
THE HONG KONG POLYTECHNIC UNIVERSITY

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THE EFFECT OF VISUAL SEARCH STRATEGIES ON LEARNING USING COMPUTER-ASSISTED INSTRUCTION (CAI) FOR PEOPLE WITH MILD MENTAL HANDICAP

BY

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CERTIFICATION OF ORIGINALITY

The design of this study and the planning of the experiments resulted from the discussion between the author and supervisor, Dr. Cecilia Li-Tsang. All experiments in this study were solely conducted by the author.

I, Wong Kai Kit hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledge has been made in the text.

Wong Kai Kit

April 2008

Abstract of thesis entitled “The Effect of Visual Search Strategies on Learning Using Computer-Assisted Instruction (CAI) for People with Mild Mental Handicap” Submitted by Wong Kai Kit for the degree of Master of Philosophy at the Hong Kong Polytechnic University in June 2007.

ABSTRACT

The purpose of this study was to investigate the effect of different visual search strategies incorporated in a computer-assisted instruction typing program for people with mild mental handicap in Hong Kong. The study was divided into two phases; phase I of the study investigated the efficacy of two visual search strategies on search behavior vary as a function of level of intelligence (i.e. people with MH and people with normal intelligence) through a series of experiments. Based on the results obtained in Phase I of the study and the pilot test, an innovative CAI program for teaching typing English was developed, which was culturally appropriate and specific to people with MH in Hong Kong. The effect of the visual search strategies for people with MH in the CAI program was then conducted in Phase II of the study.

In phase I of the study, a total of 36 subjects (18 with MH and the other 18 with normal intelligence) was recruited using convenient sampling method. A series of experiments was conducted to compare visual search strategies using either guided motion (i.e. motion contrast) or guided cue (i.e. additional cue) with the basic search tasks. Repeated measure ANOVA and Post-hoc multiple comparison tests were used to compare the performance of different visual search strategies. The results showed that the use of guided strategies was able to capture focal attention in an autonomic manner among people with MH (Pillai’s Trace = 5.99, $p < 0.0001$). Effective visual search was demonstrated by reaction time (RT) x set size slope < 10msec/item, which implied the RT for visual searching was independent of the set

size, and thus was evident of parallel search for the features. Both guided cue and guided motion search tasks demonstrated functionally similar effects, with guided motion search being more superior when compared with guided cue search. The results revealed that the visual search efficiency of people with MH was greatly improved if the target was made salient using visual search strategies (i.e. guided motion). Therefore, this phase of study provided an important practical implication and rationale for the use of visual search strategies that would be incorporated in CAI typing program design in phase II of the study.

In phase II of the study, a pilot test was conducted prior to the main study. A total of 36 people with MH was recruited and randomly allocated to either the Group I i.e. *CAI typing without cue* (n=18) or the Group II i.e. *CAI typing with visual cue* (n=18). All the participants completed the posttest-1 assessment, except that two of them in the experimental group missed posttest-2 assessment for the reason of lack of time and loss of contact. Two-way repeated measure MANOVA was performed for the outcome measures including typing speed and accuracy. The results showed that the overall model was significant for the difference on a linear combination of the two dependent variables (i.e. typing speed and accuracy) between the control and experimental groups (Wilk's Lambda = 0.456, F(4,31) = 9.248, $\underline{p}$ <0.001). The search performance of typing speed was significantly higher for the experimental group (p<0.001). However, there was no statistically significant difference on accuracy between the two groups. This study further supported the role of visual search strategies that could attract and maintain attention to the critical elements in the arrays, and thus promote the encoding process for long-term storage. It also supported the positive effect of using CAI with appropriate in enhancing functional cueing performances among people with MH.

In conclusion, this study supported the use of visual search strategies for CAI programs that might be extended to other CAI for community living skills and vocational training for people with MH such as learning IT platform, using ETC machine.

