays summarizing the content of the information space (Hornbæk and Frøkjær, 2001) and by establishing the completeness of the plans made by participants (Cushing et al., 2006). These three experiments and the eight that measure aspects of participants' learning and memory address directly the awareness acquired by users through their use of overviews. The remaining 13 experiments either did not measure effectiveness or used effectiveness measures of a sophistication no higher than what Hornbæk (2006) called binary task completion or accuracy.

Third, several experiments assess participants' subjective impressions of overviewing and overviews. Three experiments assess participants' confidence in their task solutions, for instance by asking participants to rate their confidence on a five-point scale (Lam et al., 2007). Two experiments assess participants' feelings of awareness, in both cases using rating scales (e.g., Cushing et al., 2006). Three experiments report questions about staying oriented, and one experiment asks about keeping track of objects (Hornbæk et al., 2002). Four experiments ask about the ease with which information could be located, for instance by asking participants whether "The information I needed was easy to locate" (Baudisch et al., 2002). These measures of participants' subjective impressions are used with about even frequency for all categories of task.

3.2.3. Conclusions about overviews and overviewing in the experiments

In 16 experimental papers an overview is compared with a baseline interface, for a total of 23 such comparisons (ten papers contain one comparison, five papers contain two, and one paper contains three). Typical baseline interfaces are detail-only interfaces, pan-and-zoom interfaces, and

Table 4
Dependent measures and results in 23 comparisons of overviews with baseline interfaces.

Dependent measure	Support for overview	Support against overview	No significant difference	Significance not reported	Total
Task completion time	11	4	6	1	22
Error rate	2	3	6	6	17
Satisfaction	9	1	5		15
Preference	8	1	2	2	13
Mental workload	1	1			2
Learning and memory	3	2	2	1	8
Quality of solution	3		2		5
Feeling of awareness	1				1
Confidence		1	1		2
Ease of locating	1		6		7
Staying oriented	1		3		4
Keeping track of objects	1				1

Note: Sixteen experimental papers contain comparisons of an overview with a baseline interface for a total of 23 such comparisons. In the comparisons significance is determined as $p < 0.05$. For some comparisons a dependent measure is described but the significance of results not reported (column 5).

linear, scrolling interfaces. Table 4 summarizes, for each dependent measure, whether the comparisons provide significant support for overviews. Generally, the results are mixed with support for as well as against overviews on half of the dependent measures, and with a sizable proportion of comparisons yielding no significant difference. The strongest support for overviews is in terms of users' satisfaction and preference. A near unanimous preference for overviews over the baseline interfaces is found in several comparisons that ask users to indicate their preference by rank-ordering the interfaces (e.g., Hornbæk et al., 2002; Zhao et al., 2005). In terms of efficiency, tasks are solved faster with overviews in half of the comparisons that measure task completion time (e.g., Cockburn et al., 2006), but slower in four comparisons (e.g., Thompson et al., 2007). For error rates, only two of 17 comparisons find that overviews are more accurate than baseline interfaces (e.g., Tan et al., 2007), and three that they are less accurate (e.g., Thompson et al., 2007). For the remaining dependent measures, the most apparent pattern is the low number of comparisons.

4. Three classic readings on overview

To challenge the model of overview proposed in the previous section, we next contrast it to three classic readings on overview: Shneiderman (1996), Spence (2007), and Tufte (1990, 1997, 2001, 2006).

4.1. Shneiderman

Shneiderman's (1996) taxonomy of data types and tasks has been very influential in the information-visualization community (Craft and Cairns, 2005). It has been cited more than 1100 times on Google Scholar (as of February 2010), forms part of many courses on Information Visualization, and is the only definition of overview cited in the reviewed papers. Shneiderman focuses in part on design advice for designers of visualizations, in part on tasks information visualizations may support, specifically the task of gaining an overview.

Shneiderman presents the Visual Information-Seeking Mantra as a summary of many existing guidelines for how to design visual interfaces. The mantra reads "Overview first, zoom and filter, then details-on-demand". The reference to overview is thus mainly a recommendation to designers that they should provide an initial overview to users; it is not a characterization of what makes up an overview or the nature of users' awareness when having an overview. The mantra refers to overview as an interface component or configuration that presents users with an initial overview, in the terminology of this paper, a technical use of the overview term.

