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USE OF VISUALIZATION IN DIGITAL FINANCIAL REPORTING: THE EFFECT OF SPARKLINE

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USE OF VISUALIZATION IN DIGITAL FINANCIAL REPORTING: THE EFFECT OF SPARKLINE

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Business and Economics
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By
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ABSTRACT OF DISSERTATION

USE OF VISUALIZATION IN DIGITAL FINANCIAL REPORTING: THE EFFECT OF SPARKLINE

Information visualization (InfoViz) is an essential component of decision support systems (DSS). Sparklines is a visualization tool. This study examines if Sparklines in digital financial reports aids novice investors and if so under what circumstances? Does it enhances decision-making performance and facilitates effective decision-making experience? Additionally, does it lowers decision making effort; reduces dilution effect from non-relevant data in financial reports and mitigates recency bias in using digital financial reports?

The hypothesis is guided by the theory of Proximity Compatibility Principle and the Theory of Cognitive Fit. The research methodology for this study is a repeated measure, controlled laboratory based experiment. A pilot test was conducted in with a sample of forty undergraduate students from Gatton College of Business and Economics. The sample size for this study was 275 subjects.

The result revealed that there was significant effect of sparklines on decision making performance and it provides an incremental value over a tabular format. Sparklines makes an important contribution towards mitigating recency bias. The results also suggested that the irrelevant information cue in the shareholder's report were not able to weaken the impact of relevant information in the audited financial data reported using sparklines. Sparklines increased the attention of the readers to the tables. Subjects performed the integrative tasks and spatial better when using Sparklines. For tasks such as symbolic tasks, Sparkline does not necessarily improve decision performance.

It was also found out that decision makers experience greater satisfaction when using sparklines. The overall cognitive load experienced by subjects was lower using sparklines when task demands are high (such as in a bankruptcy prediction task). Interestingly, the results indicate that there is no significant effect of sparkline on decision confidence and time. In conclusion, recall of facts and pattern among subjects was found superior with use of sparkline.

This study provides an empirical and justifiable basis for policy makers to make explicit recommendations about use of novel graphics such as sparkline in digital financial reports. Limitations of this study are noted.

KEYWORDS: *Decision support system, Visualization, Decision making, Business Intelligence, Presentation format, digital reporting.*

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July 3rd 2012
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USE OF VISUALIZATION IN DIGITAL FINANCIAL REPORTING: THE EFFECT OF SPARKLINE

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Priyanka Meharia

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1.1 Decision Support Systems

Information technology (IT) plays a key role in creating knowledge (2000) and supporting management in decision making activities (Keen and Morton ; Morton 1971; Bonczek, Holsapple et al. 1981; Holsapple and Whinston 1996; Todd and Benbasat 2000). Decision support systems are Management Information Systems that aids a decision maker in the decision making process. DSS include "*business intelligence systems, some workflow systems, groupware, conferencing software, management expert systems and model-based analytics*"(Holsapple 2003). In an article that classifies DSS architecture and types; Holsapple writes that

"DSS relaxes cognitive, temporal, spatial and/or economic limits on the decision maker. The support furnished by the system allows a decision episode to unfold

- *in more productive ways (e.g., faster, less expensively, with less effort),*
- *with greater agility (e.g., alertness to the unexpected, higher ability to respond),*
- *innovatively (e.g., with greater insight, creativity, novelty, surprise),*
- *reputably (e.g., with higher accuracy, ethics, quality, trust), and/or*
- *with higher satisfaction by decisional stakeholders (e.g., decision participants, decision sponsors, decision consumers, decision implementers)"*

As per Simon's intelligence-design-choice model; DSS should support all phases of the management decision-making process; specifically the intelligence phase that refers to the "process of searching the environment for conditions calling for decisions" (Simon 1960). In the digital era, decision makers have access to large amount of digital data

which can be used by DSS to support decision making. DSS aids the decision maker in making sense from the large amount of digital data. In a decision making setting, the decision maker progresses from six states of descriptive knowledge: data, information, structured information, insight, judgment and finally the decision (Wali Van Lohuizen 1986). IT such as DSS can support the decision maker to progress through the different states of knowledge and make more informed decisions.

1.2 Business Intelligence for making decisions

Business intelligence (BI) refers to inferences and knowledge discovered by analyzing data acquired from different sources. A data warehouse is a repository of digital data from which business intelligence can be derived. BI refers to "technologies, applications and practices for the collection, integration, analysis and presentation of business information" (AICPA 2010). BI systems can help decision makers in an organization to derive knowledge from the data to make wiser and more informed business decisions.

In today's economic climate, companies want quantifiable success measures. BI can help in extraction, analysis, and reporting of historical data or data related to comparable companies in order to provide valuable performance measure. As per the PAIR model, organizations that use BI systems can potentially increase business competitiveness through improved productivity, agility, innovation, and/or reputation (Holsapple and Singh 2001). To increase competiveness the businesses need to be more agile and innovative. They need to predict rather than react to changes in the conditions in which they operate. The BI system supports the retrospective and predictive analytics on data (detailed sales, production, and financial and other business data) from different sources.

Independent researchers have predicted high future demand for BI systems. Gartner's research reports that in spite of global recession businesses are interested in investing in business intelligence (BI) platforms that are expanding their capabilities towards advanced data visualization, scorecards and interactive dashboards. It predicts BI market's compound annual growth rate (CAGR) through 2012 to be 7.0% for stand-alone BI platforms (Hostmann 2009) . Gartner predicts *"Through 2015, organizations integrating high-value, diverse, new information types and sources into a coherent information management infrastructure will outperform their industry peers financially by more than 20%."*

As competition in the knowledge economy gets more fierce, organizations are constantly trying to get new insights from different sources of knowledge to gain competitive advantage.

As per the Knowledge Management theory, an organization has two classes of knowledge resources: content and schematic knowledge resources (Holsapple and Singh 2001). As per Holsapple et al (2001), a) Content knowledge resources are of two types: *knowledge conveyed in/by artifacts* and Participants' knowledge and b) schematic knowledge resources are of four types: culture, infrastructure, strategy, and purpose.

Artifacts are usable representation(s) of knowledge on which digital processors like the BI tools can be applied. The digital artifacts can be stored in database and be in the form of records, files, images, video, reports, documents, books and so on. Participants' knowledge is knowledge possessed by a participant in the decision making process. The knowledge to make more informed decisions can be discovered from internal participants within the organization and external participants like people in the professional and social

network, experts in the field (consultants). Knowledge can be acquired from databases, search engines, from remote sensing objects and from other environment knowledge resources. On Participants knowledge and schematic knowledge resources, BI tools can be applied if the knowledge is represented in a usable form.

1.3 Visualization in Decision Support

Information visualization (*InfoViz)* is an essential component of decision support systems (DSS) that supports Business Intelligence. Visualization is the use of "computer-supported, interactive, visual representations of abstract data to amplify cognition"(Card, Mackinlay et al. 1999). Visualization tools are computer applications that produce graphical representations that aid decision making. Visualization tools make it possible to model the digital data on the basis of queries to create digital reports that can aid decision making. Information visualization (InfoViz) has been gaining prominence recently because it supports visual exploration of data resources by the use of computer graphics. InfoViz is commonly used in reports and performance evaluation dashboards.

Business Intelligence Dashboard is a "reporting mechanism that aggregates and displays metrics and key performance indicators (KPIs), enabling them to be examined at a glance before further exploration by the additional BI tools"(Chandler 2007). InfoViz is available in dashboards as they employ dense, interactive, color coded visual presentations to provide at-a-glance information that provides situation awareness.

InfoViz is also available in simple spreadsheets to complex computer-based systems like enterprise resource management (ERP); knowledge management (KM) systems; and expert systems (ES). Sample vendors of companies selling visualization software include Advizor Solutions; QlikTech; and Tableau. There are several BI Platform Vendors with

interactive data visualization functionality and the list of such vendors include Board International, IBM Cognos, MicroStrategy, SAP BusinessObjects, SAS and Tibco Spotfire.

Chief economist of Google Inc. predicts that need for data visualization will be growing rapidly in the next few years. He writes.

"the ability to take data—to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it—that's going to be a hugely important skill in the next decade.... because now we really do have essentially free and ubiquitous data. So the complimentary scarce factor is the ability to understand that data and extract value from it… Managers need to be able to access and understand the data themselves" (Sundberg 1998)).

1.4 Interactive data format and use of visualization

eXtensible Business Reporting Language (XBRL) is an XML-based, open technology standard for the digital exchange of financial and business information in a computer-readable format. The computer readable format facilitates use of software to visualize data in XBRL documents and prepare custom reports to support decision making. The current 'paper centric' nature of reporting business information includes only few data points. XBRL deployment increases the number of data points and the variety of information that can be incorporated into management decision-making processes (Willis 2003). The financial-database available from companies like Compustat provide less than 400 data points but a typical annual report may include in excess of 3,500 unique information concepts through XBRL tags (Willis 2006). Data submitted as XBRL will facilitate the development of interactive data viewers which allow investors to find,

download, view and compare financial information across companies (SEC 2008; SEC 2009). Further, audit firms are considering using interactive data visualization to streamline analytical procedures (Bay 2006; Gunn 2007). Several companies currently incorporate interactive data visualization features on their investor relations web sites, such as hyperlinked tables of contents, dynamic graphic images, and search engines (Kelton and Yang 2008).

Starting with fiscal periods ending on or after June 15, 2011, the U.S Security Exchange Commission rules require all public companies to submit their financial statements in the eXtensible Business Reporting Language (XBRL); interactive data format, that is intended to improve its usefulness to investors (SEC 2009). The Commission has also issued rules that will require interactive data reporting by mutual funds and ratings organizations. XBRL is a global reporting language for financial supply chain management and business and financial reporting (Willis 2006). The XBRL reporting format apply to public companies and foreign private issuers that prepare their financial statements using U.S. generally accepted accounting principles (U.S. GAAP) or using International Financial Reporting Standards (IFRS) as issued by the International Accounting Standards Board (IASB). XBRL is widely used in China, Japan and Europe. In this format used globally, financial statement information is being downloaded directly into spreadsheets that will allow visualization of such data in any particular management analysis. BI tools can also be applied to create, exchange, slice and dice numbers, create analytical ratios and perform cross-company comparison of business reporting information (XBRL 2010).

1.5 Role of Visualization in Decision Making

Review of the literature on computer graphics as decision aid reports that the format in which data is presented to decision makers is critical to provide information for making decision (DeSanctis 1984; Sharda, Barr et al. 1988; Benbasat and Nault 1990). Effective visualization tools are of great importance in supporting decision making because when visualization tools are inadequate, decision making performance is impaired. Visualization tools amplifies cognition, perceptual information processing and facilitates knowledge generation in the some of the following ways.

1.5.1 Visualization as a memory aid

As per the Central capacity theory humans have limited working memory (Miller 1956). Human beings also have limited visual working memory which allows human beings to store simple images and visual objects in their brain (Haber 1969). Visualization of data may improve the storage and accessibility of the information in the visual working memory to support decision maker. It may reduce demands on working memory.

1.5.2 Visualization as representation aid

Visualization can help in representing data in a format that is easier to read and interpret. For e.g., both pairs of following numbers represent the same quantities but Arabic numbers are easier to read than roman numbers. 16 times 103 vs. XVI times CIII.

1.5.3 Visualization as supporting parallel processing in the brain

As per Dual Coding Theory, left side of the brain processes language in a sequential order, whereas the right side of the brain is more visual and processes information synchronously (Paivio 1986; Paivio 1991; Sadoski and Paivio 2001). Visualization

supports parallel processing of the visual object and the textual to aid decision making. Visualization can aids recall of information for making decisions.

1.5.4 Visualization as support for creative thinking and insight

Decision making includes problem solving (Todd and Benbasat 2000). According to Gestalt's theory of problem solving, creative solutions to complex problems need "insight". Many complex business decision making also need "insight" and insight is a sudden discovery of a solution to a problem which results in a subjectively catastrophic experience (Weisberg 1992). Visualization tools can summarize and represent large amount of data in a small screen space. This may help the decision maker to make sense of the data and in this sudden discovery of a solution to a problem. For decision making; Information acquisition task is data driven whereas the information evaluation task requires parallel use of data and mental schema (Jarvenpaa 1989). Mental schema influences what we pay attention to and what we ignore. Characteristics that are consistent with our schema gets more attention and those that are inconsistent with our schema gets filtered out (Nash 2006). The knowledge generated from effective visualization of large volume of data can help the decision maker to build their mental schema; to support information evaluation task and to solve complex problems creatively. For solving semi structured or ill structured problem, visualization tools has the potential to influence the ease of reaching an accurate solution.

1.5.5 Visualization as support for Pattern Recognition

Human brain is a powerful pattern-finding engine. Effective graph make patterns, temporal trends, correlations, clusters, gaps, and outliers visible in seconds (Tufte 1990). Effective data graphics can amplify cognition and complement the pattern finding ability

of human brain. Perceptual cues in graph can help identify the pattern, Visualization aids in perceptual information processing to identify exceptions, trends, patterns, relationship in the data (clusters, associations, causality etc.), detect outliers and to summarize data perceptually (Carpenter and Shah 1998).

1.5.6 Visualization as support for Persuasion

Vivid and interactive graph can be persuasive and inspiring (Morrison and Vogel 1998).People trust visual cues (similar to seeing is believing) and patterns. Hence, it is more persuasive in communicating ideas and for completing collaborative work.

2 Chapter Two: Survey of visualization tools and techniques

There are a host of visualization tools and techniques emerging that are commonly used today in the Business Intelligence to make sense of large volumes of data such as XBRL financial data from the Securities and Exchange Commission, FDIC call reports and other world financial, stock market and business data. Some of the popular and newer visualization tools available are discussed below.

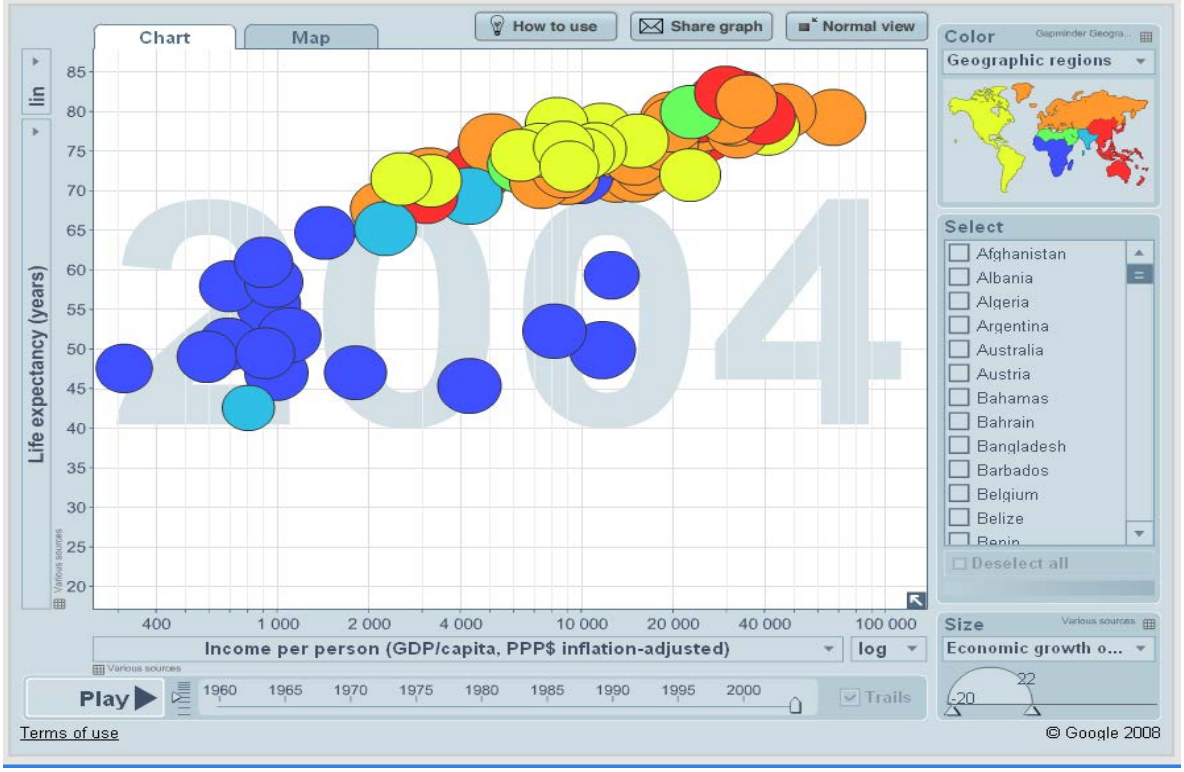
2.1 Dynamic Graph

There is a general belief that dynamic graphics should be more effective than comparable static graphics and is more enjoyable because of aesthetics, ability to attract attention or maintain motivation (Tversky, Morrison et al. 2002). For example information can be presented dynamically in the format of Motion Charts which is explained below. Over the last two decades several studies have investigated the effect of dynamic graphics on comprehension, learning, memory, communication and inference but the results have not reached a consensus. The review by Tversky et al. (2002) argued that the difficulty to reach a conclusion can be attributed to the methodological and theoretical problems with the research and that the animated and static graphics lacked equivalence between in content or procedures. Where animation presented more information or involved interactivity. Moreover, Tversky et al.(2002) agreed that conveying real-time changes and reorientations in time and space seemed to be the most promising uses of animation due to people's natural cognitive correspondences based on the congruence principle. Other studies have found evidence to say animations facilitates in faster retrieval and recall of information than static images (Rieber and Boyce 1990; Morrison and Vogel 1998). In a prior study, when practice was given to subjects ,

animated graphics were found superior to static graphics and to no graphics (Rieber 1990). Compared to static graph (SG), Dynamic Graph (DG) facilitates in faster retrieval and recall of information (Rieber and Boyce 1990; Morrison and Vogel 1998), information comprehension required for decision making (Morrison & Vogel, 1998). Dynamic graph enhances information comprehension (Morrison and Vogel 1998) but verbal narration or text in conjunction with animation improves information comprehension (Mayer and Anderson 1991). In another study it was found that in a problem solving task, subjects who were presented with information in the form of a) Text in conjunction with animation and caption performed better than subjects who were presented with information in the form of both b) text plus animation and c) captions plus animation. Animation was found to significantly improve the performance of the problem-solving task that involved the highest level of cognitive effort (Large, Beheshti et al. 1996). Animation enhances comprehension but this is determined by a variety of factors, including the level of complexity of the information and the kind of information being conveyed and differences in time lag between testing and viewing can have an effect on information comprehension (Large, Beheshti et al. 1994). Speed at which animations were portrayed effects comprehension of the display (Lightner 2001). Once such example of dynamic graph used in Management Information systems is Motion graph. *Motion chart is a dynamic chart to explore several indicators over time.* It provides multi-dimensional analysis of all the metrics. Once the Motion Chart loads, there is an array of bubbles. Each bubble represents a different metric. We can select four different dimensions to plot data: X-axis, Y-axis, Color, and Size. There are several research questions that need to be addressed with motion charts: for example, is Color

superior to size as a mechanism to target a feature in a Motion Chart? We can press "Play" at the bottom of the chart to see how metrics perform over time. The Motion chart depicting the financial ratios and key financial data for a company for the years 2004 to 2010 is illustrated in Figure 2-1.