OUTPUTS RELATED TO THE STUDY

PUBLICATIONS

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LIST OF ABBREVIATIONS

ANOVA	Analyses of variances
CA	Chronological age
CAI	Computer assisted instruction
DSM-IV	Diagnostic and Statistical Manual of mental Disorders
fMRI	Functional magnetic resonance imaging
HKPU	Hong Kong Polytechnics University
IRQ	Interquartile range
IT	Information technology
LOCF	Last observation carried forward
MA	Mental age
MANOVA	Multivariate analysis of variance
MH	Mental handicap
ms	Millisecond
PET	Positron emission tomography
rCBF	Regional cerebral blood flow
RT	Reaction time
WPM	Word per minute

CHAPTER I

INTRODUCTION

1.1 Background of the study

Based on the survey report by the Hong Kong Census and Statistics Department in 2001 (The Government of the Hong Kong Special Administrative Region, 2001), it was estimated that the total number of people with mental handicap (MH) was about 62000 – 87000, representing a prevalence rate of 0.9% - 1.3% in Hong Kong. Among the people with MH who were economically active (2.1% - 2.9%), less than 6.6% were engaged in clerical related work and the remaining (93.4%) were workers in elementary occupations (i.e. unskilled work). Although it is believed that computer literacy is increasingly important that provides people with survival skills for changing their future and assists them to gain a competitive edge when applying for jobs in the community, very few studies have attempted to address the issues such as the computer awareness, knowledge and skills among people with MH, or to improve the computer literacy among them. Despite the advances in computer technology over the past decades, people with MH still do not have an easy way to access the basic information technology (IT), either the hardware and software. Christensen, Carol & Cosden (1986) pointed out that people with MH lacked the cognitive abilities to develop computer literacy skills and had weak face validity, rather than they were rarely taught the skills necessary to use computer as a tool. The major barriers in assessing computer technology for people with MH can be explained by internal constraints (e.g. lack of physical fitness, presence of motor deficits or inadequate cognitive skills) and external constraints (e.g. social attitudes). In addition, the lack of well-designed software interface and instructional program further widens the “digital divide” - a gap between those people who can make effective use of computer technology and those who cannot (Bland, 2002).

Mechling, Gast, & Langone (2002) stated that research on computer technology in special education mainly focused on functional skill training, which facilitates a person's ability to live, work and get involved in leisure activities in community environment. In review of literature, there were lots of evidence suggesting that computer-assisted instruction (CAI) could be effectively used by people with mild MH and significantly enhance learning. The majority of the studies only mentioned the effectiveness of CAI in the literacy, numeracy and community skills training, whereas promoting computer skill training was very limited in comparison. More recently, research focus has shifted to address the instructional conditions that could optimize the use of CAI (Fitzgerald & Koury, 1996), and the effects of computer visuals have also drawn potential attention (Mayer & Moreno, 2002; Rieber, 1990; Rieber & Kini, 1991). Visual cues have been suggested effective to gain attention. It was believed that a proper visual design could address the cognitive deficiencies e.g. attention and working memory deficits in people with mild MH. Therefore the aim of this study was to investigate the effect of different cueing strategies on the visual search efficacy in people with MH, thus providing a theoretical framework on designing a CAI for typing skill training.

1.2 Objectives of the study

In view of the above-mentioned problems, this study was to investigate the effect of different visual search strategies in CAI typing program for people with mild MH by achieving the following three objectives:. They were:

a) to investigate of the efficacy of two cueing strategies on visual search behavior vary as a function of level of intelligence (i.e. people with MH and people with normal intelligence);

b) to develop an innovative CAI for typing which would be culturally appropriate and specific to people with MH; and

c) to investigate the effect of visual search strategies incorporated in CAI on the typing performance of people with MH

1.3 Hypotheses of study

The hypotheses of this study were as follow:

1. There would be significant differences in visual search efficacy in terms of speed and accuracy in the two visual search strategies (i.e. guided motion and guided cue) when compared to no cueing condition (i.e. basic search) between people with MH and people with normal intelligence.

2. There would be significant differences in visual search efficacy among people with MH when compared to people with normal intelligence in each search task.

3. There would be significant within-group differences (i.e. before and after treatment intervention) in typing speed and accuracy among people with MH.