Shneiderman also writes about the overview task, defined as the activity to "gain an overview of the entire collection". One approach to supporting the overview task is through "overview strategies". Overview strategies, however, appear to be just another way of talking about user-interface components such as "zoomed out views of each data type to see the entire collection plus an adjourning detail view" or "the fisheye strategy". These considerations make Shneiderman suggest that "adequate overview strategies are a useful criteria to look for", suggesting that a simple evaluation for the overview task is to look for an overview component.

Throughout the paper, a few hints at alternative understandings of overviewing are given. For instance, Shneiderman discusses how visual displays in general may be more helpful in "providing orientation or context" and may give "dynamic feedback for identifying changes". The support of a particular interaction technique in helping reveal "global properties" is a further example. Shneiderman also discusses the related task, which is about viewing the relationship between items; something that forms part of our model of overview. Thus, in relation to the model proposed here, Shneiderman's paper mainly sees overview as an initial activity with the aim of helping users understand a document collection.

4.2. Spence

Spence (2007) is the second edition of a textbook about information visualization. The two editions of the book have been cited a total of more than 700 times on Google Scholar (February 2010). Spence approaches visualization from the point of view that "visualization is solely a human cognitive activity *and has nothing to do with computers*" (p. 5, emphasis in original). The role of computers is to support visualization by appropriate techniques for representing, presenting, and interacting with information.

On this basis it is unsurprising that Spence's definition of overview, cited above, is explicitly and exclusively about a mental state and the perceptual and cognitive processes through which it is acquired. That is, he defines overview as overviewing. Another main characteristic of his definition of overview is that it can be acquired rapidly and without any cognitive effort. In keeping with this characteristic, Spence emphasizes visual pop-out effects and "Ah ha" reactions over the active creation and continuous recreation of an overview. This appears to be linked with his focus on perceptual and cognitive processes that are below the level of processes such as problem specification, strategy formulation, and decision-making. While such higher-order processes are heavily influenced by the user's task, Spence addresses overview at a level that mainly concerns the relation between information and how the user visualizes it, not between the visualization and the user's task. An overview may be useful for tasks such as understanding and planning but such tasks and possibly several other tasks included in our model of overview are external to Spence's definition of overview. We have included them in our model because they span from simple to complex tasks and thereby reflect the span of levels at which overview is defined and discussed in the reviewed information-visualization papers.

As in the visual information-seeking mantra (Shneiderman, 1996), Spence (2007) sees overview in contrast to detail, awareness of which he describes as usually involving cognitive effort and rarely occurring quickly (p. 20). Contrary to the visual information-seeking mantra, Spence does not require that an overview should precede an awareness of detail. Rather, overviewing and an awareness of detail may proceed in parallel, supported by alternations between overviews and detail displays. Here, Spence acknowledges that an overview will not always be acquired rapidly but may require both time and cognitive effort. It is also worth noting that Spence includes non-visual media, such as sound, in his concept of overview. Similarly, three of the 60 papers in our review are about auditory overview. Finally, it is notable that Spence defines overview in terms of awareness in the text (p. 19) but in terms of assessment in the glossary (p. 236). While overview is in both cases defined as overviewing, assessment suggests cognitive effort, attention to detail, and maybe even comparison of alternative options. Because this is contrary to Spence's primary focus on rapid, pre-attentive processing, we find that the formulation in terms of awareness best captures Spence's notion of overview and have quoted that version of the definition above. We were inspired by Spence when we in our model defined overview as an awareness, which accommodates pre-attentive cues, information reception, as well as active creation.

4.3. Tufte

Tufte's (1990, 1997, 2001, 2006) work on the graphical display of information is a landmark effort. The four books have been cited a total of more than 8800 times on Google Scholar (February 2010). In contrast to Shneiderman (1996) and Spence (2007), Tufte focuses on static visualizations, typically appearing in documents. A further difference is that Tufte pays particular attention to the visualization of large amounts of multivariate information, because he considers graphics, as opposed to text and tables, particularly suited to the presentation of such information.