Figure 2-1: Screenshot of Motion Chart in action.



In this example the user can view and compare the different financial ratios of different firms at a single screen by interacting with the data. The Motion chart is dynamic and interactive chart to explore several indicators over time. Users can use Trails to trace the path of individual bubbles. The chart generates moving graphics. The several indicators such as Income per person, Life expectancy, Economic growth and geographic regions are encoded in the graph in the form of changing color, changing shape and position of the bubble over a time of 1960-2004 over time.

2.2 Dense Graphics

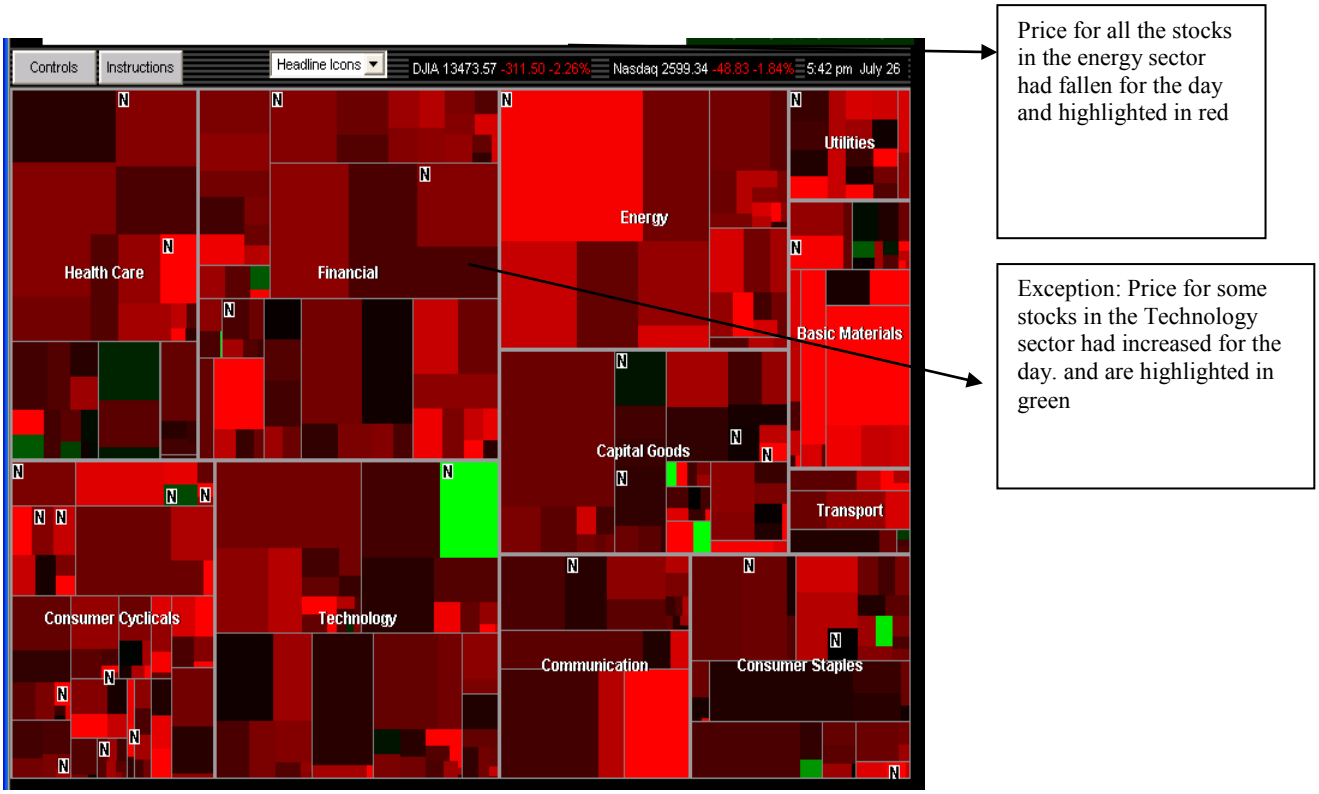
Dense graph can plot millions of records in small screen space. In today's world of pervasive and mobile computing, there is a growing demand for Mobile Business Analytics. The display area available in such smart phone and mobile PC is small. For small screen space, graph excellence for high volume of data can be achieved with creating dense graphics. Dense graphs for Business Analytics will continue to grow in demand. Dense graph are graph that can maximize data density of graphics (Tufte 1990). Dense graph would mean graph than can accommodate large set of data points in a small screen space. Data density has been defined with the following formulae.

$$\text{Data density of graphic} = \frac{\text{Number of entries in data matrix}}{\text{Area of data graphic}}$$

One such example of dense graph is Tree Maps (Shneiderman 1992). Tree Maps encodes numerical and categorical value in graphical attribute and lays them in Matrix format.

Tree map presentation (Figure 2-2) highlights that stock market had fallen on that day, with a few exceptions. This presentation can be displayed on a small screen space and is prepared using Tableu software with huge volume of single day, stock price data from different industry sectors.

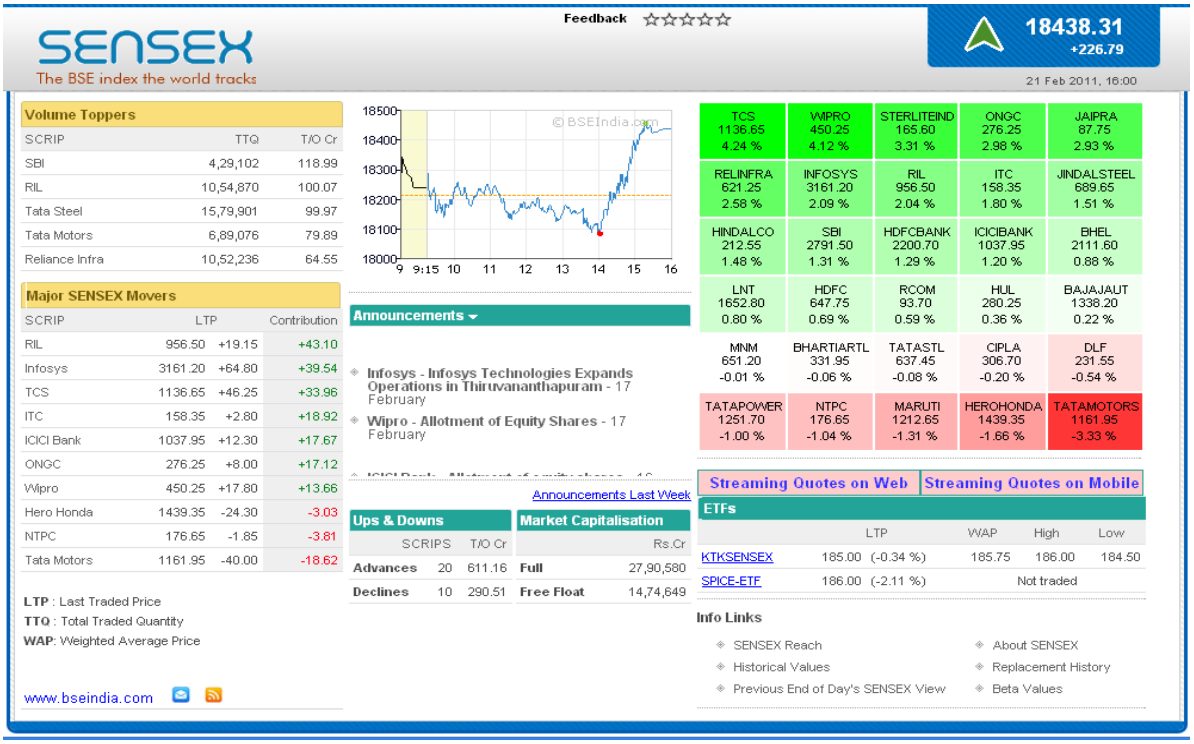
Figure 2-2: Screenshot of Tree Map highlighting stock market had fallen on that day, with a few exceptions



The combination of spatial presentations and color coding in Tree maps helps the user gain an overview of the data. Using the traffic color light schema, red meant the stock price for the particular groups of stocks in a particular industry had fallen for the day and green meant the prices had increased for the day. The Tree map illustrates that stock market had fallen on that day, with a few exceptions. The Tree map as shown in the example above can help create situation awareness by presenting current status and alerts. In the above example, the few exceptions are highlighted in green.

While tabular displays and spreadsheets can show 30-60 rows at a time on typical displays, Tree maps can accommodate hundreds or thousands of items in a meaningfully organized display TreeMaps can be used for portfolio analysis (Figure 2-3).

Figure 2-3: Tree Map showing the Bombay Stock Exchange Performance



The guidelines proposed by Tufte (1997) are to arrange for decoding of data encoded in the graph to take place at the perceptual level by making visual comparisons between large datasets and make large datasets coherent. One particularly interesting way to create dense graphics is through what Tufte calls micro/macro readings. These are graphics that convey one layer of information on a micro (zoomed in) scale and another layer on a macro (zoomed out) scale. In the Tree map above, by zooming on the green boxes users can review the details of single or groups of stock. The viewer may glance from a distance to observe an aggregate trend, and later peer in closely to examine individual pieces of that trend. In the tree map the users can look at the exceptions highlighted in green at the macro level and then zoom in on the individual stocks to get information about the stocks at the micro level. The size of the blocks shows the market share valuation of the particular segment, for example healthcare.

2.3 Interactive graph

Computer graph are often interactive and interactivity is known to facilitate performance (Narayanan and Hegarty 1998). Interactive task can be *overview, zoom, filter, details-on-demand, relate, history, and extract* (Shneiderman 1996) or dynamic projections, interactive distortion, interactive linking and brushing (Keim 2002). Interaction types can be *transformable* (decision makers can manipulate how the representation is rendered, such as zooming, panning or resizing), or *manipulable* (decision makers may control parameters during the process of image generation, i.e. filtering, visually encoding the variables). Gonzalez and Kasper (1997) proposed a framework where four properties of animation were identified: image abstraction (change of image from more realistic to abstract representation), transition (movement of image: gradually or abruptly, or by dissolving, fading, etc.), alteration (texturing, coloration, etc.), and interactivity (manipulation, navigation). It was found in their study that decision quality was enhanced by parallel navigation technique as compared to sequential navigation technique in interacting with graph (Gonzalez and Kasper 1997). In a study by Tversky, Morrison, and Betrancourt (2002), the results indicate that if learners are in control of the speed of animation and can view and review, stop and start, zoom in and out, and change orientation of parts and wholes of the animation at will, then learner performance is enhanced. The results of the study suggests that if graph are both dynamic and interactive then it can aid the decision maker better (Tversky, Morrison et al. 2002). Example of such interactive graph is illustrated in **Error! Reference source not found.**.

Figure 2-4 Interactive financial chart

An interactive line graph as shown in Figure 2-4summarizes the stock price data for Google Stock from the year 2004 to 2010. Volume data informs the decision maker how many shares of the stock have traded during the current trading period. As the user move the cursor back and forth across the interactive Chart, there are two track balls following the cursor. The first track ball moves back and forth across the historical price data of the stock that has been charted. The second track ball moves back and forth across the historical volume data of the stock. The decision makers can control the time periods for which they want to view historical price and volume data. They can zoom and get the details of stock on demand like the open, high, low and close prices for the stock on that day.

3 Chapter Three: Presentation format and decision making: a review of literature.

The objective of the study is to focus on the interface components of DSS. Several seminal laboratory based experiments that examined, the influence of information presentation format on quality, process and outcome of decision making was identified from the leading journals in Information systems and Accounting. Our literature search follows the recommended four-step process (Vom Brocke, Simons et al. 2009): First, using the MIS Journal Ranking (AIS 2010), we select six of the most popular IS journals and other Accounting journals (Webster and Watson 2002). The journals selected were Information Systems Research , Journal of Information Systems, Management Science, MIS Quarterly, Decision Support Systems, Communications of the ACM, Accounting Organizations and Society, Accounting Review, Behavioral Research in Accounting, Accounting, Behavior and Organizations Conference, Journal of Accounting and Public Policy, Accounting Education, Journal of Management and Journal of Emerging Technologies in Accounting. Second, we use EBSCO host, Google scholar, Science Direct, and Wiley Inter Science to access the journals. Third, using the keywords " Decision making" and the terms "presentation format, decision aid, decision making, visualization" we got several papers. Fourth, doing a backward and forward search, we end up with 50 relevant publications. The key findings from 50 such research papers are synthesized below. Based on the key findings and existing theories on visual perception; we develop initial research based design guidelines for new-generation Visualization tools. We also develop a research framework to study the effect of interface

components of DSS such as new-generation Visualization tools and other factors on decision outcome, as part of future research in directions in chapter six.

3.1 Key Findings from the literature

3.1.1 Effect of Presentation Format on Decision Performance

Several seminal studies have studied the effect of presentation format in organizing data, mitigating biases, accuracy and time taken to make decisions.

Roscoe and Horwoth (2009) studied the effect charting techniques on investment performance. The results suggested that charting techniques may help decision techniques to organize data but may not help decision makers to an optimal or correct situation. Hutchinson et al.(2010) studied the effect of graphs to mitigate biases in multi-attribute budget allocation decisions. Results suggested that graph were not effective in mitigating biases. Vivien A. Beattie and Michael John Jones (1993) compared the effects of visual and numerical presentations of financial information as well as demonstrated an effective alternative method of accounting education and training. The experimental studies suggested that graphs were more effective than numerical presentation. Schulz and Booth (2009) studied accuracy of subjects' sales account balance prediction as well as subjects' confidence in their account balance prediction. They inferred that when actual normative value was used to measure prediction accuracy, subjects receiving graphs arrived at a more accurate prediction of the future sales balance account than by those receiving tables. The time taken by subjects receiving graphs to complete the tasks was shorter than those receiving tables.

3.1.2 Effect of presentation format of tagged data and web syndication on decision performance

One source of knowledge to support decision making can be a document. If the document is tagged with Meta data then the tagged data can help in improving decision performance. Arnold et al. (2009)studied the effect of reports with information in XBRL format using tagged data on judgment performance. It was found that investors using the XBRL format spend less time viewing risk information than those using a standard text display format. Investors with XBRL format assessed risk and predicted stock price for a potential investment better than investors with standard text display format.

Hodge et al. (2004) studied the effect of tagged data and XBRL-enhanced search engine on decision performance. They found out that decision makers who use XBRL enhanced decision engine are more aware as they are likely to acquire footnote information and use it in making investment decisions.

Web syndication technology helps the contents from one website to be available to other people with a summary of the latest update. It could also mean to license website contents so that other websites can use it. Cong et al. (2008) studied the effect of web syndication technology on investment decisions. They found that individuals who use information presented in the form of web feeds are more effective in making decisions than individuals who do not use such technology. The results suggests that presenting information as web feeds by acquiring current information frequently and integrating information available from different sites can improve investment decision making performance.

3.1.3 Effect of presentation format and individual differences on decision performance

Carey and White (1991) studied the influence of Problem Representations (tables vs. line charts), *Graph-Reading Ability, and Forecasting Ability* on decision performance for a Time series prediction task. The results indicate that in terms of absolute errors, the better decision performance with the graphical response was significant. The study also found that there was no relationship between Graph-Reading Ability and Forecasting Ability with either numeric or graphic response.

Vera-Munoz et al. (2001) found that *experienced managers* are better able to determine relevant information than are *less experienced managers* when information is presented inappropriately. Speier and Morris (2003) found that *high spatial ability* participants using an interactive visual query interface had higher judgment accuracy than *low spatial ability* decision makers.

Cardinaels (2008) found that more *knowledgeable participants* are more accurate when using table and they spend more time in information search with tables. *Less knowledgeable participants* are more accurate using graphs. Dilla et al.(2011) found that *nonprofessional in*vestors relatively spend more time viewing graphs on a simulated investor relations web site with text and graphical displays than *professional investors*. Their results suggested that the nonprofessional investors found that graphical information was easier to use.

3.1.4 Effect of presentation format and task/environment complexity on decision performance

A study by Remus (1984) revealed that in the task of production scheduling , tabular format is a better decision making aid in environments of low complexity as it reduces the erratic component of a decision maker . In intermediate complexity environments, the graphical format is a better decision making aid.

A study by Cheri Speier and Michael G. Morris (2003) compared the use of visual and text-based interfaces on decision performance (subjective mental workload, decision accuracy and decision time) for both low and high complexity task. The results of their study concluded that when task complexity was low decision maker performed more accurately using the text-based interface, and when task complexity was high, decision makers using the visual interface performed better. When using the visual interface, the decision makers' subjective mental work-load was significantly lower, regardless of task complexity. When task complexity was low decision maker took less time using the visual interface but when task complexity was high decision maker took more time using the visual interface.

In a study by Peng et al. (2007) it was found that presentation format; using drill-down (OLAP) functionality with multi-dimensional hierarchical display of sales and advertising expense; may only be effective in improving decision performance for less complex tasks.

3.1.5 Effect of presentation format with task interruption on decision performance

A study by Speier et all (1997) concluded that when interruptions were experienced, graphical displays improved decision-making performance for complex tasks.

Interruptions consisted of four simple information acquisition tasks, which occurred during each of the four experimental tasks. Task types stated in the study were spatial, symbolic, and both simple and complex. The results of the study indicated that interruptions facilitated decision making when the decision maker concentrated he/she concentrated on a simple task and inhibited performance when concentrating on a complex task. Increased interruption frequency inhibited decision performance. Decision-making efficiency decreased when the information content between the primary task and interruption was highly dissimilar.