4. There would be significant between-group differences (i.e. visual cueing condition vs. no cueing conditions) in typing speed and accuracy among people with MH.

5. There would be significant interaction differences (i.e. visual cueing condition when compared with no cueing conditions before and after the treatment invention) among people with MH.

1.4 Significance of current study

This study would contribute to the teaching of IT in special education and in successful integration of people with MH. By examining the effects of cueing strategies on the visual search behavior and efficacy in people with MH, it would provide a theoretical relevance for the remediation strategies through CAI. The results of this study would have important implications for CAI design for people with special needs. It is believed that an optimized CAI design could undoubtedly foster the mastery of skill and enhance effective learning in people with MH.

1.5 Organization of Chapters

There are altogether six chapters in this thesis. The first chapter is introduction. Chapter II provides literature review on relevant areas, including the definition of mental handicap; cognitive deficit in people with MH especially in attention and working memory deficits; visual search in people with normal intelligence; enhancing visual search efficacy in people with normal intelligence and people with MH; definition of CAI and its effectiveness; and lastly theoretical framework for CAI. Chapter III describes the method of the study and is divided into two phases: 1) evaluation of the effects of two visual search strategies in enhancing visual search efficacy for people with and without MH; and 2) evaluation of the effectiveness of CAI in typing which is incorporated with visual search strategies. Chapter IV summarizes the results obtained from the above studies. Chapter V discusses the results and outcome. And, lastly Chapter VI provides an overall conclusion in this research, limitations and implication of future research.

CHAPTER II

LITERATURE REVIEW

This chapter begins with the definition of MH. Cognitive deficit in people with MH in the areas of attention and working memory deficit were discussed, that may impede the learning process. Behavioral and neural studies on visual search behaviours and the strategies to enhance visual search efficacy were then reviewed. This would then provide a framework for the design of effective training procedure for people with MH. Lastly, definition of CAI and its effectiveness for people with MH were presented and the theoretical framework for optimized CAI design was proposed.

2.1 Definition of Mental Handicap

The Diagnostic and Statistical Manual of Mental Disorders, Forth edition (DSM-IV) states that there are three diagnostic criteria for MH. The first criterion is significant sub-average intellectual functioning (IQ of approximately 70 or below on an individually administrated IQ test). The second criterion is the concurrent deficits or impairments in two or more of the following adaptive skills areas, namely communication, self-care, home living, social / interpersonal skills, use of community resources, self-direction, functional academic skills, work, leisure, health and safety. The last criterion is that the onset is before the age of 18. Mental handicap is classified into four degrees of severity in the DSM-IV of the American Psychiatric Association (*Diagnostic and statistical manual of mental disorders*, 2000) and the American Association on Mental Retardation (2000) (Table 2.1):

Table 2.1

Classification of mental handicap (American Psychiatric Association, 2000)

Classification of Mental Handicap	Level of IQ
Mild Grade	50 – 55 to approximately 70
Moderate Grade	35 – 40 to 50 – 55
Severe Grade	20 – 25 to 35 – 40
Profound Grade	Below 20 or 25

The classifications are primarily based on Wechsler Adult Intelligence Scale administered by psychologists. The four levels include mild MH (IQ levels of approximately 55-70), which affects 85% of the cognitively deficient population; moderate retardation (IQ levels of 40-55), which affects approximately 10% of those with retardation diagnoses; severe mental retardation (IQ levels of 25-40); and profound mental retardation (IQ levels <25).

2.2 Cognitive deficits in people with MH

2.2.1 Introduction

Cognitive deficits in people with MH could be classified from profound level with minimal functioning to mild impairment (Daniel & Tynan, 2006). Cognitive deficit is an inclusive term used to describe deficits in intellectual functioning in global disorders (e.g. MH) or specific deficit in cognitive abilities (e.g. certain learning disabilities such as dyslexia). Brain imaging studies in people with MH have also identified structural abnormalities associated with the observed cognitive deficits, such as abnormal development of the prefrontal cortex, less activation in the hippocampus, and reduced total brain and gray-matter volumes (Greicius *et al*., 2004; Pearlson *et al.*, 1998; Rowe *et al.*, 2006). This might help to explain the global cognitive disturbances, including measures of attention, memory, visual perception, language, and executive function (Bergen & Mosley, 1994; Fidler *et al.*, 2005; Palmer, 2006; Purser & Jarrold, 2005; Vicari, 2004) The following review will focus on the attention and working memory deficits in people with MH which guide the researchers and clinicians to develop effective remedial treatment programs.