Tufte (2001, p. 13) writes that graphical displays should "reveal the data at several levels of detail, from a broad overview to the fine structure". While Tufte states that "Graphics *reveal* data" (2001, p. 13, emphasis in original), suggesting that users passively receive information, his main focus is on graphics that "deliver to viewers the freedom of choice that derives from an overview, a capacity to compare and sort through detail" (1990, p. 38). Thus, Tufte sees overview as an attribute of graphics, defined mainly by its ability to enable users to explore detail actively, efficiently, intensely, and for multiple purposes. This definition has elements of overviews as well as overviewing. In total, Tufte spans most dimensions of our model of overview. Transcribed into our model, he discusses overview as an awareness of the content and structure of an information space, acquired by pre-attentive cues, information reception, and active creation, useful for exploring and understanding with good performance and subjective satisfaction, and provided by a static visualization. Contrary to Shneiderman (1996) and Spence (2007), a contrast between overview and detail is foreign to Tufte, who instead suggests that "to clarify, add detail" (1990, p. 37). This suggestion emphasizes Tufte's preoccupation with making the data stand out and his proposition of achieving this by showing the data and erasing ink that does not show data (Tufte, 2001). Tufte argues that overview is not in contrast to detail but to a large ratio of non-data ink.

As a consequence of his focus on large and complex sets of data, Tufte prefers high-density graphics and mainly focuses on high-level tasks: "High-density designs also allow viewers to select, to narrate, to recast and personalize data for their own uses. Thus control of information is given over to *viewers* […] Data-thin, forgetful displays move viewers toward ignorance and passivity, and at the same time diminish credibility of the source'' (1990, p. 50). High-density graphics present detail in context and thereby show a big picture with its inherent complexity and multiple entry points for further exploration. This way, high-density graphics support overviewing. To do so graphics must effectively show comparisons, causal explanations, and multiple variables, they must integrate different sources of evidence and document these sources, but they must first and foremost provide content (Tufte, 2006). Tufte argues that this can be achieved by designing graphics that ''have at least three viewing depths: (1) what is seen from a distance, an overall structure usually aggregated from an underlying microstructure; (2) what is seen up close and in detail, the fine structure of the data; and (3) what is seen implicitly, underlying the graphic – that which is behind the graphic'' (2001, p. 155). The first viewing depth is entirely about overviewing; the third is partly about overviewing, though in a more indirect sense than in our model.

5. Discussion

Below, we discuss three key components of our model of overview (Fig. 1). The three components are the role of awareness, the process and timing of overviewing, and the tasks for which overviews may be useful. In doing this we also discuss how our model may advance information-visualization research by emphasizing overviewing and the relation between overviewing and overviews. Finally, we present some limitations of our methodology.

5.1. Awareness

Awareness is central to our model of overview. Schmidt (2002, p. 287) characterizes awareness as ''a specific way of pursuing a line of action, namely to do it heedfully, competently, mindfully, accountably''. With this characterization, awareness is an attribute of action, and is actively created by actors. While this appears to be the more common view of awareness, a number of authors talk about awareness without referring to a line of action, as in ''Adequately visualizing awareness on top of a collection representation is also an important issue'' (Cohen et al., 2002). Schmidt (2002) emphasizes that a person is aware of something, and by characterizing awareness as an attribute of action he implies that awareness is for a purpose, namely the goal of the line of action. We have adopted this line of reasoning in our notion of overview by distinguishing the awareness of some aspect of an information space from the task for which the overview is useful. Shneiderman (1996) challenges this distinction when he talks about an overview task. The notion of an overview task entails that acquiring an overview may be a task in itself and that this task can exist and be performed for no other purpose than the acquisition of the overview. This contrasts with our model, which assumes that the tasks for which an overview may be useful have a purpose beyond providing an overview. Our rationale for this assumption is that overviewing is not a separate task that may exist in isolation or run in parallel with other tasks for which the overview is useful, rather, overviewing is intertwined with the purpose for which the overview is useful. We find some support for this assumption in Tufte's arguments for high-density graphics and in the absence of a distinction between overview and detail in his work: What constitutes an overview of an information space may differ depending on whether the task is a monitoring task, a navigation task, a planning task, or the user has some other focus.

Some research on awareness focuses only on collection awareness (Cohen et al., 2002), gaze awareness (Gaver, 1992), peripheral awareness (Matthews et al., 2007), workspace awareness (Gutwin and Greenberg, 1999), or another component of awareness. These explicitly restricted approaches to awareness are at odds with descriptions of awareness as an inner or mental picture of what is happening. Endsley (2006) finds that people in many domains spend a large part of their time building a coherent mental picture of what is happening and trying to ensure that this picture stays current and correct. This mental picture is directed at understanding what is going on in the situation. Such situation awareness has been defined as ''the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future'' (Endsley, 1995, p. 36). Based on this definition, Endsley sees situation awareness as a state of knowledge and distinguishes it from the processes through which it is acquired. A similar distinction is present in the way we use awareness in our model of overview. Despite this suggested link between situation awareness and overviewing, it should be noted that situation awareness is mentioned in only one of the sentences analyzed (Cushing et al., 2006).