3.1.6 Effect of presentation format on memory and decision performance

Study by Schmell and Umanath (1994) measured immediate and delayed Recall in terms of Directional recall(rank order), Pattern recall and Simple fact recall. The results of the study indicated that for simple task, recall between the decision makers were indifferent towards presentation format. Pattern recall by decision makers were better when they used graphs. Graphs not only helped in integrating data but also provided underlying data which was good for perceptual problem solving in the area of Integration of multi attribute data for bankruptcy prediction. Volmer (1992) studied the influence of Problem Representations (tables vs. line charts) , on decision performance for Financial ratios analysis. The results indicated that the visual information made it possible to pass quicker judgment on the financial position. They found that there was a positive correlation between the final result and strength of the memory when visual information was given, but there was none or little correlation in case of numerical information.

3.1.7 Effect of presentation format on compensatory choices under uncertainty

Compensatory choices are rational decisions that involve selecting the option with the best value. It was observed by Dilla and Steinbart (2005) that under uncertainty, with the simple information display style effect with tables, the subjects made fewer compensatory choices, more maximin choices, and selected dominated alternatives. Whereas with the simple information display style effect with graph the subjects made more compensatory choices with midpoint-variability than with min-max graphs. . Participants who received information in graphical format gave fewer dominated alternatives as compared to participants who received information in tabular format.

3.1.8 Effect of presentation format and task type (spatial vs. symbolic) on decision performance

Vessey and Galletta (1991) studied influence of problem representations (in form of tables vs. line charts) and order of problem representation on decision performance for a bookkeeping task. The results suggested that matching *both* the problem representation and the task had a greater effect on performance than matching only problem representation or task. The results showed the characteristics of the mental representations decision makers formulated were more frequently based on the problem representation than on the task. The result of the study suggested that the subjects' chose tables to respond to symbolic tasks than to spatial tasks.(Vessey 1991).

3.1.9 Effect of presentation format, time constraint, color and individual differences on decision performance

Benbasat and Dexter (1985) studied the effect of graph, color and individual differences (field dependence/Independence) on tasks where the individual has to isolate or

differentiate patterns from a complex field and disassembled parts from the whole. The results indicated that in terms of decision quality (DQ), decision time and user perception of IS attributes; color is better for graph than tabular display. Also they found that decision quality was superior for field dependent individuals with color enhanced reports.

In a continuing study, Benbasat and Dexter (1986) examined the joint effect of time and color and information presentation format (Tabular, graphical, combination) on decision quality and time. They examined the influence for different task settings (Retrieval, Communication of facts, Comparison of alternatives, Trend analysis, Recognition and recall, Problem finding, Problem comprehension, Problem solving). The results of the study suggested that under low time constraints (15 min), Tabular display resulted in accurate decision making. Combined display was superior in terms of decision quality. Under high time constraint (5 mins) condition, color led to improved decision making

3.1.10 Effect of alternative forms of information presentation on evaluating corporate performance

Jan Bell (1984) investigated whether alternative forms of information presentation affected the use of information in evaluating corporate performance. The investigation concluded that for Research and Development oriented companies, a non-numeric presentation form (such as letter or video presentation to shareholders) for president's comments was more salient than a numeric presentation form. For production companies there was no significant difference between the two forms of presenting supplementary information.

3.1.11 Effect of maps vs. table on decision performance

Dennis and Carte (Dennis and Carte 1998) studied the influence of map-based vs. tabular display on decision performance of Location selection decisions for different type of tasks (geographic containment vs. adjacency). According to the results of the study , subjects using the map-based presentation tend to use perceptual processes, irrespective of tasks. Decision makers using the map based presentations made fewer correct decisions for geographic containment task and more correct decisions for the geographic adjacency task. As per the results of the study, subjects using the map-based presentations were faster in making decision for both tasks, with greater variances for containment task.

3.1.12 Effect of novel presentation format and task type on decision performance

3.1.12.1 Effect of Virtual Reality Environment on decision performance

Nelson et al.(1999) found that participants using an immersive virtual reality (VR) were more accurate at detecting clusters and radial sparseness than those using an interactive two-dimensional visualization tool. Selection of data through a brushing technique took longer time than immersive VR. The results suggested that VR environment may be helpful to the decision maker when working with complex data sets.

3.1.12.2 Effect of 2D vs. 3D scatter plot and block model display, data type on decision performance.

Lee, MacLachlan et al.(1986) studied the influence of information representations (2D vs. 3D scatter plot and Block model display) with Continuous data and discrete data on decision performance. The results from their study indicated that 3D had a positive effect on speed and time, unlike block model as it provided visualization of the data. In terms of

decision performance: for continuous data, 3D display was better whereas for non-continuous data 3D, block model or tabular data was equally good. Arnold et al. (Arnold, Bedard et al. 2009) studied the effect of reports with information in XBRL format using tagged data on judgment performance. It was found that investors using the XBRL format spend less time viewing risk information than those using a standard text display format with more. Investors with XBRL format assessed risk and predicted stock price for a potential investment better than investors with standard text display format.

3.1.12.3 Effect of 2D, 3D vs. Rotatable 3d display on decision performance

Dull and Tegarden (Dull and Tegarden 1999) studied the influence of information representations (2D, 3D vs. rotatable 3D) on decision performance for wealth prediction. The result of the study on standardized wealth accuracy implied that as the dimensionality of the representation increased i.e. 2D to 3D to rotatable 3D, the accuracy of decision also increased. In this study, the results implied that static visual representations results in faster decision making than dynamic visual representations. Also the combined time and accuracy results suggested that the static 3D (R2) visual representations may be better than the static 2D (R1) or 3D rotatable (R3) visual representations.

3.1.12.4 Effect of 2D, 3D display and data complexity on decision performance

Kumar and Benbasat (2004) study the influence of information representation (2D, 3D graph) and Data complexity (data set with 8 or 25 data points) on decision performance for Task type (advanced and simple tasks that require extraction and comprehension). The results indicated that 3D graph is superior than 2D for both advance and elementary task with more than two variables.

Amer (1991) studied the influence of Problem Representations (bar graphs, polygon displays vs. Chernoff faces) on decision performance for an Integrative task (bond ratings determination) and Selective task (bank debt monitoring). The summarized statistics for selective covenant debt task indicates that the rank order of display with respect to decision accuracy rates is: numerical = bar > polygon > face. The rank order of the displays with respect to subjects' decision times is: numerical < polygon < bar < face. The rank order of the displays with respect to perceptions of ease of use and decision confidence is: numerical = bar > polygon > face.

Umanath and Vessey (1994) studied the influence of problem representations (Schematics faces Vs. graph vs. table) and information load (nominal vs. increased load) on decision performance for bankruptcy prediction; which involves integrating multi-attribute data. They found out that graph helped not only in integrating data but also provided an underlying data and were good for perceptual problem solving. They found that Chernoff did not provide an underlying data for judgment. The results indicated that the schematic faces would result in faster decision making than graphs but there was no difference in time as compared with tables. Consistent with previous findings, accuracy at nominal information load was lower for graph than at higher information load. Also, the prediction time for tables would be significantly higher at increased information load.

3.1.13 Effect of presentation format, Cathode Ray Tube (CRT) versus hard copy terminal and heuristic versus analytical decision makers on decision performance.

Lucas (1981) presented the results of an experiment designed to investigate the impact of computer-based graphics on decision making. For conducting the experiment performance on stimulated problems, self-reports of information usefulness, test of

problem understanding was used in conjunction with graphical output and tabular output. Comparing Cathode Ray Tube (CRT) versus Hard Copy Terminal (HCT), the results showed that the decision maker using hard copy reports had superior performance and better test scores on inventory understanding. Evidence suggested that decision makers using graphs developed a better understanding of the problem as compared to decision makers using tables. For Graphical and Tabular Versus Tabular on the CRT, the group receiving both graphics and tabular information reported greater usefulness for the simulation output as compared to the group that received tabular alone. Analytical decision makers using graphs had the highest test scores as compared to heuristic decision makers .

Hodge (2001) compared investor judgments using static hard copy displays to those using a hyperlinked online display. Participants who viewed online hyperlinked materials were less accurate than those who viewed hard copy materials. Decision aid in the form of an "Audited / Not Audited" label to online participants mitigated these effects.

3.1.14 Effect of decision guidance/decision aid on tasks

Montazemi, Wang et al. (1996) concluded that for complex task Informative Guidance (IG) is better than suggestive guidance (SG) but in the case of less complex tasks, suggestive guidance is better than informative guidance.

A study by Thomassin Singh (1998) regarding decision guidance (DG) on the efficiency and effectiveness of Planned v/s Actual Strategy together with the inclusion of unnecessary action and exclusion of necessary action concluded that decision guidance (Strategy support and memory support) improves decision effectiveness and efficiency. Vance Wilson & Zigurs (1999) also concluded that decision guidance was

welcomed by decision makers, if it did not limit their options while making decisions and also did not effect their decision performance negatively.

Todd and Benbasat (1991; 1992; 1992) conducted experiments with the use verbal protocol analysis to compare the extent of information used by aided and unaided decision makers to support preferential choice problems. With the help of unique units of information referenced, total units of information referenced and number of alternatives analyzed in details they identified the problem size and decision aid required. According to the result the number of unique units of information referenced was not different between aided and unaided decision makers. The total number of information units referenced did not differ between the aided and unaided group. There was no difference in the number of alternatives examined in detail between the aided and unaided groups for the experiments. There were no significant interactions between decision aid and problem size for any of the information use measures.

3.1.15 Effect of graph and decision strategies on decision performance

Jarvenpaa (1989) studied the influence of Presentation format (Attribute bar chart, alternative bar chart, a grouped bar chart) and decision strategies (linear strategy, conjunctive strategy, majority of confirming, elimination by aspect) on decision performance. The task was multi-attribute choice task where the users had to perform information acquisition and information evaluation. They found that the presentation format influences the selection of strategies for information acquisition and evaluation based on cost benefit considerations. The study also found support for congruence notion: i.e. match between task and display format; where congruence influences cognitive processes and decision time but not decision quality. The study reported that the

acquisition of information was dependent on information presentation format and for evaluation of information; the effect of graph was contingent on task demand.

3.1.16 Effect of decision-making incentives on decision performance

Todd and Benbasat (1999) developed an integrated model that explained the relationship of DSS with decision strategy and decision performance from an effort-accuracy perspective and incorporated the effects of decision-making incentives. The results showed that as the level of support of for Additive Compensatory (AC) strategy increased the proportion of independent evaluations and elimination operations decreased, and the portions of compensatory statements and the total number of statements in the protocols increased.

The study by Lauritzen and Nilsson (2001) provided a solution for decision problems and strategies by local computation of single policy updates with limited information. According to the results of pure strategies evaluated in the table, it showed that the obtained LIMID strategies are indeed both local and global maximum.

3.1.17 Impact of desired accuracy on preferences for different presentation formats

The study by Tractinsky and Meyer (1999) aimed to assess people's preferences for different presentation formats as determined by their objectives and motivation. The main purpose for their study was to evaluate the impact of choice of presentation format, suitability of the presentation format to the situation as well as the format of the presentation on response latency accuracy and decision quality. For the above purpose three experiments were conducted and it was observed that while conducting the first two experiments that there was no difference in the pattern of presentation preferences between presentation for decision making by one and others. According to findings from

all the three experiments that were conducted, the presenters whose objective were to impress others would have different presentation preferences than presenters whose objectives was to present for optimal decision making. According to the last two experiments it showed that there would be no effect of content desirability when the presentation objective was optimal decision making. Another finding of the study was that the presenters who tried to impress others would have different presentation preferences, depending on the content desirability of their presentation.

3.1.18 Effect of video vs. text on decision performance

Elliot (2009) found that when the CEO's firm was the only firm restating its financial statements, participants viewing the restatement announcement online via video were more confident in the firm's future ability to meet analysts' expectations and make larger investments in the firm than were participants who view the restatement announcement online via text. The effects of presentation format on decision were moderated by participants' perceptions of the CEO's trustworthiness. A study by Lim and Benbasat et al. (2000) studied the effect of information representation format (video vs. text-based) on first impression bias for an appraisal task. The result from the study suggested that subjects who used the multimedia system were able to reduce the influence of first impression bias more than were those who used the text-based system. The subjects' written justifications indicated that multimedia lowers the effect of first impression bias by making information more vibrant and less ambiguous, thus making it difficult for the decision maker to not pay attention to content or reinterpret in different ways.

A continuing study by Lim and Benbasat on presentation format (video vs. text based) for Task type (analyzable vs. less analyzable) on Perceived equivocality and Perceived

Usefulness of information system (Lim and Benbasat 2000) The results of the study indicated that for analyzable tasks, there would be no difference between the multimedia and the text-based representation in terms of perceived equivocality. For less-analyzable tasks, the multimedia representation, when compared to the text-based representation, would lead to a lower level of perceived equivocality (ambiguity). Thus, consistent with both the tasks, it suggested that only the video-based representation led to lower perceived equivocality. The result on perceived usefulness states that the multimedia representation would be perceived as more useful than the text-based representation.

Jiang and Benbasat (2007) studied the effects of information presentation format (vividness and interactivity of product presentations) and its influence on customer buying decisions. The results of the study indicated that design features of product presentations influenced the consumers perceptions regarding efficacy of the presentations, diagnosticity of websites, the compatibility between online shopping and physical shopping experiences. Furthermore, Shopping enjoyment derived from a particular online shopping experience jointly influenced consumers' attitudes toward shopping at a website; and both consumers' attitudes toward products and their attitudes toward shopping at a website contributed to their intentions to purchase the products displayed on the website.

In another study by Jiang and Benbasat (2007)) examined the product presentation format (static pictures, videos without narration, videos with narration, and virtual product experience (VPE)) and its influence on decision performance in terms of consumers' product understanding, actual product knowledge and perceived website diagnosticity. The results of the study indicated that as compared to statics pictures, both videos and

VPE resulted in better perceived website diagnosticity. Under a moderate task complexity condition, both VPE and videos lead to the same level of actual product knowledge. Under a high task complexity condition, all four presentation formats lead to same actual product knowledge. Consumers are more likely to revisit websites that are perceived useful. It was found that Perceived website diagnosticity and not actual product knowledge prompted the perceived usefulness of websites.

Wheeler and Arunachalam (2008) studied the effect of information presented using text or video only and both text and video environment on judgment performance in familiar (general knowledge) and unfamiliar (accounting) tasks,. Results suggested that the text and video environment appeared to decrease task understanding. Thus, decision makers were more willing to apply externally provided decision weights when using multimedia for both task types.

Based on the findings of the literature analysis, we synthesize the following initial design guidelines for new-generation Visualization tools in table below.

Table 3-1: Research Based Guidelines for Design and use of Visualization Tools

1. Visualization should match task type
2. Visualization tools should also match data type
3. The impact of visualization tool on decision performance is moderated by task complexity/demand.
4. Visualization should aid perceptual process and analytical process
5. Visualization should make use of color to aid decision makers under time constraints.
6. Visualization should match organization type
7. Visualization influences the selection of strategies for decision making
8. Visualization could make use of guidance to aid decision makers
9. Online reporting format is not always better than hard copy printed reporting format.
10. Visualizations of XBRL tagged reports can help decision makers make more informed decisions
11. Visualization should be appealing and engaging

The findings of this review have been used to set up an empirical study to how do information visualization techniques such as Sparklines influence decision-making performance.

4 Chapter Four: Review of theory frameworks used in visualization research

There are several theories that have been used in the several research articles that study presentation format and its effect on decision support. Review of such theory can help in developing research hypothesis for current and future research studies related to this field. Several such theories are identified and reviewed in brief below.

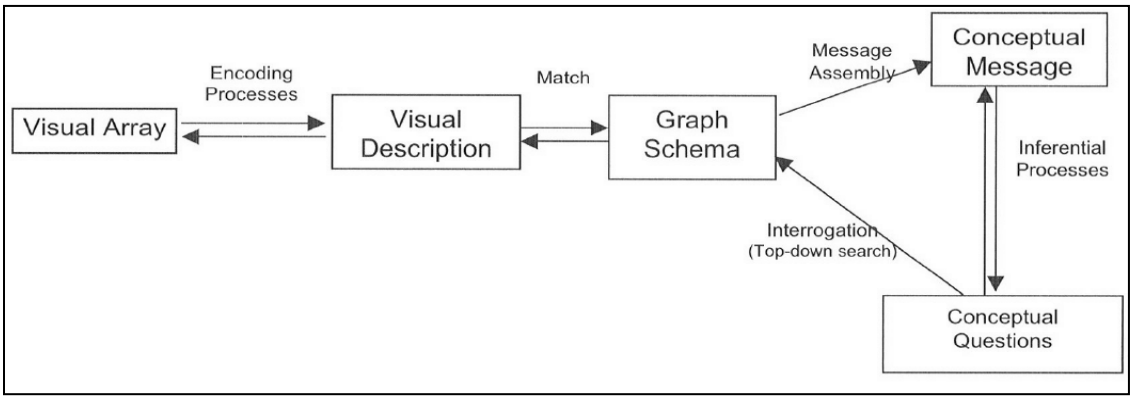
4.1 Distributed cognition theory (Zhang and Norman 1994; Hollan, Hutchins et al. 2000; Zhang and Patel 2006)

This theory proposes external representations aids memory but also provides affordance and structure cognitive behavior. A cognitive process can be distributed among an actor and the environment, external representations (artifacts),among many actors that are co-located in a shared physical space or not co-located(Hutchins and Norman 1988; Hutchins 1995; Hollan, Hutchins et al. 2000) *Internal representations* - are in the mind, as propositions, productions, schemas, mental images, connection and networks, or other forms. *External representations* - are in the world. External representations can change the nature of the task by building the connection between internal and external representation. External representations can provide information that can be perceived directly

4.2 Theory of Graph comprehension (Pinker 1990)

This theory describes the processes that a graph viewer undertakes while interpreting a graph. It emphasized that relevant prior knowledge is an important part of facilitating graph comprehension. According to Pinker's information processing paradigm, graph comprehension involves an interaction between bottom-up and top-down processes.