2.2.2 Attention deficit in people with MH

While attention is a cognitive construct referring to information processing, it has also been assumed to have a behavioral component (Desimone & Duncan, 1995). It is believed that the ability to focus attention, concentrate and resist distraction is critical for any task engagement. Attention has been recognized to involve a selection process. When multiple sensory stimuli or locations in space compete for attention, the brain processes certain types of stimuli more fully, at the expense of others. This is a consequence of the limited capacity of the brain to process multiple stimuli simultaneously (Krupski, 1979).

Attention can be considered as an information processing filter. However, difficulties in shifting attention and engaging in new object might was commonly found in people with MH who often show difficulty focusing attention on a task when mental or physical distractions are present. Mental pre-occupation and environmental distractions were suggested to compete for the attention (Maki & Leuin, 1972). One type of attentional deficit, for example, that can interfere with learning is overselective attention in which restricted portions of complex stimulus displays are attended only. People with overselective visual attention demonstrate a type of ‘‘tunnel vision’’. Krupski (1979) noted that people with MH often have difficulties in complex discriminations since they may respond “overselectively”, attending to only one or a restricted number of cues of a compound stimulus. Dickson & colleagues (2006) described the procedure for overselectivity research using delayed matching to sample with multiple sample stimuli. A series of matching-to-sample trials were presented with two or more sample stimuli on each trial (e.g., A and B). The participant compared and found the identical samples from the display (e.g., A, C, and D) and reinforcers that followed selections of the identical comparison were given (Cherry *et al.*, 2002; Numminen *et al.*, 2002). Overselectivity was operationally defined by intermediate accuracy scores, indicating stimulus control by some of the sample stimuli. Overselective attention has been reported in people with developmental disabilities and it can be very extreme among individuals with autism and severe levels of MH (Huguenin, 2000). Although overselectivity seems predictable in people with autism and severe MH (Huguenin, 2000, 2004), it may also be expected in some people with relatively mild disabilities (Dickson *et al.*, 2006).

In attention research, one influential theory attempting to explain how visual attention is shifted came from Posner and Petersen. Posner has developed a three-stage model of spatial attention based on the brain damage and the cued spatial orienting paradigm (Posner, 1980). The concept is that in order for a person to reorient to a new target, he would first have to disengage from whatever attending. Next, the physical shifting of the attention would occur from one location to the new location. And finally, attention would be engaged, or focused onto the new location. By using Positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) in lesion studies during attentive tasks, patients with damage to specific areas of the brain experience specific deficits in operations. Damage to the posterior parietal cortex appeared to impair the disengage operation; damage to the superior colliculus impaired the move function; and damage to the lateral pulvinar nucleus of the thalamus impaired the engage function (Posner and Petersen, 1990). On the other hand, some researchers have studied the neural correlates of physical shifts of attention, specifically focusing on the observer factor i.e. covert and overt attention, as well as, stimuli factor i.e. voluntary and automatic attention shifts. Spatial covert attention is the selective processing of visual information at a given location in the absence of eye movements to that location. Covert attention can be either voluntarily allocated to a given location according to the search goals (=top down factor) or involuntarily allocated, in a reflexive manner, in response to a cue that appears suddenly in the visual field (=bottom up factor).

2.2.3 Working memory deficit in people with MH

The topic of memory structure in people with MH has drawn a fair amount of attention in recent years (Baddeley, 1986, 2000). The capacity of memory function has shown important consequences on different aspects of learning to acquire knowledge and new skills, and to carry out complex cognitive operations. The working memory model, outlined initially by Baddeley & Hitch (1986, 1974) and refined by Baddeley (2000), account for a range of phenomena associated with short-term memory (STM) performance in both typically and atypically functioning individuals (Figure 2.1). The following reviews describe the model of working memory in people with normal intelligence and working memory performance in people with mild MH. Also, the implication of research construct is discussed with reference to the role of working memory in learning.