Schmidt (2002) cautions against seeing awareness as a tacit process of passive reception because this may mystify what we need to understand: the practices through which people accomplish heedful, competent, mindful, and accountable actions and the system designs required to support such action. In relation to overview, we agree that some of the uses of the term in the reviewed papers seem to bypass important issues by assuming that the mere presence of an overview display somehow gives the user an overview. This is seen in the widespread use of passive versions of acquiring an overview. We also argue that the use of overview in ''overview information'' and ''overview tasks'' does not clearly specify what the overview is of and for. Finally, we note that the majority of papers that speak of overview together with an object focuses on the content or the structure of the information space; rarely do studies focus on awareness of changes in the information space.

5.2. Acquiring an overview

Our review has uncovered three views of the processes by which users acquire an overview: pre-attentively, information reception, and active creation. All these processes appear to play a role in the description of overview and all have been discussed in the literature. For example, Spence (2007) tends to focus on pre-attentive cues in his definition of overview but to reserve active creation for the broader activity of visualization, which he defines as forming a mental model or mental image of something (p. 5). Conversely, Tufte (1990, 1997, 2001, 2006) leaves room for active creation in his use of overview. Also, work on sensemaking (Russell et al., 1993) describes awareness as actively created and maintained, while work on graphical perception (Cleveland, 1993; Mackinlay, 1986) emphasizes on how visual information may be perceived pre-attentively. Thus, while the active application of cognitive effort can no doubt be crucial to reaching an understanding of information, it may or may not be considered part of acquiring an overview of the information. We have not attempted to account in more detail for the relation between the processes for acquiring an overview. While we recognize the complementary relation of pre-attentive and more active overviewing, in particular over time, the various views of the acquisition of an overview suggest a lack of integration of theories that may inform research in information visualization.

Our view of the acquisition process resonates with influential work on awareness, which has focused on how people render visible selected aspects of their activities to have others unobtrusively notice and discover events that might otherwise pass unnoticed (Heath and Luff, 1992; Heath et al., 2002). The resulting smoothness, seamlessness, and apparent ease with which awareness is acquired bear resemblance to how overviewing is talked about in much of the work that sees overview as acquired by pre-attentive cues. Awareness is, however, not necessarily acquired instantaneously and without apparent effort but may be built up over time (Endsley, 1995). Including active creation in the notion of overview emphasizes on overviewing and entails that the same overview display may provide some, but not all, users with an overview, for example depending on their level of domain knowledge. Conversely, if an overview is seen to be acquired mainly by pre-attentive cues then overviewing becomes a near-automatic byproduct of overviews, suggesting that the notion of overview is restricted to low-level processes akin to filter, cluster, and correlate (Amar et al., 2005). Seeing overview as a low-level process is consistent with conceptualizing it as preceding more directed and attentional exploration of the information space. While this could possibly be a reading of the visual information-seeking mantra, Shneiderman (1996) presents the mantra as design advice, not as an account of a psychological process. Acquiring an overview by active creation suggests that overviewing is a higher-level process, more akin to the formation of a mental image, and it is readily linked to a need for continually creating and recreating an overview throughout a task. This need is particularly prominent if the information space changes frequently, either as a result of external events or due to user interaction with the visualization.

Understanding and supporting the active creation and continuous recreation of awareness appear major challenges for future research in information visualization. We see three key components of these challenges. First, the role of details in acquiring an overview differs among the reviewed papers and among the three classic readings. For example, Shneiderman (1996) employs a sharp distinction between overview, which comes first, and detail, which comes later and only on demand. Spence (2007) acknowledges that overviewing may involve alternations between overviews and detail displays. Tufte (1990, 1997, 2001, 2006) advocates effective presentation of rich detail and does not contrast overview and detail. This issue is related to whether an overview develops from an initial perception of global features or from local detail. The former is supported by findings that the global features of a visual scene are perceived earlier or more effortlessly than local features (Navon, 1975; Nygren et al., 1992), the latter by findings that adequate awareness occurs through continuing interaction with detail (Heath et al., 2002; Trafton et al., 2000).