Figure 4-1: Theory of Graph comprehension (Pinker 1990)



Pinker's theory (Refer Figure 4-1: Theory of Graph comprehension (Pinker 1990)) outlines four procedures involved in graph comprehension: 1) *matching*, which involves recognizing the graph type by matching the current graph to the viewer's existing graph schemas; 2) *message assembly*, which involves combining information into a conceptual message; 3) *interrogation*, which involves retrieving and encoding new information in response to the comprehension task required; and 4) *inferential processing*, which involves applying logical and mathematical rules in order to draw conclusions about the information presented in the graph. Integration is also stressed, both as a way to guide selecting and organizing, and as a way to fulfill higher-level tasks, such as making inferences and drawing conclusions about the data in the graph. Difficulty in interpreting graph emerge from limitations of human memory and processing capacity and failure to activate appropriate prior knowledge (Pinker 1990; Carpenter and Shah 1998).

a. Visual Array: two dimensional *pattern* of intensities on the retinas

b. Visual Description : structural description created by *visual encoding processes called the graph schema.*

c. *Conceptual question:*the particular sort of information the reader wishes to extract

d. *Conceptual message* :the information that the reader takes away

4.3 Integrative Model of Graph Comprehension (Carpenter and Shah 1998)

This theory proposes that there are three major types of processing take place while viewers attempt to comprehend a graph. i) encoding or selecting major visual features and patterns from the graph, ii) translating them into conceptual relations and iii) relating them back to the corresponding labels in order to form an understanding of the information displayed in the graph. This iterative cycle that is repeated with increasingly more complex "visual chunks" until the viewer builds a coherent interpretation of the main information in the graph.

The implication of these two theories is that the best way to promote graph comprehension is to maximize a viewer's ability to detect patterns and organize the information by making relevant elements of the graph more salient.

4.4 Theory of dual coding (Paivio 1986; Paivio 1991; Sadoski and Paivio 2001)

As per the dual coding theory, cognition consists of two sub systems: Visual and Verbal. The theory specifies that when information is represented visually, the recall is easier and the human brain can process changes in shape, color and motion parallely. The dual coding theory (Paivio 1986; Paivio 1991; Sadoski and Paivio 2001) proposes that memory consists of separate but interrelated nodes for information processing. The two distinct mental representation systems are: verbal and visual. The verbal and visual systems can be activated independently but interconnections exist that allow dual coding of information. The contribution of this theory is that information is much easier to retain

and retrieve when dual coded because of availability of two representations instead of one. Recall is easier with visual system than verbal system. Visual system accesses information synchronously and verbal system accesses information sequentially (Rieber 1994).

4.5 Theory of Propositional Representation (Pylyshyn 1973)

Criticism of dual code theory comes from Propositional theory. This theory proposes that all information verbal and visual can be stored in long term memory thus a second code is not necessary. Both the theories differ in the way information is processed and stored. Propositional theory suggests that all types of information is stored with a single code in the long term memory in a single way whereas dual code suggests that human brain process and store words and pictures separately. But both the theories propose that visual representation is better than verbal representation in context of perception and recall (Rieber 1994).

4.6 Cognitive Load Theory (Van Merrienboer and Sweller 2005)

This theory suggests that that people have a limited working memory capacity which can easily be overwhelmed if they are given too much information to process or if they are unfamiliar with the material. The more inferences one has to generate about which variables are relevant, what the components of the graph are referring to, what a particular configuration means, and how different parts of the graph relate to each other, the more demands are placed on working memory and the harder it is to extract meaningful information from the graph.

Graphical perception theory (Cleveland and McGill 1984; Cleveland and McGill 1987)

This theory focuses on visual-spatial properties that made some graphs easier to understand than others. The main implication of this model is that graph comprehension relies heavily on perceptual processing of a graph's visual-spatial elements. To facilitate comprehension, graphs should employ visual elements that people can select and organize easily. They propose that graphs represent information primarily through position, shape, color, size and symbols, and that viewers decode that information by taking it in, organizing it, and detecting patterns and structures.

Figure 4-2: Different physical features of a graph and accuracy of judgments

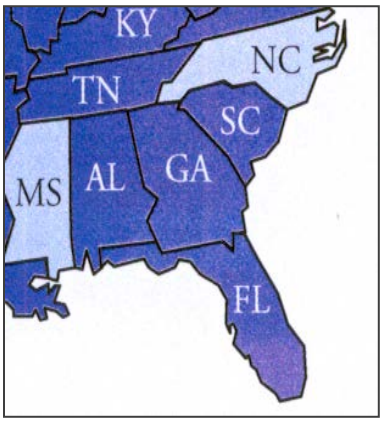
Most Accurate	Position (Common)
	Position (Nonaligned)
	Length
	Slope
	Angle
	Area
	Volume
	Color hue-saturation-luminance

Different physical features of a graph, such as the length or position of a line, or the use of area, angles, or color require viewers to perform different elementary perceptual tasks, some of which lead to more accurate judgments than others. Length judgment is more accurate than Slope and angle judgment, which in turn was more accurate than area judgment. Area judgment is more accurate than volume judgment.

4.7 Stevens' Power Law for estimating magnitudes

This theory states that when values are presented as area or volumes, perceptions of the decision makers are affected by shape. Decicion makers as per this law, underestimate large values relative to small ones and overestimate small values relative to large ones

Figure 4-3: Stevens' Power Law for estimating magnitudes in area map



In the figure above (Figure 4-4), it appears that Florida is larger than Georgia, but in reality, it is slightly smaller. Perceptually it was easier for users of this map to overestimate the smaller one (Florida) and underestimate the larger one (Georgia).

4.8 Computational model of graphical perception (Lohse 1993; Lohse 1997)

This proposed that graph viewers first detect and encode visual primitives such as shape, color, and length and then build a visual description from localized scanning and rescanning of the graph. They then match this description to a graph schema in long-term memory which contains rules and procedures about where and what to look for when retrieving information.

4.9 Weber's Law of Just Noticeable Differences (Weber, Ross et al. 1996)

The 19th century experimental psychologist states that the Difference Threshold (or "Just Noticeable Difference") is the minimum amount by which stimulus intensity must be changed in order to produce a noticeable variation in sensory experience (Weber, Ross

et al. 1996). The theory States that it is relative rather than absolute differences which are perceived when we compare lengths. Weber found that the smallest noticeable difference in weight was proportional to the starting value of the measurement. This kind of relationship can be described by a differential equation as, $dp = k\frac{dS}{S}$, Where dip is the differential change in perception, do is the differential increase in the stimulus and S is the stimulus at the instant. A constant factor k is to be determined experimentally. Example: Say for the length of magnitude, I, of 10 cm, the increment threshold for detecting a difference is ΔI of 0.10 cm. for a 5 cm length, the just noticeable difference is 0.5 cm. Ratio of ΔI/I (0.2/2.0=.5/5) = 0.1. In a noisy environment one must shout to be heard while a whisper works in a quiet room. Using the Weber's Law in line length in visual representation, detection of the difference in lines happens due to the ratio of the size of lines and not of the lines itself. Small changes in line are not easily perceived to be a changed. If the change in line is of some magnitude, chance of detecting a difference increases (Benbasat and Nault 1990).

5 Chapter Five: Research Framework

5.1 Importance of reporting format

Format in which data are presented to decision makers is critical to provide information for making decision (DeSanctis 1984; Sharda, Barr et al. 1988). Importance of study on visualization tools and its effectiveness in disseminating financial information in the accounting context; to aid decision making; stems from a) progression of annual reports and other financial reports from the traditional hard copy to digital format (Dull and Tegarden 1999) and b) increasing need of the decision makers in the knowledge economy to have access to real time access to information and c) increasing use of business intelligence software for reporting purposes. According to FASB Statement of Financial Accounting Concepts No.1, financial statements should provide information beneficial to investors, creditors, analysts and other users in supporting their decision (FASB 1978).

It is also important to study the use of visualization tools in developing digitized financial reports because it is worried that management may be interested in manipulating the graphic presentation (Beattie and Jones 1993; Beattie and Jones 1997). There are several propositions for the development of professional guidelines or standards for use of graphical presentation of financial data (CICA 1993).

This study is a continuation of a rich area of research on reporting format of financial information and its influence on decision performance in the area of accounting and information system. Subjects enrolled in finance and accounting courses prepare or study business reports to compare and/or evaluate performance of different companies. Investors, Creditors, Auditors, Management team and other Stakeholders of the company

also study such business reports to make decisions. Traditionally business reports are presented with tables, line graph, bar graph and text. Past research on alternative reporting methods has focused on Graph (Bar, Line, 2D, 3D, Rotatable 3D, Animated, Interactive), Tables, Schematic faces (Chernoff faces), Polygon diagram, Business animator.

The traditional reporting format has some limitations. Traditional reporting format has been used with low volume of data that are easily comprehensible in tables or graph. In the digital environment, as information becomes ubiquitous, getting managers' attention and helping them find and focus on the most relevant data becomes increasingly difficult(Davenport and Beck 2001). The mobile knowledge workers need access to real-time opportune and appropriate information to make decisions. Mobile knowledge workers need access to high volume of data in small screen space like smart phones.

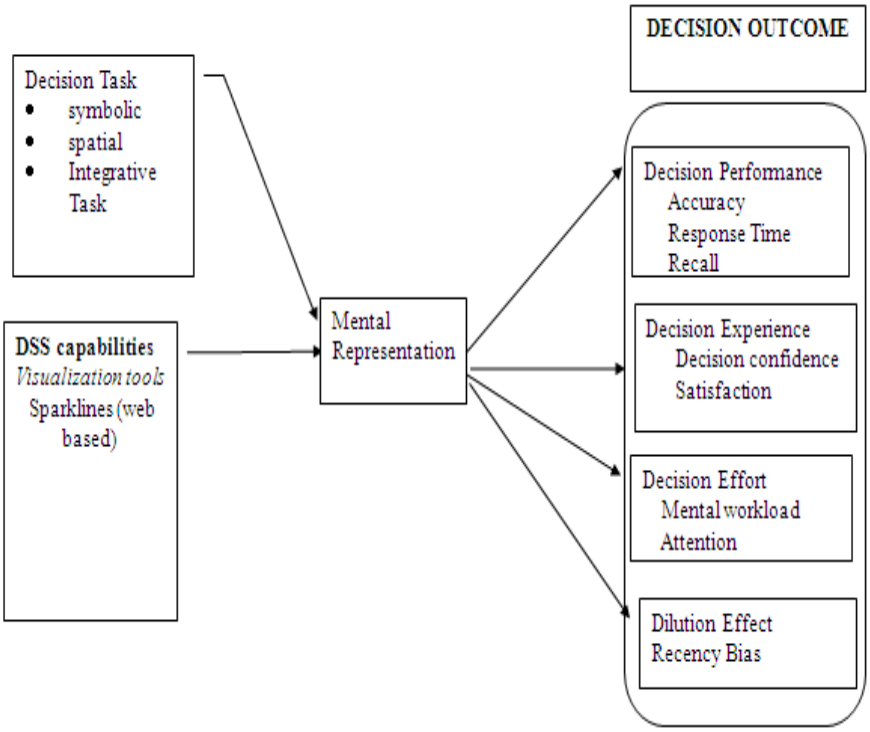
There have been several calls on research or the study of visualization tools. Research examining information visualization largely focuses on the construction of visualization techniques and has not focused on the evaluation of these techniques (Carey and White 1991) Empirical studies that assess the effectiveness of visualization techniques are needed (Mirel 1998). Research is needed to study the behavioral factors associated with how the visualization tools are used on an everyday basis (Dillon 2000). Visualization tools may enable improvements in decisions, but if used ineffectively may also lead to negative cognitions and outcomes such as overwhelm decision makers, leading to information overload. Accounting literature has emphasized the need for studying the role of presentation format in the efficiency and effectiveness of decision-makers' decision quality in order to provide empirical evidence on the effect of presentation

format on decision quality (Debreceny and Gray 2001; Abdolmohammadi, Harris et al. 2002). To address this gap in the literature, the research questions guiding this research related to digital financial reporting are as follows:

1. Does an information visualization technique such as Sparklines improve decision-making performance?
2. Does an information visualization technique such as Sparklines improve decision-making experience?
3. Does an information visualization technique such as Sparklines have an impact on decision-making effort?
4. Does an information visualization technique such as Sparklines have an impact on reducing dilution effect from non relevant data in financial reports?
5. Does an information visualization technique such as Sparklines have an impact on reducing recency bias in using digital financial reports?

The research model developed and applied in this study is presented in Figure 5-1.The figure illustrates that Sparklines with *visual proximity of graph and text* in digital financial reports enhances decision making performance, decision making experience and reduces decision making effort. In addition, Sparklines can reduce decision effort; reduce dilution effect from non-diagnostic information and in mitigation of recency bias. These assertions and the corresponding hypothesis are developed below.

Figure 5-1: Research Model: Factors influencing the impact of visualization on decision making performance



In the next section we discuss the sparklines.

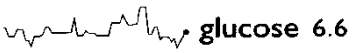
5.2 Sparklines

Sparklines is a new data visualization tool that is now part of Microsoft Excel 2010 (Johnston 2010) and many other Business Intelligence software (SAP-business objects-Xcelsius, IBM Cognos). Sparklines are "small high resolution graphics usually embedded in a full context of words, numbers, and images" (Tufte, 2006).However, the use of Sparklines is beginning to be used in business decision making; its impact on decision performance has not been explored carefully in the AIS and MIS field.

Sparklines are small graph that are the same size as words and are embedded within text or tables in close proximity. Sparklines are "data words"- Data intensive, design-simple, word-size graphics. Sparklines are data graphics constructed at the resolution of letters.

Several Business Intelligence software vendors like Board International, IBM Cognos, MicroStrategy, SAP Business Objects, SAS and Tibco Spotfire make use of sparklines. A snapshot of a mobile application developed for executive dashboard using Sparkline is given below (Figure 5-2.)

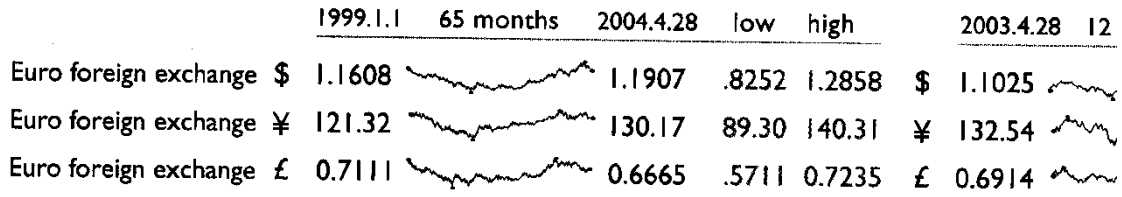
Figure 5-2: : snapshot of a mobile application developed for executive dashboard using Sparkline

Tufte explains the rationale for developing Sparklines in his book titles beautiful evidence. He writes that traditionally in data display a noun is accompanied by a number, glucose 6.6. This presents a person's glucose reading as 6.6. When this reading is put in the context, a single number gain meaning 

.Now the glucose reading of the same person over a period of time is show as a graph ;the size of the word; next to the graph. After adding scale of measurement to the graph which shows the normal range for the variable, glucose, shaded in the grey area; the eyes can now perceptually know the times when the glucose readings has gone out of the normal range

in the past  glucose 6.6 . They are read the same way as words. They present an overall shape and aggregate pattern along with plenty of detail. In the below example (Figure 5-3), As explained in the book by Edward Tufte , each Sparkline tracks 250 days of price of exchange; they present both overall view and details.

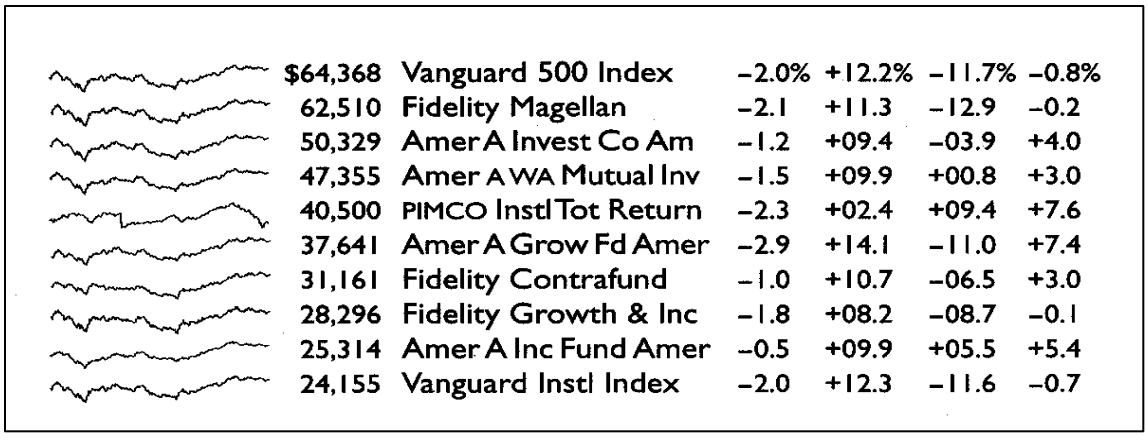
Figure 5-3: Sparkline tracks 250 days of price of foreign exchange



Source: Beautiful Evidence by Edward Tufte

Sparklines can visualize high volume of data in a small screen space (Figure 5-4). As per Tufte. Sparklines are capable of displaying 400,000 additional data per 5-column financial page in the following form.

Figure 5-4: Column financial page with Sparkline in Newspaper



Source: Beautiful Evidence by Edward Tufte

5.3 Theory and Hypothesis

5.3.1 Theory of proximity compatibility

As stated in the theory, we expect that sparkline can impact decision performance. This study examines if visual placement of related elements in close proximity has an effect on decision outcome. Using the theory of proximity compatibility (Wickens and Carswell 1995) it is argued that proximity of related visual elements is especially critical to success in decision making. The success of visualization tools in supporting decision making is dependent on effective visual processing of information. Much of the success of visual processing of information depends on how information is positioned on a page or computer screen. If related elements are positioned too far apart, the brain can no longer identify and process relationships.