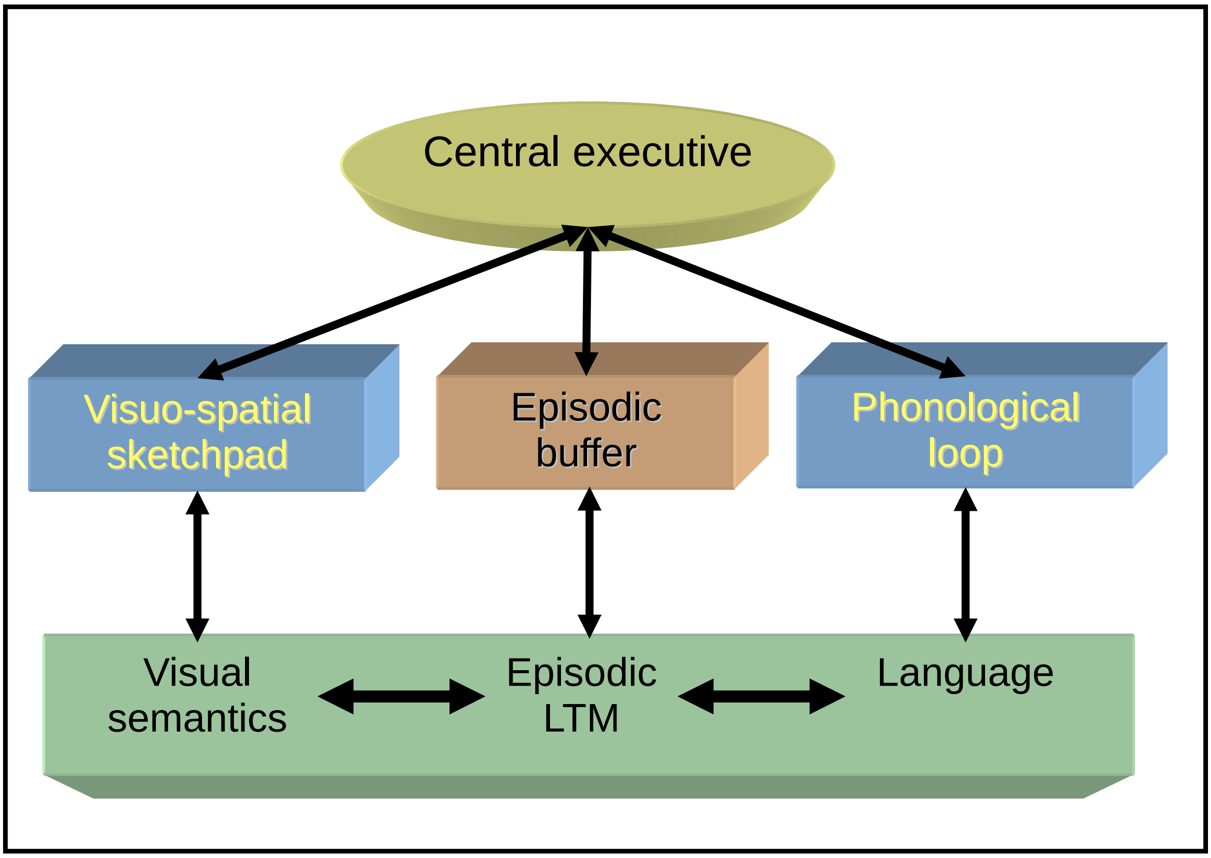


Figure 2.1

Working Memory Model (Baddeley, 2000)

