CHAPTER II

LITERATURE REVIEW

Millions of people all over the world are continuously using computers for performing various tasks. They are accessing information using a large number of web pages hosted on the internet. The visual display terminals (VDT) are the primary medium through which humans and computers interact. The work environment plays an important role in the ergonomic design of work systems. Studies have shown that working environment has a significant impact on operator's task performance (Acosta, et al., 1999; Hill and Scharff, 1997). On the basis of the literature available on the topic, it can be said with a fair amount of certainty that the principles related to the design of the modern day tool are being given least consideration. A number of design issues appear to remain unresolved in developing a proper web page. These issues throw challenge to ergonomists/ human factors engineers to present a more efficient system, needed for today's working environment, where apart from visual display unit (VDU) related functions, environmental stressors also are to be given due consideration. They should be designed keeping in mind both regular and non-specialist users. Consideration of environmental stressors becomes all the more important in the light of the fact that a large number of user population is accessing information using internet from almost everywhere. Many researches conducted in the past have shown that excessive, ever increasing computerization has led to an increase in health related complaints. These complaints may get aggravated further in the presence of noise and illumination. The literature collected on the topic was found to be widely scattered in nature which was systematically studied and reviewed and has been presented briefly as follows:

2.1 Studies on web design and their use

The fast development of the World Wide Web has allowed people to get information and interact globally (Hamel and Sampler 1998). Zviran et al. (2006) showed that there was a growing interest in identifying design principles and features that could enhance user satisfaction. According to Nielsen (2000) a key factor in retaining visitors to web sites was the usability of these sites. A particular factor that affected usability was screen design. Poor screen design could also have a negative
significant effect on user’s performance by decreasing search speed and aggravating errors (Streveler and Wasserman, 1984). The studies conducted by Schaik and Ling (2001a,b) showed that design guidelines were important for web designers to produce more usable web pages if they were based on experimental research. However, it was observed that many guidelines were based on personal experiences and observations (Shneiderman, 1997; Borges et al., 1998), therefore their validity was uncertain. Similar were the findings of the studies conducted by Venkatraman (2000) and Tullis (1997). One consideration web designers needed to take into account was the appearance of screen elements as this might have an effect on both visual preferences of users and on task performance (Tractinsky et al., 2000). In another study conducted by Schenkman and Jonsson (2000) it was found that look of the screen had a significant impact on the usability of a site. However, Nielsen (2002) reported that there was a need of text recognition and the presentation of the text was an important factor. It was found that most web sites were only concerned with the content of the text and hence there was a great need to make their web sites more usable (Trewin et al., 2004). It was very important that web sites were constructed to enable a high level of usability for all users (Shneiderman, 2000) because many users of the internet might have a degree of visual impairment or dyslexia or users had a lower literacy (Nielsen, 2005). Streveler and Wasserman (1984) observed that consideration of human factors should be an important aspect of the design process as poorly designed layouts might quickly lead to fatigue with a resultant lowering of speed and accuracy of task performance. Aesthetic considerations were also important for usability (Schaik and Ling, 2003a,b) because they might be linked closely to individuals’ motivation and satisfaction (Moneta and Csikszentmihalyi, 1996). Several authors have argued against presenting large amounts of text on screen, as users would not be able to read it (Morkes and Nielsen, 1997). This view was upheld in web-authoring guidelines, which encouraged web designers to use text carefully or to break it up into small pieces to avoid scrolling (Bradley, 2002; Briem, 2002), in spite of the fact that navigating between pages may take more time (Ingraham and Bradburn, 2003). In another study, List (2001) found that the best way to improve readability was to keep the reader away from any disturbance and the text should be visible without any kind of hindrance. In this regard designers have to play a role to get the reading improved from a computer screen by providing a better working environment. Ingraham and
Bradburn (2003) concluded that three basic elements, namely typeface, spacing and colour must be considered for developing a highly readable page. Nielsen (2001) showed that there was a great need for comprehensive research into web usability taking into account the different requirements placed on users of internet.