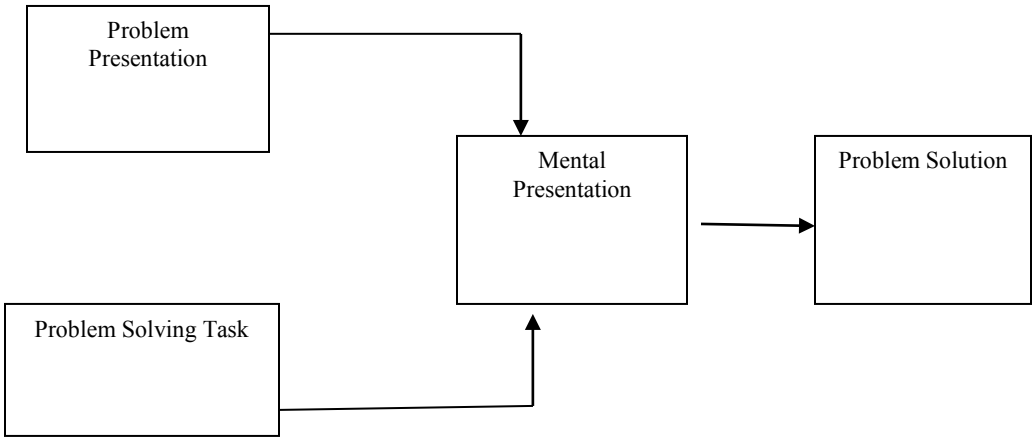
When stock reports are developed with information dispersed with graphs and tables that are positioned too far apart, and then it makes it more difficult for the decision makers to grasp and process relationships. Placing related information close together improves the cognitive processing of information because decision makers can immediately find and integrate related concepts before them. This enables more meaningful interaction with content of the financial report. Using the theory of proximity compatibility as our main theory guiding this study we propose several hypothesis below.

5.3.2 Theory of Cognitive Fit

Another theory used to guide the development of hypothesis is the theory of cognitive fit. As per the theory of cognitive fit, complexity in the task environment will be effectively reduced when decision aids supports the task strategies required to complete the task(Vessey 1991). This theory was used to explain the discrepancy in the graph vs.

table research. The theory states that the problem solving performance results from the interaction between the external presentation and the problem solving task. The problem solvers acquire the information from the external presentation, internalize and assimilate it to its mental representation to arrive at a solution. Matching the problem presentation to the task leads to effective and efficient problem solving. The Cognitive Fit Model is shown in Figure 5-6.

Figure 5-5 Theory of Cognitive Fit



5.4 Development of Hypotheses

5.4.1 Decision Experience: Decision Confidence and Satisfaction

From the point of the affective and conative aspect, decision makers form positive, negative or neutral attitude towards the presentation format as they examine the reports. Another study suggests that providing additional information to the decision makers do not always result in higher decision quality, but it can lead to increased decision confidence (Oskamp 1965). Confirming this result is another study which indicates that providing baseline financial information and additional news information to the decision maker results in increased decision confidence and less decision accuracy as compared to

providing just the baseline financial information (Davis, Lohse et al. 1994). There are studies that demonstrate a significant difference in decision confidence due to presentation format (Amer 1991; Anderson and Mueller 2005). Contradicting these results there are some studies that find no significant difference in decision confidence due to presentation format (DeSanctis and Jarvenpaa 1989; Lim, Benbasat et al. 2000; Schulz and Booth 2009). The research hypothesis that we propose is

H1a Compared to traditional stock report, decision makers using stock report with Sparklines will have greater decision confidence

H1b Compared to traditional stock report, decision makers using stock report with Sparklines will have greater decision satisfaction

5.4.2 Decision effort: Cognitive load and Attention

Visualization must organize and explain information, relate views, provide knowledge and engage decision makers. When the visualization is not clear, decision makers can become confused and daunted. When using stock reports, the shareholder's report and the financial statements with key ratios are provided to the decision makers in the form of hyperlinks. The decision makers are asked to link from page to page, information is dispersed in the form of separate table and graph. This could make it difficult for decision makers to connect the related pieces. In the Sparkline condition, decision makers are also asked to link from page to page, but the graph and the table on the financial report is placed in close proximity using Sparkline. Guided by the theory of Proximity Compatibility Principle, we propose that the visual proximity of graph and table in the form of sparkline could make the visual processing of the information easier in the form of reduced cognitive workload.

H2a Compared to traditional stock report, decision makers using stock report with Sparklines will experience reduced a cognitive workload.

Attention is the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things(Anderson 2004). Attention has also been referred to as the allocation of processing resources. As per the capacity model of attention The task attention can be of two types (a) off-task activities, (b) on-task activities (Kahneman 1973). As per this theory, in a complex task, when *task demands are high*, the decision maker will pay close attention to the on- task activities or be more engaged leading to greater performance. Conversely, when *task demands are lower* the decision maker may concentrate on off-task activities. Performance can be represented by "joint function of the subject's relative attentional capacity (i.e., cognitive ability) and the proportion of the subject's total capacity actually devoted to the task (motivation)" (Larkin and Simon 1987). Tables show only current levels or recent changes. We hypothesize that sparklines with table will improve the attention span of the tables. So when task demand is high sparkline improves attention and when task demand is low there is no difference between sparkline with table. In a bankruptcy prediction task, task demands are high, so sparkline with table should improve on task attention and reduce off task attention as compared to table and graph separately.

H2b Compared to traditional stock report, decision makers using stock report with Sparklines will experience greater on task attention.

H2c Compared to traditional stock report, decision makers using stock report with Sparklines will experience lower off task attention.

5.4.3 Dilution effect

Cognitive Load Theory (Van Merrienboer and Sweller 2005) suggests that that people have a limited working memory capacity which can be overwhelmed if they are given too much information to process. The limited working memory capacity affects how the information is processed during decision making (Miller 1956; Baddeley 1992; Libby Ken 1993). The limited working memory causes a burden on our working memory known as cognitive load and this cognitive load is negatively associated with learning (Sweller 1988). Decision makers not following normative patterns of behavior and adopting processing strategies or heuristics, such as the representativeness heuristic, to reduce cognitive effort are often the result of the limited cognitive capacity of the brain (Einhorn and Hogarth 1981; Payne 1982). This use of heuristics in combination with limited mental processing capacities of the brain leads to decision biases, such as dilution effects (Kahneman and Tversky 1979; Nisbett, Zukier et al. 1981). The source of dilution effect research is that the nondiagnostic information (irrelevant data) dilutes the impact of the diagnostic information (relevant). *Thus, dilution effect is the result of any irrelevant information cue weakening the impact of relevant information.* Several studies in the accounting field suggests that investor decisions are influenced when financial statements are presented to investors in combination with other types of information such as a letter from a company's president (Kaplan, Pourciau et al. 1990) and supplementary news information (Davis, Lohse et al. 1994). Kaplan et al. (1990) suggest that nondiagnostic or irrelevant information may be given to better manage the opinion of existing and potential investors. A dilution effect occurs when predictions based on a

combination of relevant and irrelevant information are less extreme than predictions based solely on relevant information (Nisbett et al. 1981).

When the potential investors are presented with stock reports containing audited financial information (relevant information) and shareholder's report (irrelevant information) then using the theory of PCP, we can predict that the visual proximity of table and graph in table prepared with sparklines should aid decision makers. The relevant information required to make bankruptcy prediction are placed in close proximity when using sparklines. With sparklines the decision makers should have lower demands placed on working memory, making it easier to make inferences about which variables are relevant, what the components of the visualization are referring to, what a particular configuration means, and how different parts of the visualization relate to each other.

We hypothesize that the presence of bankruptcy prediction based on a combination of relevant and irrelevant information are less extreme in sparkline condition as compared to the non-sparkline condition.

H3 Compared to traditional stock report, decision makers using stock report with Sparklines will experience lower dilution effect from irrelevant information contained in the shareholder's report.

5.4.4 Recency Bias

Recency bias is the persistent overweighting of recent events in making decisions. By showing recent changes in relation to many past changes, sparklines provide a context for nuanced analysis and one hopes for better decisions (Tufte 2006).

Tufte writes that "If the visual task is contrast, comparison and choice – as so often it is – then the more relevant information within eye span, the better"(Tufte 1995). This study

proposes that visual proximity of graph and table in Sparklines may vastly improve the data within the eye span and intensify routine capabilities of the human eye-brain visual processing of information, seeing distinctions and making comparisons and hence mitigate the effect of recency bias.

H4 Compared to traditional stock report, decision makers using stock report containing Sparklines will experience lower recency bias.

5.4.5 Decision Performance: Accuracy and Time

Accuracy and response time is often used as an indicator of performance in decision making tasks using different presentation formats (Benbasat and Dexter 1985; Benbasat and Dexter 1986; Amer 1991; Volmer 1992; Umanath and Vessey 1994). Cognitive effort refers to the total expenditure of cognitive resources required to complete a task (Frownfelter-Lohrke 1998). Decision accuracy is probably the most commonly used criterion for measuring decision making performance (Remus 1984; Benbasat and Dexter 1985; Benbasat and Dexter 1986; Lee, MacLachlan et al. 1986; Jarvenpaa 1989; Amer 1991; Carey and White 1991; Vessey and Galletta 1991; Volmer 1992; Umanath and Vessey 1994; Montazemi, Wang et al. 1996; Dennis and Carte 1998; Dull and Tegarden 1999; Vance Wilson and Zigurs 1999; Chan 2001).

Using the theory of cognitive fit as explained earlier; we propose that if information presentation format and decision subtask match, there will be greater level of cognitive fit, resulting in better decision performance.

Symbolic task is decision making task which requires the decision maker to manipulate discrete sets of symbols. According to the effects of the Spatial and Symbolic Problem Solving elements, the result of a study suggested that the decision makers' chose tables to

respond to symbolic tasks than to spatial tasks (Vessey and Galletta 1991). So for symbolic tasks, Sparklines will increase mental load, distract attention and can negatively effect decision performance.

H5a Compared to traditional stock report, decision makers using stock report with Sparklines will have lower decision accuracy rate for symbolic tasks

To find relationships, trends or patterns graphs outperform the tables (Vessey 1991). Spatial task is a decision making task that requires decision maker to establish relationships among those discrete sets of symbols. Sparklines with table provide word size line graph placed in close proximity to the table that can help provide trend over time. So for Spatial task Sparklines provide a good Cognitive fit as information presentation format (sparklines with table) matches the task type (finding relationships among these discrete variables); which will result in improved decision performance.

H5b Compared to traditional stock report, decision makers using stock report with Sparklines will have higher decision accuracy rate for spatial task.

Sparkline helps organize graph and table in close proximity. Sparkline also contain word size graph which can be analyzed together with the discrete numbers available in the table. This form of information presentation will induce the decision makers to develop mental representations based on the task. Tasks can also be classified as Integrative task or Selective task. Integrative task is a decision making task which require the decision maker to integrate multi-attribute data.(Umanath and Vessey 1994; Crossland, Wynne et al. 1995). In this type of task the large volume of data cannot be processed cognitively (analytically) hence Sparkline can reduce the cognitive load of the decision maker to arrive at the judgment. This type of task is called a holistic task.

(Vessey and Galletta 1991). Thus, for Integrative tasks, Sparklines provide a good Cognitive fit as information presentation format (sparklines with table) matches the task type (integrate multi-attribute data); which will result in improved decision performance. Based on the theory of cognitive fit that we assert that effectiveness of close display proximity of graph and text in the form of Sparkline is greatest for tasks where data from different sources needs to be processed together such as in integrative task.

H5c, Compared to traditional stock report, decision makers using stock report with Sparklines will have higher decision accuracy rate for integrative task.

Decision-makers often rely on perceptual cues present in the data which consume less time (Umanath and Vessey 1994). Cognitive effort refers to the "total expenditure of cognitive resources required completing a task" (Frownfelter-Lohrke, 1998). Cognitive effort is often measured by total decision or response time (Dull and Tegarden 1999). Therefore we select response time as a measure of decision performance efficiency. Less time means less cognitive effort required to do the task and more efficient decision making. Guided by the theory of Proximity Compatibility Principle, which identifies that placing related information close together improves the cognitive processing of information because decision makers can immediately find and integrate related concepts before them quickly; we hypothesize the following.

H5d Compared to traditional stock report, decision makers using stock report with Sparklines will take less response time.

Recall

The dual coding theory (Paivio 1986; Paivio 1991; Sadoski and Paivio 2001) proposes that memory consists of separate but interrelated nodes for information processing. The two distinct mental representation systems are: verbal and visual. The verbal and visual systems can be activated independently but interconnections exist that allow dual coding of information. The contribution of this theory is that information is much easier to retain and retrieve when dual coded because of availability of two representations instead of one. Recall is easier with visual system than verbal system. Visual system accesses information synchronously and verbal system accesses information sequentially (Rieber 1994).

H5e Compared to traditional stock report, decision makers using stock report with Sparklines will have greater pattern recall

H5f Compared to traditional stock report, decision makers using stock report with Sparklines will have greater fact recall

The summary of hypothesis is given in Table 5-1.

Table 5-1 Summary of Hypothesis

	Dependent Variables		Decision Outcome
H1a	Decision confidence	Sparkline >No	Decision Experience
H1b	Satisfaction	Sparkline > No	
H2a	Cognitive load	Sparkline< No	Decision Effort
H2b	On task attention	Sparkline > No	
H2c	Off task attention	Sparkline < No	
H3	Recency Bias	Sparkline < No	Recency Bias
H4	Dilution effect from nondiagnostic	Sparkline < No	Dilution Effect
H5a	Decision accuracy for Integrative	Sparkline > No	Decision Performance
H5b	Decision accuracy for Spatial Task	Sparkline > No	
H5c	Decision accuracy for Symbolic	Sparkline < No	
H5d	Reponses Time	Sparkline > No	
H5e	Pattern Recall	Sparkline> No	
H5f	Fact Recall	Sparkline> No	

5.5 Research Design

The study employs a controlled laboratory experiment to empirically test the effects of Sparkline on Decision performance for different task types. The experiment control for the independent, moderating, dependent, and possibly confounding variables to achieve a high degree of internal validity (Singleton, Straits, Straits, & McAllister, 1999). It is a repeated measures design where the same measures were collected two times for each subject but under two different reporting format conditions. Besides economizing on the number of participants , the use of a within-subject design for the interface design enabled control over individual differences like spatial ability (Large, Beheshti et al. 1996), cognitive style, knowledge of participants (2008), comprehension abilities, which otherwise could have significantly influenced the dependent variables (DeSanctis 1984). Within subject we have a) representation type- Sparkline vs. Graph representation and b) task type: Spatial vs. Symbolic vs. Integrative Task.

5.6 Experimental Procedures

The digital financial report was launched on the web using Google site which is a web application that can add to other Google applications such as documents, forms (to collect data), spreadsheet (to store data) etc.

i. In the first screen signed consent was taken from the participants were taken to participate in the project (Refer Appendix 8.1)

ii. Second screen providing instructions to participants to complete the experiment

iii. Pretask questionnaire related to demographics, participant knowledge and other background information was collected (Refer appendix 8.3)

iv. A brief presentation on sparkline was provided to decision makers using power point which included images of sparklines along with explanation. They then asked question about the sparkline to evidence their familiarity with the new visualization tool called sparklines. (Refer appendix 8.4). We provided the decision makers with case scenario, and hyperlinks connected to shareholders report and 5 year overview with key financial rations of two similar anonymous companies in two different presentation formats. We maintained *equivalence of information in both conditions*, the decision makers studied the reports individually, and then performed some tasks and answered questionnaire (Refer appendix 8.6 and 8.7).

v. They finally completed the experiment by answering the post experiment evaluation questionnaire (Refer appendix 8.8)

5.6.1 Development of stock reports

To simulate experiment close to real world experiences and to increase the generalizability of the findings, we used a stock report of a random company from TD Ameritrade, and developed prototype stock reports using Sparkline. We selected Microsoft Excel 2010 to develop Sparkline as it is a commercial product commonly used by accountants and analysts to develop financial reports. The experimental task of bankruptcy prediction was developed based on prior research (Umanath and Vessey 1994; Zhao 2008). Two anonymous firms (which went bankrupt in the sixth year) were selected from their data set. Altman Z-Score (Altman 1968) was calculated for the two dataset of two companies that actually went bankrupt using the formula given in Table 5-2. Based on the formula of z score of the two companies for which the stock reports were prepared, were 1.6 and 1.9 respectively. This suggested that there is a high probability

chance that these two company will go bankrupt within 2 years of operations from the date of financial figures given. In this study specifically, two types of stock reports were created with two different types of presentation format- Sparklines and no sparklines, for the use of non-professional investors. The answers from the decision makers were evaluated to reflect on our research objective.

Table 5-2: Altman z score calculation

	RATIO	WEIGHTAGE
A	EBIT/Total Assets	x. 3.3
B	Net Sales /Total Assets	x 0.999
C	Market Value of Equity / Total Liabilities	x 0.6
D	Working Capital/Total Assets	x 1.2
E	Retained Earnings /Total Assets	x1.4

5.7 Measures

5.7.1 Independent Variables

In this study we examine the effectiveness of two types of online financial report formats that are applied widely in company websites: traditional financial report with graph, table, text; and new report with table, text and Sparkline; and investigate the moderating role of task type.

5.7.2 Dependent Variables

Major objective dependent variables that have been used to measure decision performance has been decision accuracy, recall and response time.

For the first, labeled *decision accuracy*, Decision makers had to perform 3 spatial tasks, 4 symbolic tasks and 1 integrative task each, under both conditions and for each tasks there was only 1 accurate answer. Accuracy was measured by the number of correct answers. Response time was measured using the time log automatically recorded in the experiment to complete the tasks and answer the questionnaire under each condition. The total number of correct answers under each condition is then used to analyze the differences between the means.

Degree of *recall* can be measured by % of correct answers (Watson and Driver 1983). In the study recall has been measured by the number of correct answers for two questions for recall of pattern/trend and one question of recall of specific fact each under both conditions (Schmell and Umanath 1988). The total number of correct answers under each condition is then used to analyses the difference between the means.

Given that an important goal of financial report on websites is to disseminate financial information to investors and other stakeholder's knowledge, it is important to assess the

effects of the two presentation formats on perceptual constructs that can potentially influence usage of visualization. The perceptual measures used in the study are Decision confidence and perceived satisfaction. *Decision confidence* is measured by five questions regarding decision makers' decision confidence for the tasks under each condition (DeSanctis 1984; Benbasat and Dexter 1986; Amer 1991).The average of the decision confidence under each condition is then used to analyses the difference between the means. *Satisfaction* has been measures using two questions under each condition. *Attention* on (a) off-task activities and (b) on-task activities (Kahneman 1973) has been measured using two questions under two conditions.

Effectively understanding the level of cognitive load or stress on working memory from the use of Sparkline can help gauge the effectives of such visualization tool in reducing the decision effort. The major dependent variables have been used to measure cognitive cost is mental workload and attention. *Subjective cognitive workload* was measured using the NASA Task Load Index (NASA-TLX)(Hart and Staveland 1988). This instrument has been extensively used and validated in human factors research. In this research the dimensions scores for each variable was added to generate the overall cognitive load on the decision makers. The NASA Task load has been modified to suit the purpose of our study and the variables used in this study is given in Table 5-3. The variables physical effort and time constraints from the original NASA TLX were not suitable for this study and were not used in the study.