Second, the active acquisition of awareness of an information space allows for user interaction with the visualization to explore the information space and to change its content. The role of interaction in relation to overviewing is, however, unclear. On one hand, interaction is a key component of information visualization (Yi et al., 2007), whose potential is what distinguishes the field from many other fields. On the other hand, some of the problems in the design of overviews are related to interaction (e.g., switching between overview and detail displays). Tufte (1990, 1997, 2001, 2006) is mainly concerned with static visualizations, which do not provide for interaction, but his notion of multiple, simultaneously present viewing depths suggests that overviews are effective only when they enable swift and recurrent shifts in viewing depth. This bears some similarity to interaction. Conversely, Shneiderman is generally a strong proponent of interaction as a means of exploring information spaces (e.g., Shneiderman, 1982, 1994), but in relation to overview he appears to restrict interaction to panning and scrolling while interactions that involve zooming, filtering, and viewing details are subsequent to an overview. He, for example, classifies dynamic queries as filtering (Shneiderman, 1996). The distinction between ways of acquiring an overview seems not only to be a matter of definition. It may also reflect different uses of overviews. For instance, Nekrasovski et al. (2006) distinguish glancing at an overview from interacting with it. The latter is mainly about interaction, whereas the former may also be about overviewing.

Third, the integration involved in maintaining a coherent mental picture of an evolving situation suggests that overviews should not only broadcast information but also aim to integrate multiple pieces of information. Burns (2000) compared a process-control interface consisting of one integrated display with another interface distributing the same information onto four displays. Whereas the time to detect anomalies was shorter with the four-display interface, the integrated display resulted in shorter time to diagnose anomalies and higher diagnosis accuracy. Thus, the intricately related activities of becoming aware of an anomaly and reaching an understanding of it pointed toward interface designs that differed in information density. This may be an argument for separating overviews (aimed at awareness) from detail displays (aimed at understanding) but it also emphasizes on the need for smooth integration because people in many real-world domains repeatedly switch between these two activities.

5.3. Tasks, measures, and outcomes

About two-thirds of the tasks used in the evaluations of overviews focus on navigation and exploration. A concern with this choice of tasks is that in particular the navigation tasks are simple and brief (a median of 80 s, ranging from 15 s to 6.5 min). Thus, the ambitious goal of designing for overview and overviewing is in several studies evaluated only with respect to two of the goals that may be supported and only with rather simple tasks. The use of understanding tasks in some of the studies is interesting, also because these studies make more frequent use of complex measures of outcome, such as measures of retention of objects in the information space. For the majority of studies, however, the outcome measures were predominantly task completion time, error rates, and satisfaction/preference. Combined with the selection of tasks, the evidence on overviews and the development of overviewing is mainly based on simple tasks and simple outcome measures.

Whereas awareness is central to our model of overview, it receives little direct attention in evaluations of overview. Instead, studies focus on the usefulness of having an awareness of the information space, that is, the row "useful for" in Fig. 1. In contrast, research on situation awareness frequently discusses and uses direct indices of situation awareness (Endsley and Garland, 2000). For example, the Situation Awareness Global Assessment Technique (Endsley, 2000) is used to assess participants' situation awareness by pausing their primary work and asking them questions about their situation awareness. In sensemaking research, Slaney and Russell (2005) try to tap the process of overviewing by probing users for their understanding of a 300-article collection after they have interacted with it for 5 and 15 min. Similar approaches to data collection are widely used in studies of how people understand maps (Foo et al., 2005). This idea seems applicable also to studies of overviews and may involve questions about participants' awareness of the content, structure, or changes in an information space. We see it as promising for describing and understanding the effect of overviews.

Our model and work in other areas suggest alternative evaluation measures, which could help generate a richer understanding of overviewing. First, overviewing could be addressed more directly by automatically derived measures. For instance, research has investigated automatic measures of participants' lostness when navigating hypertext (Smith, 1996). We are unaware of work on developing a similar indicator of having an overview. Second, it is possible to use observers to rate participants' situation awareness (e.g., Gawron, 2008). We are unaware of information-visualization studies that employ such ratings of overview during interaction. Third, we can consider awareness of an information space as something in part spatial. In an evaluation of Scatter/Gather, Pirolli et al. (1996), for example, asked participants who had been using Scatter/Gather for finding papers in a large text collection to draw tree diagrams of the topics represented in the collection. Pirolli et al. used the drawings to derive descriptive measures, such as the number of nodes, as well as to analyze the topic names on the diagrams.