2.2 Studies on the effect of ambient illumination

Almost no work appears to have been conducted in the past to evaluate the performance of operators carrying out readability task on various internet sites under the impact of illumination. However the studies conducted on visual display units have shown that proper illumination level was needed to achieve better task performance. In order to ensure a certain minimum level of ergonomic performance it was important to measure, control and reduce reflections of ambient light sources from the visual display screen (Menozzi and Kriiger, 1990). Gavhed (2007) while conducting a study on working conditions in a call centre emphasized the need to follow the directives and recommendations related to visual ergonomics to prevent discomfort as the various sources of ambient illumination such as windows, bright walls, ceiling luminaries, light bulbs, etc. might be reflected by display screen thus reducing the contrast of the displayed information leading to visual discomfort or sometimes disabling visual information recognition (Becker, 1998). According to Menozzi and Kriiger (1990) the refocusing of the operators' eyes between the information on the screen and the images of various light sources caused visual stress and fatigue. Ambient illumination was an important factor in VDU workplace design and many recommendations existed regarding ambient illumination. An ambient lighting in the range of 200 to 450 lx (ANSI/HFS 100-1988, 1988) has been recommended for better working (Ostberg, 1980). It was revealed on the basis of experimental investigations that low ambient illumination was more appropriate for work as high ambient illumination could cause the screen images to fade (Ostberg, 1980). In a study Shieh and Lin (2000) found that subjects showed greater preference for lower illumination (200 lx) than for higher illumination (450 lx) but the difference was observed to have no statistical significance. The study conducted by Chen and Lin (2004) found that ambient illumination did not significantly affect visual recognition. They observed that lower illumination (200 lx) was slightly better in terms of both visual recognition and preference ratings compared to higher ambient
illumination (700 lx). The study further showed that lower ambient illumination (200 lx) and the normal office ambient illumination (450 lx) were appropriate for VDT work with regard to both visual recognition and subjective preference. Lin and Huang (2006) showed that ambient illumination did not significantly affect character identification performance at normal office lighting levels. However they found that the screen luminance combination significantly affected character identification performance.