Table 5-3: NASA Task Load Index

Variables	Questions
Mental Demand	How mentally demanding was the task?
Temporal Demand	How hurried or rushed was the pace of the task?
Effort	How hard did you have to work to accomplish your level of performance?
Frustration	How insecure, discouraged, irritated, stressed, and annoyed were you?

The second dependent variable, labeled, *recency bias* is defined as the persistent overweighting of recent events in making decisions. To assess recency bias we used the measure used by DeSanctis and Jarvenpaa (DeSanctis and Jarvenpaa 1989). Monte Carlo simulation was used to prepare future income statement and retained earnings and total assets for the firm in the sixth year using last 2 years, 3 years, 4 years and 5 years of historical data. In this study, if the subject's forecasting model was based on very few historical periods such has last 2 or 3, this was considered to be evidence of extreme recency bias. That is, the subject's forecast was based on the three or two most recent data periods as opposed to including data from any earlier historical periods, the subject overemphasized recent data, to the exclusion of historical data.

Shelton (1999) indicates that in spite of individuals being aware that nondiagnostic information is irrelevant, their judgments are still persuaded by the nondiagnostic information. Under both the conditions the firms go bankrupt in the 6^{th} year and decision makers under both conditions are exposed to irrelevant and relevant information. If the decision makers in the non-sparkline condition were not able to predict bankruptcy as correctly as compared to decision makers in the sparkline condition, this was considered to be evidence of extreme *dilution effect*. After assessing the bankruptcy the decision

makers was asked how much of the $5,000 you would invest in this firm. If is the decision makers are overly influenced by shareholder's report to not to be able to predict the bankruptcy accurately, then the decision makers would be more likely to invest in that firm, evidencing the presence of strong dilution effect. On the other hand, if the decision makers are relying heavily on the relevant information encoded in graphs and tables to make decisions, then they are less likely to invest in the firm which will go bankrupt. To assess dilution effect we have used the method used by Kelton (2006). Dilution effects are measured by the differences between participants in the sparkline condition and participants in non-sparkline condition for investing in the firm, using both relevant and irrelevant data.

5.8 Control variables

Demographic factors may influence decision maker's performance and therefore collected information on the background of the participants. We controlled for individual differences such as knowledge, graph preference, Gender, GPA, sex, age and others by using a repeated measure design.

5.9 Pilot Study Procedure

Students were randomly assigned in to two groups. Group 1 had the presentation order as Sparkline followed by non-sparkline condition. In Group 2 the presentation order was reversed as non-sparkline condition followed by sparkline condition. There were in total 40 students in both treatment and the control group. There were 24 female and 16 male for the pilot study. The results from our pilot study supported our hypotheses that predicted the superior effects of Sparklines on decision outcome. This indicated that our stock reports and tasks were all successful and could be incorporated into our proposed

larger study. Based on oral feedback from some of our experienced participants it was observed that two of the questions required minor grammar corrections in the framing of the questions which was incorporated in the main experiment. Feedback was received from the participants.

6 Chapter 6: Main Study

The first step after collecting the data was data preparation. The codebook was prepared to define how each questionnaire is coded for data entry. All the questions in the digital questionnaire were required entry and hence there was no missing value. .

6.1 Participants

This study examines the use of visualization with users with lower level of financial understanding and how the use of novel graphics affects their judgment and decision. Dilla et al.(2007) find that nonprofessional investors spend relatively more time viewing graphs on a simulated investor relations web site with text and graphical displays than professional investors. Their results suggest that the nonprofessionals spend relatively more time viewing the graphical display (Dilla, Janvrin et al. 2007). Hence to study the effect of visualization, our decision makers are from a pool of non-professional investors who have lower level of financial understanding. In Bransford, Brown, & Cocking, R.(2000) , it is recommended that for novice learners related information be placed close together so that the learners are led through the process of recognizing key information and visualizing the connections between ideas internally. For the more expert learners, who are already more able to see connections between the information, they suggests that it is important to present sufficient amounts of data to encourage greater interest in the topic and opportunities for deeper levels of learning. Undergraduate students having limited or no prior experience in making investments in stock and had taken finance and accounting courses investments participated in the study. These students have taken some finance and accounting courses in general and have a low level of financial understanding

as compared to professional investors. To encourage participation, participants were given course credit.

The demographic characteristics of the sample as shown in Table 4: 52 percent were male, 91 percent were younger than age 25 and the distribution of majors was consistent with the student population from which the sample was drawn. The majority 64 percent had prior investing experience, although only 2 percent of these decision makers have investment experience of more than 3 years. Thus, our sample reflects what one might expect of a typical end-user population of novice investors as opposed to one made up of professional investors.

A controlled experiment is sufficient for internal validity (Smith 1982). However, in order to generalize and transfer the experimental results to other situations, (for external validity); several studies test parallelism by direct comparisons of the outcomes of an experimental setting between different samples recruited from a student and a professional (field) pool (e.g., Smith et al. 1988; Drehmann et al. 2005). In these situations, both the student and the field pool were confronted with the same experimental context (e.g., laboratory setting or Internet experiment). In addition to the student pool, members with advance degree or professional degree in accounting with some experience in investing were recruited to test for parallelism. The latter group included six women and twenty men, aged 22 to 51-years-old, with mean job experience of years in investment (Refer Table 5-4).

Table 5-4. Differences in participants' backgrounds.

	All participants	More experienced investors	Novice investors (undergraduate students)
Total number of recruits	275	26	249 (130 Male)
Fail to pass the manipulation checks	17(6.1%)	0	17 (7.0%)
Gender — Male (%)	146 (53%)	16(61.5%)	130 (52%)
Average age		30	22.19
Class standing			
Freshman	56	0	56
Sophomore	111	0	111
Junior	78	0	78
Senior	4	0	4
Taken Accounting/ Finance courses	100%	100 %	249 (100 %)
Have personal investments in debt or equity securities	90 (32%)	26 (100%)	64 (26%)
Have more than 3 years of investment experience	27 (9.8 %)	24 (92 %)	3 (1%)
Have a lot of experience reading digital financial reports	34 (12.3%)	25(96%)	9 (4%)
Preparing for professional certification	69 (25%)	6(24%)	63 (25%)
Professionally Certified	6 (2.9 %)	8 (32%)	0
Have no experience with Sparkline	268(97.45%)	24(96%)	244 (99%)
Have work experience of less than 3 year	195 (70%)	0	195 (78.3%)
Education less than Bachelor's Degree	216(78.5%)	0	216 (86.7%)

6.2 Validity checks

6.2.1 Counterbalancing

Half the participants started with the Sparkline Condition, and the other half started with the Non-Sparkline condition. On average, completion of tasks within each condition took 15 minutes. The overall experiment took around 30-40 minutes to complete. Order of testing was counterbalanced to prevent the learning effect and fatigue effect that might be associated with the ordering of the presentation format.

6.2.2 Manipulation check

Participants' motivation is often low and they frequently don't pay attention to the very things that are supposed to influence them. We used a questionnaire to test whether the participants training on sparklines was effective. Approximately 93% answered correctly indicating that they had undergone the training correctly. We asked questions as a manipulation check to be sure that participants actually read and used the different reports provided to them in the form of hyperlinks. For both the sparkline with table and graph with table format, we asked information about the management letter was from which executive on the company and management letter states which of the following? Around 90-92.5% gave right answers. Therefore we can conclude that participants actually read the different reports for making the decision. We also asked the following questions to make sure that the participants actually read the relevant information in the form of financial reports and the irrelevant information in the form of the letter from management in making their decisions.

How important was the Management Letter to your judgment of Bankruptcy Prediction?

How important was the Financial Statement to your judgment of Bankruptcy Prediction?

For Bankruptcy Prediction, how much weight did you place on information from the financial statements and for Bankruptcy Prediction, how much weight did you place on information in the management letter?

Under the treatment and the control group the results indicated that decision makers placed weight more on the financial report under the sparkline condition than the non-sparkline condition. This indicated that the decision makers under the sparkline condition paid attention to the relevant information in the financial reports more, which influenced them to experience significant lower dilution effect from the control group ($t = 3.863$, $df = 274$, $p<.01$). A statistically significant effect for presentation format on other dependent variable such as spatial accuracy was also observed ($t = 2.832$, $DF = 275$, $p<.01$). This shows that the means for the answers to the above questions were significantly different under the two treatment groups indicating that our treatments via different presentation formats were successful. It suggests that decision makers paid enough attention to a manipulation for it to influence them.

We also checked on the counterbalancing of the order in which the two presentation type, Sparklines without sparklines, were given. Independent t-test confirmed that the order of the presentation format is not significant as a main effect ($t (275) =0.8970$, $p = 0.3706$; 2.30 answers were accurate versus 2.42 answers out of the 3 questions). This means that we were successful in counterbalancing any learning effect that might be associated with the ordering of the tasks. Hence the participants did not experience decreased performance on the dependent measure due to being tired or less enthusiastic as the experiment continues. No significant differences were seen in results between the

two gender (t (247) =.0.303, p= 0.7631). Hence we can conclude that the random assignment of participants to the assignments were successful.

6.3 Results

6.3.1 Data analysis

6.3.1.1 Factor loadings and Scale reliability

The five items of decision confidence, four items of cognitive workload, 2 items of satisfaction and 2 items of on task and off task attention were pooled to conduct a factor analysis. All five items of decision confidence has factor loadings of greater than .6 (Cronbach alpha .855). All four items of cognitive workload has factor loadings of greater than .6 (Cronbach alpha .762). The two items of satisfaction and attention had factor loadings of greater than .60. The results of the principal component analysis and reliability analysis of the scales used in the study are reported in Table 6.1. It is seen that the reliability of these measures as gauged by Cronbach alpha was above the satisfactory threshold of .6 (Hatcher, 1994; Nunnally, 1978).

Table 6-1: CFA of the perceptual constructs

Principal Component Analysis									
Decision Confidence		Cognitive Load		On Task Attention		Off Task Attention		Satisfaction	
Variables	Factor Loadings	Variables	Factor Loadings	Variables	Factor Loadings	Variables	Factor Loadings		Factor Loadin
DeConf1	.727	Mental	.70	Ontask	.951	Offtas	.569	Sat	.75
Deconf2	.818	Time	.65	Ontask	.951	Offtas	.569	Sat	.75
Deconf3	.764	Effort	.70						
Deconf4	.827	Frustratio	.65						
Decon5	.646								

Reliability Statistics									
Decision Confidence		Cognitive Load		On Task Attention		Off Task Attention		Satisfaction	
Cronbach's Alpha	No of Items	Cronbach's Alpha	No of Items	Cronbach's Alpha	No of Items	Cronbach's Alpha	No of Items	Cronbach's Alpha	No of Items
.855	5	.757	4	.683	2	.642	2	.614	2

In this study, measures were obtained twice. The hypotheses tested using paired t-test to compare the means between the same subject for the two conditions (sparkline and control group) and capture any within-subject variation across tasks. The results on the sample of student population (Novice investors) are reported in Table 6.2, of the working professionals (more experienced investors) reported in Table 6.3 and all the participants are reported in Table 6.3 and all significant relationships are illustrated.

Table 6-2:Summary of Hypothesis testing for Student Sample

Accounting Students					
Dependent	T statistic	p-value (1 tail)	Sparkline with table (Experiment group)	Table with graph (Control Group)	Hypothesis
	Df=248		Mean (s.d.)	Mean (s.d.)	
Experience					
Decision confidence	1.18	.120	4.97 (1.48)	4.62 (1.32)	H1a not supported
Satisfaction	1.80	.036**	3.03 (1.16)	2.81 (1.09)	H1bsupported
Effort					
Cognitive Workload	5.57	.000***	4.01 (1.87)	4.86 (1.59)	H2a supported
On task Attention	1.39	.084	3.26 (1.10)	3.09 (1.19)	H2b supported
Off task attention	1.39	.13	1.99 (.61)	2.09 (.68)	H2c not supported
Performance					
Decision Accuracy					
• Symbolic Task	1.72	0.043**	2.32 (1.0)	2.46 (.99)	H5a supported
• Spatial Task	2.35	0.010**	1.87 (.80)	1.69 (.80)	H5b supported
• Integrative Task	9.48	.000***	.83 (.38)	.47 (.50)	H5c supported
Decision Time	1.38	.158	11.00 (2.34)	11.41 (2.70)	H5d not supported
Pattern Recall	2.76	.003***	.57 (.35)	.47 (.39)	H5e supported
Fact Recall	2.04	.021**	.57 (.50)	.49 (.50)	H5f supported
Recency Bias	2.37	.009***	.94 (.90)	1.08 (.68)	H3 supported
Dilution effect	1.90	.029**	.61 (.49)	.53 (.50)	H4 supported

Significant at $p < .10$ level; * Significant at $p < .05$ level; ** Significant at $p < .01$ level;***.

Table 6-3: Summary of Hypothesis testing for sample of experienced investors

More experienced investors					
Dependent	T statistic	P - value (1 tail)	Sparkline with table (Experiment group)	Table with graph (Control Group)	Hypothesis
	Df=25		Mean (s.d.)	Mean (s.d.)	
Decision confidence	1.90	.12	5.92 (.8180)	5.59 (1.15)	H1a not supported
Satisfaction	2.29	.01**	3.42 (1.12)	2.65 (1.01)	H1bsupported
Cognitive Workload	2.47	.01**	3.69 (1.92)	4.92 (1.32)	H2a supported
On task Attention	2.27	.01**	3.15 (.82)	3.60 (.75)	H2b supported
Off task attention	.39	.34	2.03 (.631)	1.98 (.519)	H2c not supported
Recency Bias	5.72	.000***	1.77 (.587)	.65 (.745)	H3 supported
Dilution effect	5.93	.000***	.69 (.471)	.04 (.196)	H4 supported
Decision Accuracy					
• Symbolic Task	2.07	.28	2.27 (.827)	2.38 (.941)	H5a supported
• Spatial Task	1.83	.04**	2.15 (.881)	1.65 (.797)	H5b supported
• Integrative Task	5.83	.000***	.90 (.20)	.42 (.504)	H5c supported
Decision Time	1.79	.120	12.85 (1.46)	10.08 (2.69)	H5d not supported
Pattern Recall	2.68	.006**	.538 (.47)	.29 (.28)	H5e supported
Fact Recall	1.83	.036**	.69 (.47)	.38 (.49)	H5f supported

Significant at $p < .10$ level; * Significant at $p < .05$ level; ** Significant at $p < .01$ level;***.

Table 6-4: Summary of Hypothesis testing for all participants in the study.

All participants					
Dependent	T Df=275	p- value	Sparkline with Mean (s.d.)	Table Mean (s.d.)	Hypothesis
Decision confidence	1.54	.12	5.06 (1.45)	4.71 (1.33)	H1a not supported
Satisfaction	1.84	0.015**	2.94 (1.15)	2.73 (1.07)	H1b supported
Cognitive Workload	5.9	.00***	3.77 (1.93)	4.60 (1.73)	H2a supported
On task Attention	2.25	.01**	3.41 (1.22)	3.15 (1.28)	H2b supported
Off task attention	.99	.16	2.14 (.77)	2.19 (.76)	H2c not supported
Recency Bias	2.37	.01**	.85 (.89)	.98 (.71)	H3 supported
Dilution effect	3.86	.00***	.72 (.60)	.54	H4 supported
Decision Accuracy					
• Symbolic	1.53	.06*	2.32 (.997)	2.44	H5a supported
• Spatial Task	2.83	.00***	1.90 (.813)	1.68	H5b supported
• Integrative	3.63	.00***	.85 (.36)	.46	H5c supported
Decision Time	1.61	.13	9.99 (3.8)	10.39	H5d not supported
Pattern Recall	2.35	.07	.76 (.76)	.75	H5e supported
Fact Recall	2.57	.01	.57 (.49)	.47 (.48)	H5f supported

Significant at $p < .10$ level; * Significant at $p < .05$ level; ** Significant at $p < .01$ level;***.

Table 6-5: Summary of results

	Dependent Variables	Alternate Hypothesis	Decision Outcome
H1a	Decision confidence	Sparkline>No Sparkline	H1a not supported
H1b	Satisfaction	Sparkline > No Sparkline	H1b supported
H2a	Cognitive load	Sparkline< No Sparkline	H2a supported
H2b	On task attention	Sparkline > No Sparkline	H2b supported
H2c	Off task attention	Sparkline < No Sparkline	H2c not supported
H3	Recency Bias	Sparkline < No Sparkline	H3 supported
H4	Dilution effect from nondiagnostic information	Sparkline < No Sparkline	H4 supported
H5a	Decision accuracy for Symbolic Task	Sparkline < No Sparkline	H5a not supported
H5b	Decision accuracy for Spatial Task	Sparkline > No Sparkline	H5b supported
H5c	Decision accuracy for Integrative Task	Sparkline > No Sparkline	H5c supported
H5d	Reponses Time	Sparkline > No Sparkline	H5d not supported
H5e	Pattern Recall	Sparkline> No Sparkline	H5e supported
H5f	Fact Recall	Sparkline> No Sparkline	H5f supported

Given the possibility of a task accuracy/time trade-off (i.e., decision makers could have spent more time to get more accurate answers), a correlation analysis was performed on decision accuracy and time. There were no significant correlations and, thus, a multivariate analysis was not needed.

Table 6-6: Correlations between the dependent variables

		Time	Symbolic Task Accuracy
Time	Pearson		-.042
	Sig. (2-tailed)		.513
Symbolic Task Accuracy	Pearson	-.042	1
	Sig. (2-tailed)	.513	

Decision Experience

Paired t-test was conducted to evaluate whether decision makers experienced enhanced decision experience (confidence and satisfaction) when using advanced visualizations such as sparklines in digital financial reporting. The results indicated no significant difference in decision confidence between decision makers in both conditions (t = 1.54, p = .12). Decision makers on an average experienced lower confidence (4.71 out of scale of 1-7) using stock reports without sparkline as compared to reports with sparkline (5.06 out of 7). H1a which predicted that compared to traditional stock report, decision makers using stock report with Sparklines will have experience greater decision confidence was not supported. Perhaps the novelty of the Sparkline can be attributed to not obtaining significant difference in the subject confidence when using reports. With continued usage, novelty of Sparkline could wear out resulting in equal or higher confidence in future. Paired t-test to on subject satisfaction indicated significant differences in results between the two conditions (t = *1.838, p=.03).* However, participants reported significantly higher satisfaction with the use of Sparkline reports (mean =2.94) than the non-Sparkline reports (mean =2.73). H1b which predicted that compared to traditional stock report, decision makers using stock report with Sparklines will experience greater decision satisfaction was supported.