The outcomes of using overviews merit discussion. We see a disappointing effect of support for overviewing with overviews; the performance benefits of overviews are not in any way clear across the studies reviewed. The studies do suggest an effect of providing overview displays on satisfaction and preference, similar to the review by Cockburn et al. (2008). More generally, Hearst (2009) argued that overviews in the domain of search interfaces have been largely unsuccessful. In discussing the visualization of search results as clusters or starfield displays, she noted, "Although very frequently proposed, these kinds of graphical overviews of large document spaces have yet to be shown to be useful and understandable for users. In fact, evaluations that have been conducted so far provide negative evidence as to their usefulness" (pp. 273–274). The present paper suggests that this state of affairs may be due to (a) a lack of clarity about the tasks overviews aim to support, (b) too much focus on brief, navigation-oriented tasks, (c) simple measures of the outcomes of using overviews, (d) infrequent use of measures that gauge learning and the development of awareness, and (e) insufficient focus on the process of continually creating and recreating an overview of an information space.

5.4. Limitations

Our model of overview is based on an analysis of a selection of papers and three classic readings in information visualization. This approach raises a couple of objections. First, we base our selection of papers on the presence of the term "overview". We may, thereby, miss alternative ways of speaking about overview, such as the near synonyms used in the reviewed papers (e.g., "the big picture" and "sense of context"). We agree that the notion of overview is principally different from the term "overview" and would like to see follow-up work collect, categorize, and analyze the uses of synonyms to overview(ing). The present approach, though, focuses directly on a key term in that "overview" undeniably plays a key role in information visualization. Second, a large part of our review uses the sentence as its unit of analysis. This may disregard meanings and uses of overview explained over a series of sentences. We agree in principle to this objection but our feeling from reading the reviewed papers is that it has not biased our review. In addition, we have supplemented the sentence-level analysis with a more overall analysis of how three classic information-visualization readings speak about overview. Third, our model defines overview in terms of awareness. There is considerable literature about awareness, and we have only covered selected issues of particular importance to our discussion of overview. While a review of awareness is clearly beyond the scope of this paper, we consider the contribution of linking overview and awareness important.

6. Conclusion

We have reviewed the meanings and uses of the notion of overview in 60 information-visualization papers from the period 2000–2008 and in three classic readings on information visualization. Our review shows that the papers mainly discuss a technical sense of overview, in which an overview is a display that shrinks an information space and shows information about it at a coarse level of granularity. The most frequently mentioned technique, overview+detail, couples such overviews with displays showing details for the current focal point in the information space. Overview is, however, also used in a user-oriented sense, in which overview is an awareness of an aspect of an information space acquired by pre-attentive cues, information reception, or active creation. When using overview in a user-oriented sense, the reviewed papers often beg the question of the relation between such overviewing and overviews. Even the classic readings on information visualization were found to forego description of the exact meaning and implication of overview.

A large portion of the reviewed papers uses the notion of overview rather loosely. To become more precise about the meanings and uses of overview we have developed a model that incorporates the most important aspects from our review (Fig. 1). The model describes overview as an awareness, and thereby emphasizes overviewing. The model also describes how an overview is acquired, what it is useful for, and how overviews may provide it. Specifically, the model ties overviewing to an object and a task; that is, it is an overview of something and for a purpose. Relative to this model, Shneiderman's visual information-seeking mantra and Spence's definition of overview seem to capture only modest parts of overview. In particular, their respective emphasis on getting an overview first and preferably pre-attentively is at odds with descriptions of overviewing as actively created throughout a task.

We see four implications of our work. First, the distinction between a technical and a user-oriented sense of overview raises the important research question to what extent overviews support users in overviewing an information space. Previous evaluations of overviewing with and without overviews suggest that overviews lead to improved subjective satisfaction, whereas the effects of overviews on task performance are unclear. Second, prominent definitions of overview under-recognize that overviewing may be actively created and recreated throughout a task. This raises a research question about whether and, if so, how overview definitions and designs can be extended to incorporate active and ongoing creation of an overview. We suggest that answering this question implies building stronger links between research on information visualization and situation awareness. Third, the tasks and measures used for studying overview are incomplete and limit the possibilities for integrating research findings across studies. Research on, for example, situation awareness and map understanding may provide inspiration for tasks and measures that can supplement those currently used, which are biased toward simple and brief tasks. Finally, the relation between overview and detail needs further work. At the extremes, Shneiderman recommends overview first, whereas Tufte strives for detail at all times. Resolving this issue requires more knowledge about how different overview designs are useful for different kinds of task, about the relative contributions of the global and local features of a visual scene in creating an overview, and about the role of interaction in overviewing.

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