2.3 Studies on the effect of text-background colour combination

Colour combination may affect visual performance (Shieh and Lin, 2000) and hence should be considered as an important factor in the design of web sites. Moreover it can effectively be used to enhance the human computer interaction (Pastoor, 1990; Shieh and Chen, 1997). International ergonomic standard calls for VDT design requirements such as polarity, legibility, detectability and comprehensibility to obtain good visual comfort (Bodrog, 2003). Ingraham and Bradburn (2003) reported that the colour was one of the basic element to be considered for designing a highly readable web page. Shieh and Chen (1997) reported that the subject’s viewing distance was significantly affected by the text-background colour difference. According to them a colour combination with a colour difference value approximating 140 might be required for adequate screen design. Pearson and Schaik (2003) found that there was no effect of link colour on visual search tasks, however the blue was found better than red in an interactive search task. The study also showed that the subjects were having a liking for blue colour. Pastoor (1990) reported that there was no effect of polarity on reading time or time needed to search a word among the distracters. Similarly Ling and Schaik (2002) reported no improvement in search performance for words blue on yellow as oppose to yellow on blue text display. The study conducted by Hall and Hanna (2004) concluded that there was no statistically significant readability rating difference between positive and negative polarity. However at a descriptive level higher readability ratings were achieved for positive polarity. Wang et al. (2002) also concluded that colour difference had a significant effect on search performance. The search error was found to decrease when the text/ background colour difference increased. Colour difference was also found to be a significant factor in the subject’s reading performance (Wang
and Chen, 2003). It was suggested that designers should use as few colours as possible to maximize the colour contrast between text and background (Sanders and McCormick, 1993). White background was shown to be a significant factor in the understanding the leading display (Tullis, 1997). It was recommended that designers should select colour combinations with white background and adopt those colour combinations, which have higher colour difference. If the background colour was set with other colours, the effect of text-background colour combination for leading display design needed further investigation. Garcia and Caldera (1996) found that the display colour was one of the most important factors for determining how good the viewers' visual performance was. Inappropriate use of colour could result in poor performance and a higher incidence of visual strain (Luria et al., 1989; Matthews, 1987; Shieh and Chen, 1997). However, there were no proper guidelines available about what colours should be displayed to the users (Fukuzumi and Hayashi, 1989). Various researches (Murch, 1984; Galitz, 1997; Marcus, 1997) have suggested that blue should be used as a background colour. Galitz (1997) was of the opinion that colours such as red compelled users to read them. Galitz (1997) found blue colour to be acceptable to some researchers while unacceptable to others. Shieh and Lin (2000) showed that colour combination had a significant effect on the subject's visual performance and preference rating. Polarity too was found to have significant effect on visual performance and preference rating for VDT work. They further showed that contrast ratio might play a more important role on visual performance than chromaticity contrast. Wang and Chen (2000) observed that the contrast ratio significantly affected visual performance. Chen and Lin (2004) showed that contrast ratio had significant effect on visual recognition and subjective preference. Several researchers (Nishiyama, 1990; Taptagaporn and Saito, 1990; and, Saito et al., 1993) have shown that polarity played a significant role in visual performance. Results of the study conducted by Lin (2003) revealed that better visual identification performances were obtained when the contrast ratio was higher as compared to the lower contrast ratio and also the text colour had no affect on visual performance if an acceptable level of contrast ratio were maintained. Similar findings were obtained when he studied the effects of screen luminance combination and text colour on visual performance (Lin, 2005). Garcia and Calderia (1996) found that there was no significant effect of colour combination on task completion time. A lot of studies have
been done in the past to find out the best colour combination to be used for designing but no concrete formula was available for determining the of effect of colour on readability of screen text (Garcia and Calderia 1996). Shieh and Chen (1997) revealed that screen colour combination also affected the viewing distance, such as red text on a green background resulted in shorter viewing distance and a greater standard deviation of viewing distance in comparison to other colour combinations. In some of the findings it was suggested that blue was a good text colour when white was used as a background colour (Tullis, 1997). Woods et al. (1992) stated that blue colour can run from a deeply saturated blue to a pale cyan, and it was difficult to read when an object was small or thin. Kiritani and Shirai (2003) while studying search information about certain topics in actual directory reference showed that white, blue and green backgrounds made the people feel longer time requirement while red and yellow backgrounds needed less time overestimation. Also the background led bigger time error produced less irritation, fatigue and poor impression of achievement to the reader. In another experiment conducted by them subjects performed visual searching and content understanding - the two main aspects of reading sites. It was found that there was no effect of background colours but white background made the subjects devoted in visual search tasks. Buchner and Baumgartner (2007) showed that proof reading performance was better for light background with dark text than with the reverse arrangement. They also contradicted the findings of Murch (1984) who argued that the blue was an excellent background colour. Huang (2007) concluded that colour combinations white on yellow and white on blue required less time to find an item in search field. In another study Shieh and Ko (2005) observed that figure background colour combination was having an effect on performance. Hill (1997) however showed that there was no combination of foreground/background colour, which could lead to fast readability. Lin and Chen (2006) showed that background colour did not affect the visual acuity while it was found to have significant effect on subjective ratings. The ratings for blue, cyan, green and purple colours were found to be significantly more than that of red. They concluded that subjects liked cool colours for background. Properly selected colours have been reported to improve the performance and they decrease the probability of visual fatigue (Galitz, 1997; Travis, 1991).
2.4 Studies on the effect of noise