Decision effort

Paired t-test was conducted to evaluate whether subject had to use less effort (cognitive load, attention) when making decisions using visualizations such as sparklines in digital financial reports. The results indicated significant difference in cognitive load between

the conditions, (t=5.90, *p=.000).* The decision makers also experienced significantly lower cognitive load with the use of Sparkline reports (mean =3.78) than the non-Sparkline reports (mean =4.60). H2a which predicts that as compared to traditional stock report, decision makers using stock report with Sparklines will experience reduced cognitive load is supported.

The results indicated significant difference between on task attention (t= 2.25, p= .01). The off task attention between the two groups was not statistically significant. (t=.99, p=.16). The results of the study suggest that on-task attention under Sparkline (mean= 3.41) was higher than under non-Sparkline condition (mean= 3.15). H2b which predicted that decision makers using stock report with Sparklines will experience greater on task attention is supported. Tables show only current levels or recent changes and the results indicate that sparklines with table improved the attention span of the tables.

The off task attention under Sparkline (mean= 2.14) was lower than under non-Sparkline condition (mean= 2.19). These differences were not significant t (275) =0.99, p=0.16). Hence we fail to reject the null hypothesis in favor of the alternate and we are 95% confident that the difference in the means could be attributed to chance alone. H2c which predicted that decision makers using stock report with Sparklines will experience differences in off task attention under the two conditions was not supported. In a bankruptcy prediction task, task demands are high. Perhaps due to high task demands, under both conditions the decision maker was not able to concentrate on off-task activities leading to no difference in the results in these conditions.

Recency Bias

The results indicated significant difference in recency bias experienced between the conditions (p=.01). *Recency Bias* in the Non-Sparkline treatment (mean = .98/1 or 98 percent) were more pronounced than those in the Sparkline treatment (mean = .85/1 or 85 percent). H4 which predicted that as compared to traditional stock report, decision makers using stock report containing Sparklines will experience lower recency bias is supported. The results suggest that Sparkline were useful in mitigating recency bias to a certain extent as compared to traditional reports.

Dilution effect

Both the firms had strong potential to become bankrupt in the sixth year and a wise investor must avoid investing in such a company. Investors experiencing dilution effect will not be able to assess the financial status of the company accurately and not take an extreme view of the situation. Such investors could be inclined towards investing in such a firm. Paired t test was conducted to evaluate whether decision makers experienced dilution effect using Sparkline or traditional report. The results indicated significant difference under the two conditions (t=3.86, p=.00). Participants in the Sparkline treatment reported that they were less likely to invest in the firm likely to go bankrupt (mean = .72/1 or 77 percent than the non-Sparkline treatment (mean = .54/1 or 54 percent). The results suggest that the decision makers using stock reports (with tables, separate line graphs and shareholder's report) experienced dilution effect and hence were not able to make investment decision wisely. Results indicates that, H#, which proposed that, as compared to traditional stock report, decision makers using stock report with

Sparklines will experience lower dilution effect from irrelevant information contained in the shareholder's report were also supported.

Decision performance

In this study, paired t test was conducted to evaluate whether decision makers experienced greater decision performance (accuracy, time, recall) using Sparkline or traditional report. The results indicated significant difference in decision accuracy related to symbolic task, (t= 1.53, p=.06). The predictions based on the theory of cognitive fit were supported. Participants reported lower accuracy for the *Symbolic task* in the Sparkline treatment (mean = 2.44/3 or 71.6 percent) than the non-Sparkline treatment (mean = 2.32/3 or 85.66 percent). Thus, H5a, which predicts that as compared to traditional stock report, decision makers using stock report with Sparklines will have lower decision accuracy rate for symbolic tasks was supported.

An analysis on data suggests that decision makers experienced greater accuracy using sparklines for spatial task (t=2.83, p=0.00). For *Spatial task,* the decision makers were significantly more accurate in the Sparkline treatment (mean = 1.9/3 or 63 percent) than the non-sparkline treatment (mean = 1.68/3 or 56 percent). Thus, H5b, which predicted that as compared to traditional stock report, decision makers using stock report with Sparklines will have higher decision accuracy rate for spatial task is supported.

The results indicated significant difference between decision accuracy between the two groups (t=3.63, p=.00. Moreover, accuracy for the Integrative task (Bankruptcy prediction) in the Sparkline treatment (mean = .85/1 or 85 percent) were also not significantly higher than those in the Non-Sparkline treatment (mean = .46/1 or 46 percent) for Integrative task. Thus, H5c, which predicts Sparkline, will have more

significant effects than non-sparkline reports on investor's decision accuracy for integrative task are also supported. The predictions from Proximity Compatibility Principle are also supported. The close proximity of related visual elements (the tables and the graph in the form of sparklines) proved critical for success in decision making for an integrative task. As the related elements were positioned close to each other and hence the information was processed together by decision makers in the sparkline condition.

The difference between accuracy rate percentages under both treatment conditions were more pronounced for integrative task (85 percent) than the spatial task (75 percent). As per the findings of this study, Sparklines are hence best usable for integrative task and spatial task. Sparklines are less useful for symbolic tasks.

Response Time

Participants reported lower response time to do the tasks in the Sparkline treatment (mean =9.99 or 9 minutes 99 seconds) than the non-sparkline treatment (mean = 10.39 or 10 minutes 39 Secs). The differences between the conditions was statistically significant (t=1.61, p=.13). H5d which predicts that as compared to traditional stock report, decision makers using stock report with Sparklines will take lower decision time for all tasks was not supported. In this study data was presented to the decision makers were for last five years. If data of 10 or more years was presented, then maybe the decision makers would have found sparklines to be an efficient tool in decision making by having a quick response time.

Recall

The results from the paired t test provides sufficient evidence to reject the null hypothesis, in favor of the alternative hypothesis that pattern recall is significantly higher

in the sparkline condition than the non Sparkline condition (t= 2.35 p=0.07). Decision makers were able to recall slightly higher (.76/2 or 38% of the decision makers) in the sparkline condition than the non sparkline condition (.75/2 or 37.5%). The results of the study also provides sufficient evidence to reject the null hypothesis, in favor of the alternative hypothesis that fact recall is significantly higher in the sparkline condition than the non Sparkline condition (t=2.57, p=.01). Participants reported significantly higher *fact recall* rate in the Sparkline treatment (mean =.57/1 or 57%) than the non-sparkline treatment (mean = .47 or 47%). The hypothesis *H5e that as compared to traditional stock report, decision makers using stock report with Sparklines will have greater pattern recall will be supported.*

H5f , as compared to traditional stock report, decision makers using stock report with Sparklines will have greater fact recall is also supported.

6.4 Limitations

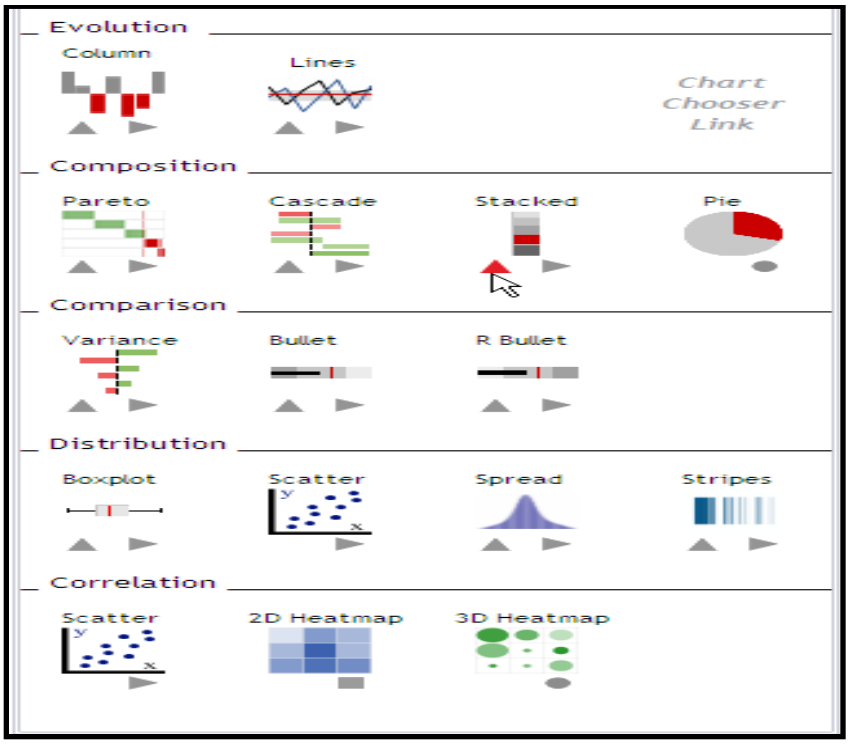
This study as with other studies in general have some limitations. This study only examines sparklines in the context of bankruptcy prediction task and other symbolic and spatial task. The limitation of this study provides avenue for research to researchers working in this area. This need more tasks to be tested. Due to the use of repeated measure design and to avoid participant fatigue, we used 1 trial under each condition. In future studies the trials of the tasks can be increased to increase the robustness of the results. The volume of data used in preparing the financial reports is for the last five years. Future studies can incorporate financial data of more than five years to study the effect of sparkline with more complex data set. We have also controlled for individual differences in this study by using a repeated measure design. Future studies can study the

interaction effect if any of individual differences and effect of visualizations tools on decision outcome. Several future research directions as outlined from the review of the literature and findings of this study are discussed in the next section.

6.5 Future Research Directions

The role of information presentation in alleviating functional fixation is another possible future research direction (Ghani et al. 2009). Moderating role of individual differences, task types, times constraints on presentation format and decision performance can also studied in future extension to this study. Use of web based Sparklines with XBRL tagged data in a cloud computing platform can be another direction of the study. This study can be replicated with other tasks and data types. Reports using sparkline in print format and reports using sparkline in web based format could provide difference in performance results and the conditions under which the difference exist could be examined in future studies. Currently the software available in the market offers use of sparklines (small word size graph) in the form of line and bar graph. Can this concept of small word size graph if extended to other types of graph such as scatter plot, distribution diagram, etc (Refer Figure 6-1) be useful to decision makers?

Figure 6-1: : Graphs that can be represented in word size format



6.6 Contributions of the study

6.6.1 Implications for research

The result from this empirical study revealed that there was significant effect of use of sparklines in digital financial reports on decision outcome and provides an incremental value over a tabular format in accounting data or in financial statements.

As per research on information processing visually, processing can be of two types, graphical perception and graphical cognition. The results indicate that sparklines support spatial tasks which require *graphical perception* more than symbolic tasks that require *graphical cognition*.

Preattentive vision is an amount of information that a small glimpse can pick up. Graphs that convey their information at this unconscious level allow us to extract information

without any conscious effort on our part using preattentive vision. In the context of extracting information from the graph, we call this visual processing *graphical perception*.

On the other hand, graphical cognition is visual processing that requires that we inspect things that we are looking at and psychologists refer to as cognitive activity. In the context of visual processing by inspect things such as to highest point; lowest point etc extracting information from the graph, we call this visual processing, *graphical cognition*. For tasks that require graphical cognition such as symbolic tasks, the study supports out assertion that Sparkline does not necessarily improve decision performance. In this study it was found out that when symbolic tasks were performed, multi-object displays were associated with superior performance

The results from the main study provide an empirical and justifiable basis for policy makers to make explicit recommendations about use of novel graphics such as sparkline in digital financial reports. The results from this study provide contribution to theory of cognitive Fit to match information presentation format to task and contribution to theory of Proximity Compatibility Principle with use of visualization tools for digital financial reporting.

Both the IS literature and Accounting literature has emphasized the need for studying the role of presentation format in the efficiency and effectiveness of decision-makers' decision quality in order to provide empirical evidence on the effect of presentation format on decision quality. The need of such research has also been identified by other academics in accounting (Abdolmohammadi, Harris et al. 2002)and (Debreceny and Gray 2001).The role of information presentation in alleviating functional fixation is another

possible future research direction (Ghani, Mara et al. 2009). This research is important to provide empirical empirically supported guidance to researchers and practitioners for the design and use of dense, interactive visualizations in business decision making with high volume of data.

6.6.2 Implications for practice

These findings have important implications users of visualization tools such as sparklines in digital financial reporting. This research provides empirical evidence to the users of sparklines in favor of use of Sparkline in mitigating recency bias to a certain extent as compared to traditional reports. Another result that could be very useful to the preparers of digital financial reports is that the irrelevant information cue in the shareholder's report was not able to weaken the impact of relevant information in the audited financial data reported when that data was presented with sparklines. The results indicate that decision makers experience greater satisfaction when using sparklines. In a controlled laboratory setting, Sparklines were able to successfully reduce the cognitive load on the decision maker when task demands are high (such as in a bankruptcy prediction task).The sparklines were able to increase the attention of the readers to the tables as the tables was integrated with the sparklines in close proximity in the sparklines condition.

Decision makers also perform integrative tasks and spatial tasks better when using Sparkline with table as opposed to multi-object displays of graphs and tables not placed in visual proximity. Sparklines are hence best usable for integrative task and spatial task. Sparklines are less useful for symbolic tasks.

End users of today's BI tools fall across a broad range of functional areas. Reports from such BI systems are generated on a fly by users rather than information systems

professionals. End users' need to work with large data sets and Sparklines help users see the whole picture. Visual proximity of graph with text and tables is useful in context of providing support for integrative and spatial tasks.

In conclusion, Sparkline is a useful reporting tool for supporting the recalls of facts and patterns reported in digital financial reports.

This study provide empirical evidence of effect of Sparklines in providing user support for information recall, mitigation of recency bias to a certain extent, reduce dilution effect from non-diagnostic information, improve decision performance, reduce decision effort and improve the decision making experience.

Appendices
Appendix A: Scanned copy of the Consent Form

IRB Approval
10-0675
THIS FORM VALID
1/9/12 – 1/7/13

Consent to Participate in a Research Study

Business Data Visualization for Decision Support: An Experimental Investigation

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?

You are being invited to take part in a research study about effectiveness of summarization and visualization of business data for decision support. You are being invited to take part in this research study because you are enrolled in the Research Experimental Program (REP) in the Gatton College of Business and Economics or taking courses from Gatton College of Business and Economics. If you volunteer to take part in this study, you will be one of about 400 people to do so at the University of Kentucky.

WHO IS DOING THE STUDY?

The person in charge of this study is Mrs. Priyanka Meharia of University of Kentucky Department of Decision Science and Information System and is being guided in this research by Dr. Radhika Santhanam. There may be other people on the research team assisting at different times during the study.

WHAT IS THE PURPOSE OF THIS STUDY?

This study is part for a thesis for a doctoral degree in business administration at the graduate school at University of Kentucky. This survey investigates the use of visualization and summarization of business data and its effectiveness in providing decision support. By doing this study, we hope to learn if business data visualization enhance decision performance.

ARE THERE REASONS WHY YOU SHOULD NOT TAKE PART IN THIS STUDY?

None.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

The research procedures will be conducted at University of Kentucky Gatton research lab. You will need to come one time and this study will not exceed two hours.

WHAT WILL YOU BE ASKED TO DO?

The experiment has five parts.

Part 1: Background Questionnaire: In this part please answer some questions about your background.

Part 2: Introduction to sparklines: In this session images of sparklines will be presented along with text. Please take some time to familiarize with the new business data visualization format.

Part 3: In the following session you will be given financial report for first company in first format. As part of the research, you have to review the report; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 4: Evaluation of second company: As part of the research, in this session you will be given financial report for second company. You have to review the reports; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 5: Evaluate and report your preference for presentation format for reporting financial system.

When you finish part five you have completed the experiment.

The order of viewing the stock reports under different format will be randomized and hence experiment participant may by chance either view the stock report with sparkline first and stock report without sparkline second or vice versa

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

You will not get any personal benefit from taking part in this study. However, your willingness to take part in this study may, in the future, help society as a whole better understand this research topic, and will be used to guide future research in this area.

DO YOU HAVE TO TAKE PART IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to participate in this study, there are two other choices in accordance to the Research Experimental Program (REP): 1) to participate in another study proposed through the REP program; or 2) to write a two page essay on a research topic which will be assigned by the REP administrator (for further details, please refer to the REP documentation provided to you when you enrolled in this program). Non-REP students who do not wish to participate in the study can write a one page essay on a topic as assigned by their instructor for the 10 points bonus.

WHAT WILL IT COST YOU TO PARTICIPATE?

There are no costs associated with taking part in the study.

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Part 1: Background Questionnaire: In this part please answer some questions about your background.

Part 2: Introduction to sparklines: In this session images of sparklines will be presented along with text. Please take some time to familiarize with the new business data visualization format.

Part 3: In the following session you will be given financial report for first company in first format. As part of the research, you have to review the report; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 4: Evaluation of second company: As part of the research, in this session you will be given financial report for second company. You have to review the reports; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 5: Evaluate and report your preference for presentation format for reporting financial system.

When you finish part five you have completed the experiment.

The order of viewing the stock reports under different format will be randomized and hence experiment participant may by chance either view the stock report with sparkline first and stock report without sparkline second or vice versa

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

You will not get any personal benefit from taking part in this study. However, your willingness to take part in this study may, in the future, help society as a whole better understand this research topic, and will be used to guide future research in this area.

DO YOU HAVE TO TAKE PART IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to participate in this study, there are two other choices in accordance to the Research Experimental Program (REP): 1) to participate in another study proposed through the REP program; or 2) to write a two page essay on a research topic which will be assigned by the REP administrator (for further details, please refer to the REP documentation provided to you when you enrolled in this program). Non-REP students who do not wish to participate in the study can write a one page essay on a topic as assigned by their instructor for the 10 points bonus.

WHAT WILL IT COST YOU TO PARTICIPATE?

There are no costs associated with taking part in the study.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

If you are recruited through the REP program, you will receive 1 research credit for your participation in this study in accordance with the REP program. Non-Rep students who will participate in this research will be awarded 10 points as bonus by the instructor, in the class from which they are recruited.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?

Your information will be combined with information from other people taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be personally identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private.

CAN YOUR TAKING PART IN THE STUDY END EARLY?

If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study. The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Priyanka Meharia at Meharia@gmail.com /859.257.8715. If you have any questions about your rights as a volunteer in this research, contact the staff in the Office of Research Integrity at the University of Kentucky at 859-257-9428 or toll free at 1-866-400-9428. We will give you a signed copy of this consent form to take with you.

WHAT ELSE DO YOU NEED TO KNOW?

If you want to participate, please remain in the room, and sign and date this consent form below. If you do not want to participate, you may leave now.

Appendix B: Experiment

First, let me start by thanking you for your participation. The experiment has five parts.

Part 1: Background Questionnaire: In this part please answer some questions about your background.

Part 2: Introduction to sparklines: Images of sparklines will be presented on next screen. Please take some time to familiarize with the new business data visualization format.
Part 3: Evaluation of first company: In the following session you will be given financial report for first company in first format. You have to review the reports; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 4: Evaluation of second company: In the following session you will be given financial report for second company. You have to review the reports; make assessment of companies' current earnings performance, judgments of future earnings potential and investment decisions.

Part 5: Evaluate and report your preference for presentation format for reporting financial system.

When you finish part five you have completed the experiment. There is no time limit, however do not spend too much time on any one question. Remember to answer the questions as accurately for yourself as possible.
Once again! Thank you for participating! If you have further questions please raise your hand and an administrator will assist you.
When you are ready to begin click the CONTINUE button below

Appendix C: Pretask questionnaire (Demographics and background)

Please answer each of the following questions and then click the submit button. Then click continue to go to the next sheet.
* Required

What is your age? *

What is your gender *

What is your highest level of education *

How many accounting/Finance courses have you completed? *

How many years of accounting work experience do you have? *

Do you currently own investments in debt or equity securities? *

How many years have you been investing in debt or equity securities? *

- 0 -3
- 3 - 5
- 5 -10
- 10 -15
- >15

How much experience do you have with the digital financial reports? *

	1	2	3	4	5	
No Experience	●	●	●	●	●	A Lot of Experience

How much experience do you have using Sparklines? *

	1	2	3	4	5	
No Experience	●	●	●	●	●	A Lot of Experience

Do you have professional certification? *

- CPA/CA
- CMA/ICWA

- ☐ CS
- ☐ Not Applicable
- ☐ Other: _____

Are you preparing for professional certification exams? *

- ☐ CPA/CA
- ☐ CMA/ICWA
- ☐ CS
- ☐ Not applicable
- ☐ Other: _____

What is your major at University of Kentucky? *_____

I am currently a *

- ☐ Freshman
- ☐ Sophomore
- ☐ Junior
- ☐ Senior
- ☐ Graduate
- ☐ Not applicable

Appendix D: Introduction to Sparkline

Power point presentation on Sparklines is provided to the decision makers in the form of six slides.
Please view all the 6 slides and answer the question below.
Manipulation check to see if the decision makers went over the slides

What is a Sparkline? *

- ☐ Word Size Graph
- ☐ Large size Graph
- ☐ Table
- ☐ Graph that sparkles

Appendix E: Using tables

Tables are one of the most widely used representations in financial analysis. In this study, you will see one table for each firm, including information on all of the financial indicators across the five-year period. The balance sheet items are in the upper part of the table, and the ratios are presented in the bottom part of Table 1. Now you may take 5-10 minutes to become familiar with the table structure and financial indicators. If you have any questions, please feel free to ask the experiment administrator. When you are ready, please go to the next page.

Table 1 Table representation using averages of firms

	Year				
	1	2	3	4	5
($ 000)					
Total assets	69,886	91,198	110,733	126,527	138,588
Capital	25,543	29,354	35,307	36,405	43,199
Debt	44,236	61,704	75,678	87,411	95,634
Paid-in capital	7,653	7,912	10,087	10,855	11,150
Retained earnings	17,998	21,583	24,968	28,262	31,805
Debt service	12.15	16.42	18.66	10.57	7.76
Current ratio	2.12	1.98	2.02	2.20	1.86
Self financing	0.28	0.28	0.25	0.26	0.27
Receivables turnover	134.10	81.88	153.32	99.28	127.53
Inventory turnover	10.51	11.64	10.95	10.12	10.27
Payable turnover	14.25	12.83	12.89	13.36	13.38

Appendix F: Case Scenario for the first condition

Assume you want to invest money in a stock and the stock report containing the shareholder's report, financial data organized in the form of table and graph for a company High Tech Systems Corporation is provided to you in the hyperlinks below. You will evaluate several sets of financial data. Each set contains real data, on the financial condition of a firm over five consecutive years. You need to make a prediction that the company will go bankrupt or not in the sixth year of operation based on the information presented. Before you do so you need to forecast the future retained earnings and total assets for the sixth year. You also have to perform some tasks, assess the financial status of the firm and make an investment decision.

When making the forecasts, consider only the financial reports you are given. Bringing other knowledge about the market, the economy or the industry will lower the quality of the forecasts. You can refer to the Shareholder's report, financial report (Table, Graph) of the firm at any point by clicking on them. They will open in separate window. Keep in mind that the firm is not randomly selected from the software industry. You have to use the side scroll bar to access all the questions. After you have answered the entire questions click the SUBMIT button. Then click CONTINUE.

SELECT THE REPORT YOU WANT TO READ FROM THE LINKS BELOW.

- Shareholders' Report
- 5-year overview with key financial ratios Table
- 5-year overview with key financial ratios Graph

Appendix G: Shareholders Report of High Tech Systems Corporation Inc.

High Tech Systems Corporation Inc.

MANAGEMENT LETTER

To our shareowners:

High Tech Systems Corporation Inc. enters the 2009 well positioned and confident.

- We are strategically well positioned
- We are confident of our market and our product strategy
- We have a large number of smart, relentless, customer-devoted people across all areas of the company.
- We will be offering low prices, reliable delivery, and improve our in-stock position on even obscure and hard-to-find items.
- Additionally, our Company has experienced significant changes during 2010 that have dramatically improved the foundation of our Company.

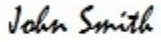
We plan to make improvements in customer experience so we can afford to offer customers ever-lower prices, and many others by:

- increasing selection,
- speeding delivery,
- reducing cost structure

Let there be no doubt about our dedication to success. High Tech Systems knows how to anticipate market trends, provide solutions that answer real needs, and deliver them with compelling timing and cost performance. I look forward to the future growth of our company.

We also know that we can still be much better, and we're dedicated to improving further.

Thank you for your continued support.



John Smith

Founder and Chief Executive Officer

High Tech Systems Corporation Inc.

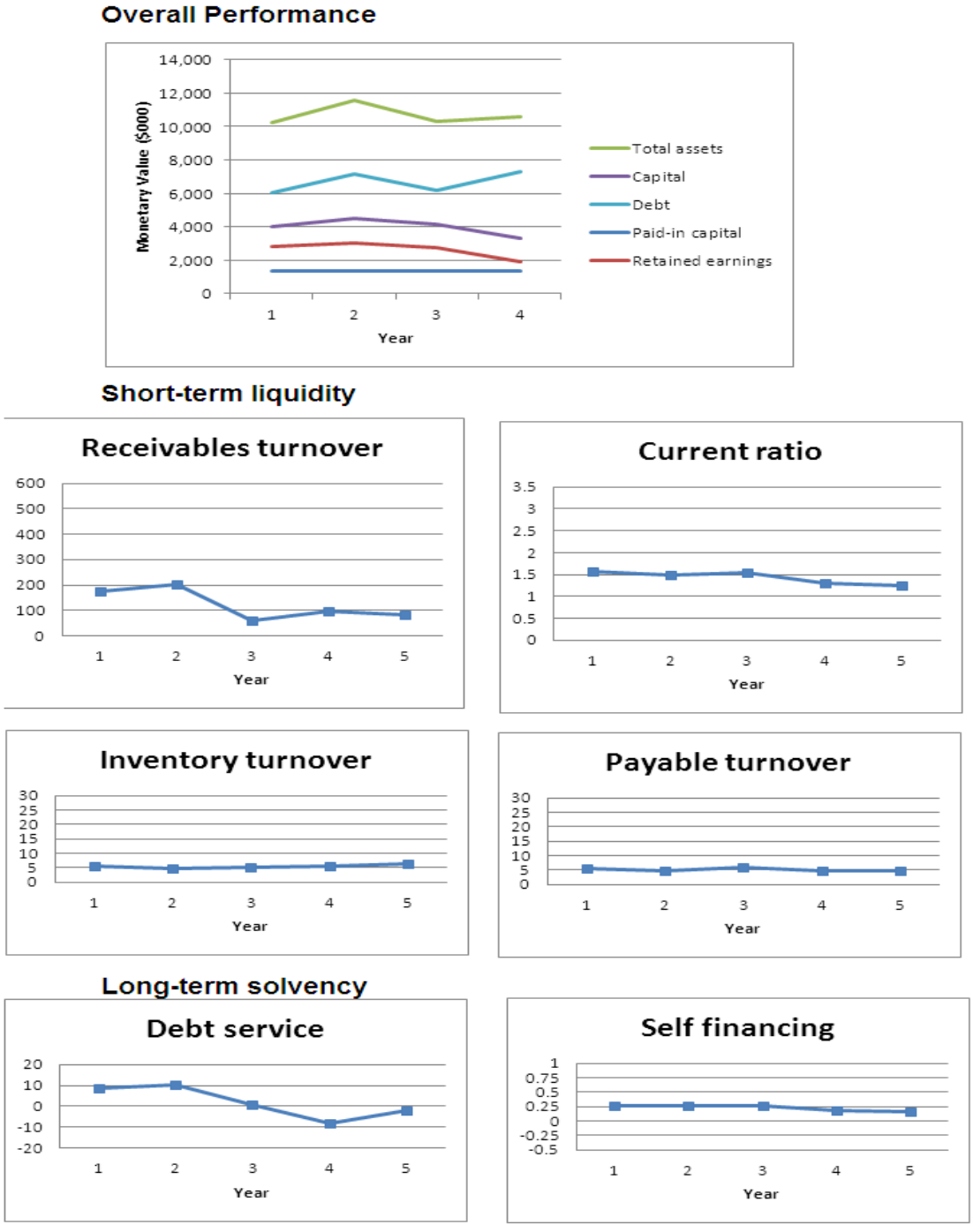
5-year overview with key financial ratios – Table (High Tech Systems Corporation)

High Tech Systems Corporation

	Year				
	1	2	3	4	5
($ 000)					
Total assets	10,226	11,589	10,330	10,568	9,738
Capital	3,988	4,470	4,144	3,287	2,994
Debt	6,069	7,178	6,187	7,281	6,745
Paid-in capital	1,359	1,359	1,359	1,359	1,359
Retained earnings	2,798	3,052	2,784	1,928	1,634
Debt service	8.39	10.45	1.08	-8.18	-2.14
Current ratio	1.58	1.50	1.54	1.29	1.24
Self financing	0.26	0.27	0.27	0.18	0.17
Receivables turnover	175.32	201.04	58.75	96.74	81.38
Inventory turnover	5.47	4.73	5.29	5.59	6.24
Payable turnover	5.58	4.95	6.03	4.69	4.90

5-year overview with key financial ratios – Graph (High Tech Systems Corporation)

High Tech Systems Corporation



Appendix I: Case Scenario for second condition

Assume you want to invest money in a stock and the stock report containing the shareholder's report, financial data organized in the form of table and graph for a company Prime Tech Systems Corporation is provided to you in the hyperlinks below. You will evaluate several sets of financial data. Each set contains real data, on the financial condition of a firm over five consecutive years. You need to make a prediction that the company will go bankrupt or not in the sixth year of operation based on the information presented. Before you do so you need to forecast the future retained earnings and total assets for the sixth year. You also have to perform some tasks, assess the financial status of the firm and make an investment decision.

When making the forecasts, consider only the financial reports you are given. Bringing other knowledge about the market, the economy or the industry will lower the quality of the forecasts. You can refer to the Shareholder's report, financial report (Table, Graph) of the firm at any point by clicking on them. They will open in separate window. Keep in mind that the firm is not randomly selected from the software industry. You have to use the side scroll bar to access all the questions. After you have answered the entire questions click the SUBMIT button. Then click CONTINUE.

SELECT THE REPORT YOU WANT TO READ FROM THE LINKS BELOW

- Shareholder's Report
- 5-year overview with key financial ratios - Table with Sparkline

Appendix J: Shareholder's Report for the treatment condition

Prime Tech Systems Inc.
MANAGEMENT LETTER

To our shareowners:
Prime Tech Systems Inc. enters the 2009 well positioned and confident.
We are strategically well positioned
We will add new product categories around the world in 2010
We will increase our pace of innovation, launching many new services and features.
We will add more customers in 2011, including many large enterprise customers.
Additionally, our Company has experienced significant changes during 2010 that have dramatically improved the foundation of our Company.

We plan to make improvements in customer experience so we can afford to offer customers ever-lower prices, and many others by:

- increasing selection,
- speeding delivery,
- reducing cost structure

We also know that we can still be much better, and we're dedicated to improving further. Let there be no doubt about our dedication to success. Prime Tech Systems knows how to anticipate market trends, provide solutions that answer real needs, and deliver them with compelling timing and cost performance. I look forward to the future growth of our company.

Thank you for your continued support.

Kerry Sullivan
Founder and President
Prime Tech Systems Inc.

Five year overview of Prime Tech Systems Corporation with key financial indicators

		Year				
	$0	1	2	3	4	5
Total assets		20,505	27,074	33,642	43,188	32,021
Capital		8,725	9,261	10,092	9,795	-12,567
Debt		11,781	17,814	23,698	33,394	44,590
Paid-in capital		3,400	3,974	3,938	4,297	4,455
Retained earnings		5,324	5,286	6,006	5,497	-17,024
Debt service		3.79	0.93	3.45	1.78	1.92
Current ratio		1.77	0.82	1.31	1.21	0.64
Self financing		0.26	0.2	0.18	0.13	-0.53
Receivables turnover		21.35	22.94	20.2	8.2	11.27
Inventory turnover		6.34	6.75	5.58	1.93	8.88
Payable turnover		17.33	7.99	5.98	5.1	6.49

Appendix K: Measurement Scales

Construct	Measure
On-task attention	When using financial statement with Sparklines for bankruptcy prediction and forecasting task, I focused my total attention on making fewer errors
Off-task attention	When using Stock Report with Sparklines for finding specific values from tables or graph, I daydreamed while doing the task
	When using Stock Report with Sparklines for finding specific values from tables or graph, I let my mind wander off the task.
Satisfaction	My overall satisfaction with report without Sparkline for making decision is
	My overall satisfaction with the decision making process using sparkline is
Mental Demand	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Time Demand	*How much time pressure did you feel due to the rate or pace at which the tasks occurred? Was the pace slow and leisurely or rapid and frantic?
Effort	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration Level	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?
Decision confidence	How confident are you in your answer to the above question (Debt)
	How confident are you in your answer to the above (Inventory Turnover) question
	How confident are you in your answer to the above (Retained Earnings) question
	How confident are you in your judgment of Bankruptcy Prediction
	How confident are you in your in your investment decision?

Questions to measure Accuracy, dilution effect, recency bias, recall

What was the inventory turnover ratio in year 5 *

- ☐ 6.34
- ☐ 6.75
- ☐ 5.58
- ☐ 1.93
- ☐ 8.88

The management letter was from which executive on the company *

- ☐ Vice President
- ☐ Chief Executive Officer
- ☐ President
- ☐ Chief Information Officer

From year 1 to year 5, the firm is earning beyond the cost of its debt? *Debt Service (interest coverage) represents the number of times the interest cost for the year is covered by the company's earnings. The higher the ratio, the more the firm is earning beyond the cost of its debt

- ☐ Yes
- ☐ No
- ☐ Don't Know

MANAGEMENT LETTER states which of the following? *

- ☐ We will add new product categories around the world in 2010
- ☐ We will increase our pace of innovation, launching many new services and features.
- ☐ We will add more customers in 2011, including many large enterprise customers.
- ☐ All of the above

Of periods 1, 2, 4, and 5, which year has the largest Debt *

	1	2	3	4	5	
Year 1	●	●	●	●	●	Year 5

Read the financial statement for the firm and forecast the RETAINED EARNINGS for the firm in year 6 *

- ☐ -5,449
- ☐ -4,197
- ☐ 4601
- ☐ -4601

Read the financial statement for the firm and forecast the TOTAL ASSETS for the firm in year 6 *

- ☐ -37613
- ☐ 32820
- ☐ 26357
- ☐ 29670

Bankrupt in the sixth year? *Use the information provided in shareholder's report, Financial Tables and Sparklines

- ☐ Yes
- ☐ No

In which year the company had the highest Retained Earnings *

	1	2	3	4	5	
Year 1	●	●	●	●	●	Year 5

Assume you have $5,000 to invest in a stock. How much of the $5,000 would you invest in this firm *

	1	2	3	4	5	6	7	
Nothing At All	●	●	●	●	●	●	●	The Entire Amount

How important was the Management Letter to your judgment of Bankruptcy Prediction? *

	1	2	3	4	5	6	7	
Not very relevant	●	●	●	●	●	●	●	Very relevant

How important was the Financial Statement to your judgment of Bankruptcy Prediction? *

1	2	3	4	5	6	7

Not very relevant ● ● ● ● ● ● ● Very relevant

For Bankruptcy Prediction, how much weight did you place on information from the financial statements? *The weights must add up to 100%

For Bankruptcy Prediction, how much weight did you place on information in the management letter *the weights must add up to 100%

Recall

The Retained Earnings for Prime Tech Systems Corporation had an *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ Inclining Pattern
- ☐ Declining Pattern
- ☐ Remained constant
- ☐ Consistent, then sharp decrease

The Retained Earnings for High Tech Systems Corporation had an (Non Sparkline Condition) *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ Inclining Pattern
- ☐ Declining Pattern
- ☐ Remained constant
- ☐ Consistent, then sharp decrease

The DEBT for Prime Tech Systems Corporation had an *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ Inclining Pattern
- ☐ Declining Pattern
- ☐ Remained constant
- ☐ Other:

The DEBT for High Tech Systems Corporation had an *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ Inclining Pattern
- ☐ Declining Pattern
- ☐ Remained constant
- ☐ Other:

The retained earnings for Prime Tech Systems Corporation in the fifth year were *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ 5,324
- ☐ 5,286
- ☐ 6,006
- ☐ 5,497
- ☐ -17,024

The Retained Earnings for High Tech Systems Corporation in the fifth year was *Please recall the trend from your memory. Do not go back to look at the graph.

- ☐ 2,798
- ☐ 3,052
- ☐ 2,784
- ☐ 1,928
- ☐ 1,634

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