Visual attention on the screen was necessary for better performance and prevention of human error. Since it was dependent on a number of environmental factors, distraction from the task could take place, leading to mental load and fatigue. Performance loss and productivity decrement was observed due to noise (JN7845, 2004). The studies in the context of noise while performing web based tasks were found to be almost nonexistent, related studies however shown negative significant effect on subjects. Noise was observed to be one such factor, frequently found interfering (Haider et al., 1990; Berglund and Lindvall, 1995). Many studies have suggested that noise caused annoyance (Bergland et al., 1994). Speech comprehension was found to be adversely effected in the presence of noise above 55 dBA (Kjelberg et al., 1996). Effect of noise on performance and on human error was found to be related to attention processes of perception, memory and/or action (Smith, 1991). The study conducted by Straker et al. (1997) revealed that noisy condition helped in quicker but less accurate VDU work performance than the quiet condition. Noise a well-known environmental stressor, might be responsible for the increase in irritation, blood pressure, and negative psychological mood (Cohen and Weinstein, 1981). Generally VDU workstations were quiet, as working with a VDU required a high level of concentration, and any kind of interference from outside noise might affect performance. It has been reported by WHO (2007) that if several computers were placed in the same room the noise level might reach or even exceed 60 dBA, thus creating an uncomfortable working environment. As per the guidelines of Occupational Safety and Health Service (OSHS, New Zealand, 1996), the background level of 55 dBA (Leq) at the operator position was regarded as an upper limit and it was desirable to achieve a lower level such as 35 dBA. The OSHS (1996) reported that the prevalent noise level was much higher than 35 dBA in the working environments. Melamed and Bruhis (1996) concluded that high levels of noise (85 dBA to 90 dBA) caused fatigue and irritation. This noise, when reached at an irritating level could affect health and productivity. Impact of noise has been shown to be more significant among the subjects of higher age group (Fasten and Plomp, 1990). Stress levels were found to depend upon the amount and type of noise in the office (OSHS, New Zealand, 1996). Some times office noise reached to the levels, which were hazardous to hearing. Ghavhed (2007) while conducting a study on working
conditions in a call centres emphasized that there was a great need to stick on the international recommendations and directives to prevent discomfort due to excessive noise. These levels were found to exceed 85 dBA. Wolfson and Case (2000) while reviewing the studies on the effect of noise concluded that extreme noise levels could lead to impaired performance in difficult tasks. Noise is one of the problems in open offices, with common complaints about interference from nearby conversations and telephones. The bad ventilation of ducts sometimes also caused annoyance. Several standard methods have been recommended for controlling noise to avoid productivity loss and to create a better working environment.

2.5 Studies on physiological effect on web users

Balci and Aghazadeh (2004) reported that the persistent use of computers might result in complaints of eyestrain, musculoskeletal discomfort, headache, and job stress. These were the results of badly designed workstation environment such as poor air quality, improper lighting, glare, noise, job design duration, lack of rest and poor posture. Eyestrain and fatigue of neck and arm muscles were the common health problems for wide range of VDU workers reported by Hosokawa et al. (1997). Sheedy (1992) on the basis of survey conducted by the American Optometric Association revealed that eyestrain, blurred vision, and headache were the top three vision related complaints associated with video display terminal (VDT) work. In another study conducted by Mocci et al. (2001) it was found that visual complaints were dependent upon the type of VDT activity. Watten et al. (1992) reported that 2 to 4 hours of VDT work resulted in the reduction of visual sharpness and contrast sensitivity. It was observed that pain in muscles, head, neck, and upper back might occur due to near-point reduced oculomotor strain. Some studies (Bergqvist and Knave, 1994; Rubino et al., 1993) reported that eye discomfort would depend upon duration of VDT work. Studies conducted by various researchers (Colombini, 1998; Li and Buckle, 1999) have reported that there were musculoskeletal disorders in VDU work related environments. Matias (1996) observed that if daily work duration on VDTs was increased from 1 to 4 hours the probability of occurrence of cumulative trauma disorders was increased from 45% to 92%. Faucett and Rempel (1994) found that the longer work duration on VDT increased chances of musculoskeletal disorder related problems of hands, arms, or upper torso. Eye blinking has been recommended

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as a tool in the field of human computer interaction for assessing workers' attention, concentration, mental workload, fatigue and interest while working on VDUs. Investigations on the relationship between spontaneous eye blinking and mental states have also been conducted by many researchers (Tsuda and Suzuki, 1990; Omori et al., 1996). Spontaneous eye blink rate was also found to get affected while working on computers. It has been shown that blink rate fell below the resting conditions (Yaginuma, et al., 1990; Patel, et al., 1991; Tsubota and Nakamori, 1993). An increase in tear evaporation was observed while working on VDUs (Tsubota and Nakamori, 1995). The dryness of the ocular surface has been the origin of the ocular discomfort signs reported by computer users (Tsubota and Nakamori, 1993). These included burning or itching, foreign body sensation, lacrimation, photophobia, ocular or orbital pain and headache. There were ample evidences that various mental activities including reading, memory use, or emotions modify blink rate (Tanaka and Yamaoka, 1993). The findings of Acosta et al. (1999) showed that during performance of a computer task, the blink rate of young subjects decreased by about half. Use of computers for prolonged periods of time was often accompanied by complaints of ocular discomfort (Bergqvist, 1989). Study conducted by Emina (2003) revealed that there was a significant reduction in the mean blink rate during visual task. Some of the studies however have contradictory findings. Lam et al. (1999) observed that there was no good scientific evidence available, which might show that computer use was responsible for the damage of the eye. The use of VDTs has always been associated with various eye symptoms. Such symptoms might arise from pre-existing minor eye problems that surface when the visual task was demanding. In addition, inadequate awareness of VDT ergonomics and poor visual hygiene might also contribute to ocular fatigue and other eye related symptoms.

2.6 Studies on the effect of age

People of diverse age and various backgrounds use internet to carry out a wide variety of tasks. Various studies have been conducted on age in the context of VDUs. It has been shown that adults with more search experience performed more effective searches and used more complicated approaches than those with less experience (Chen et al., 1998; Hill and Hannafin, 1997; Palmquist and Kim, 2000). Pollock and Hockley (1997) too found that, while using the internet, people of various age groups
missed relevant information because they lacked the knowledge necessary to use appropriate terminology. Adults older than 50 years had more problems associated with grammar and understanding search results than younger users (Kelley and Charness, 1995). The decrease in colour discriminating ability was found with age (Kline and Scialfa, 1997). The contrast sensitivity was reported to decrease with aging by Burton et al. (1993). Older people were found to have less attention capabilities in comparison to younger ones (Reuter-Lorenz, 2002). Younger viewers were also able to read poor displays while this was not the case with the older users Hill and Scharff (1997). Sit (1998) concluded that many older adults progress little beyond the novice stage due to inconsistent use of computers. The newer computer technology was found to be appropriate for a large group of growing population (Anna et al., 2005). Mead et al. (2000) while comparing the behaviour of novice younger adults (18–33 years) to that of older adults (61-80 years) found that online databases were not as accessible to older adults as they were to younger adults. Older people over 60 years of age not familiar with computers felt anxious while using them in comparison to younger people (Marquie et al., 2002). It has been demonstrated that older adults were likely to experience difficulties related to vision and cognition while using internet (Hawthorn, 2000; Echt, 2002; Czaja and Lee, 2003). Researches have indicated that older adults were poor performer compared to younger ones when complicated and cluttered display was presented to them (Newell et al., 2003; Fisk et al., 2004). Researches have also shown that older adults have slower reaction and movement times and experience difficulty in making finer motor movements (Fozard et al., 1994; Walker et al., 1997). The decrease in motor movements and control may cause problems for elderly in operating computer related devices. Similar were the findings of Chadwick (2003) who showed that people of 55 years of age experienced more difficulties using the web sites than their younger counterparts. They took more time for the task completion and were low in completing the task successfully. Worden et al. (1997) showed that design modifications carried out for older users might often be advantageous to younger users as well. Older users made more grammar errors, had less understanding of logic, and used fewer advanced tools than younger adults with similar experience. Inappropriate interface designs were a fundamental barrier for older adults who found standard interfaces harder to use than younger adults even when computer experience was controlled (Chadwick-Dias et al., 2003; Worden et al.,
Older people were also significantly more likely to be inexperienced computer users (ONS 2004; Fox, 2004). Lack of experience made it relatively more difficult for older adults and had negative computer experiences (Todman and Drysdale, 2004). Inexperienced users were observed to sometimes encounter difficulty with terminology (Janicki, 2002; Crystal, 2001) and with a range of interface conventions (Ellis and Kurniawan, 2000). On the other hand, more encouraging experiences provoked a more positive attitude towards computers (Morris, 1992). Hawthorn's Senior Mail a redevelopment of the Microsoft Outlook Express was developed to support the use by older adults which altered the visual presentation of the system (bigger buttons, larger font size, etc.) and had a list of possible actions presented in a simplified menu, and simplified navigation (Hawthorn, 2002 and 2003). This work was designed for the experienced users and was optimally designed for beginners. 

Amott et al. (2004) developed a prototype email system for older users of varying experience. They found that inexperienced users from a variety of age groups approached the internet. A lack of internet experience, however, often led to quick rejection of the internet as an information resource. People who did not understand the internet sometimes could not truly access (Coyne and Nielsen, 2002). Usually the children and older adults were more likely to lack internet experience than other users.

2.7 Studies on internet use duration

The internet use duration has been observed to increase continuously as millions of people world wide using internet for their day to day work viz. on line trading, downloading, browsing, messaging and purchasing (Teo et al., 1998). The web performance with 24 hours availability has become the issue of concern for webmasters because of its application in various situations (Menasce, 2000). Also, the use of internet in teaching and learning has been growing at a faster pace with the invent of new searching tools (Nazim and Chaudhary, 2004). Many studies (Asemi, 2005; Igun 2005) have been conducted in the past in the context of internet use duration. Singh (1998) found that in Malaysia 90% librarians were using internet for their browsing work. In another study, Laite (2000) revealed that majority of students at graduate and undergraduate level used internet 1-2 times per week for their browsing requirements but e-mail service was used by almost 100% students. Badu and Markwei (2005) also found that teachers and students mostly used e-mail.
et al. (1992) observed that 2 and 4 hours of VDU work were responsible for significant reduction in visual activity and contrast sensitivity. Moreover eye discomfort increased with the increase in work duration (Bergqvist and Knave, 1994). Akporido (2005) while performing the study on usage pattern in a Nigerian suburban setting found that motivation of users, frequency of use, knowledge of search engines were some factors on which usage was dependent. Nazim (2008) reported that 36% of the total internet users in an University devoted 8 hours per week, while 6% spent 2 hours only for information requirement. It was also noted that 31% of the total respondents spent on an average of 1 hour a day using internet. The results of the survey conducted by Taloustutkimus (1995) and reported by Lindroos (1997) showed that 5% of the population in Finland who use internet once a week spent 3.3 hours on an average per week. Dillon and Emurian (1996) who evaluated the visual fatigue over the time devoted on VDU task, found that physiological functions of eyes were not affected for short durations, however more than 4 hours caused temporary discomfort to users.

2.8 Summary

The literature reviewed on the theme of the effect of noise, illumination, text-background colour combination and internet use duration on the task performance of the subject has led to the following conclusions:

1. It was revealed that noise had a bearing on the subjects carrying out computer-based tasks. Although past studies have reported the effect of noise on luminance contrast, no research appears to have been done in the past to investigate the effects of noise, illumination, text-background colour combination and internet use duration on the performance of the subjects. As large number of persons are using internet it becomes necessary to study their performance in various work environments.

2. The literature scanned has shown that the effect of age has not been investigated much in the past. In the light of the fact that people of varying age groups use internet, it becomes important to investigate the effect of age in different working environment.

3. No research seems to have been conducted in the past to investigate the performance of operator while carrying out a web based task for varying text-
background colour combinations under different environmental conditions. Since the number of web sites is growing at a very fast rate, it becomes necessary to investigate how the text-background colour combination affects users performance.

4. Studies have shown that the common visual complaints reported by users are eyestrain, irritation, blurred vision etc., so it would be worthwhile to study task performance of the user from the point of view of the visual fatigue.

5. Further investigation on these lines will develop better understanding of the influence of age and experience, user interface design for regular users of internet.