Working memory consists of multiple components: the central executive, and two subordinate slave components, the phonological loop and visuo-spatial sketchpad. The new component – episodic buffer was proposed in the latest version by Baddeley (2000). It is assumed to be a capacity-limited temporary storage system that stores information in multidimensional codes, and provides a temporary interface between the slave systems and long term memory. The central executive reflects controlled attention handling similar functions as attention, while phonological loop and visuo-spatial sketchpad analogous to the *auditory* and *visual working memory*, which represent more restricted memory functions responsible for temporary processing, and maintenance of verbal (Baddeley, 1986) and visual or spatial (Logie, 1995) information. Controlled attention is responsible for the control of information flow between the working memory components as well as the retrieval of information from other memory systems, such as long-term memory (Duff & Logie, 1999). The visual working memory supports the storage and manipulation of visuo-spatial information (Gathercole & Baddeley, 1993) that is important for geographical orientation and for planning the spatial tasks. Visual working memory has also been used to account for performance in a wide of visuo-spatial tasks, including perceptuo-motor tracking and immediate recall of visual image (Henry & MacLean, 2002; Numminen *et al.*, 2000; Numminen *et al.*, 2002; Rosenquist, 2001). On the other hand, auditory working memory retains verbal material in phonological form for brief periods of time, that has been found to play a critical role in reading skill and language comprehension (Gathercole & Baddeley, 1993; Singh *et al.*, 1998).

Previous research studies have showed that performance in working memory tasks is deficient in people with mild to moderate MH (Rosenquist, 2001), which in general, can only be focused and attentive during short, familiar and simple memory tasks. The difficulties in maintaining attentiveness may be one of the major constraints influencing performance on the capacity of immediate memory. Some studies have suggested that people with MH have shorter memory span than people with normal intelligence who are of equivalent chronological age (CA) and mental age (MA) (Marcell *et al.*, 1988; Marcell *et al.*, 1995; Sweller *et al.*, 1990). It is interesting to note that people with normal intelligence showed better recall of information presented auditorily than visually, whereas people with MH do not.

A recent research reported that the auditory working memory tends to be impaired in individuals with MH, in contrast to visual working memory (Henry & MacLean, 2002), while Rosenquist (2001) reported that people with MH performed similarly compared to people with normal intelligence on the visual span task, suggesting that the maintenance process is not as impaired within the visual working memory in comparison with the auditory working memory for people with MH. Martin and his colleagues (2000) found that people with mild MH were weaker on the verbal memory subtests compared with visual memory subtests in the Rivermead Behavioural Memory Test (RBMT). Similar findings have been reported that children with MH showed relative advantage in simple visuo-spatial short-term storage compared to the children matched MA (Baldassi & Burr, 2000). Other studies have also suggested that that people with MH could form and utilize non-verbal memory codes as effectively as normal individuals in analyses of recognition performance (Wright *et al.*, 2002). The general superiority of visual working memory provided a better understanding in teaching method for people with MH that should focus on the use of visual and spatial materials rather than the more typical verbally based method. This could have important implications for studying the visual search behaviour and the strategies of enhancing visual search in people with MH.

2.3 Visual search abilities in people with normal intelligence

2.3.1 Definition of visual search

Many theories have proposed that visual working memory plays an important role in visual search. Visual search is a type of perceptual task requiring attention and vigilance. In daily life, it involves an active scan of the visual environment for particular objects or features of the array. Human perform hundreds of visual searches everyday: looking for the correct key on the keyboard, and searching for the mouse cursor on computer screen. The ability to effectively locate a visually distinctive item in a given scene while limiting attention to distractor elements is crucial in most educational tasks, especially among people with MH, who are known to be easily distractible (Conners *et al.*, 1986).

2.3.2 Visual search theories

In a standard visual search, participants have to find the pre-defined target items as quickly and accurately as possible among distractors in a visual scene. The total number of distractor items in the scene is known as *set size.* Participant is required to make one response if the target is found and another if not. Many previous studies have analyzed the outcome measures of reaction time (RT) and accuracy on the number of search items in the scene (Irwin *et al.*, 2000; Laarni, 2001; Nothdurft, 1999; Turatto & Galfano, 2000). In the plots of the RT as a function of the set size, one may observe flat or steep functions (i.e. set-size slope) depending on the type of array used. RT x Set size slope equals the slope of the fitted regression line (Wolfe *at al.*, 1992), which measures the efficiency of search through the display.

During the past decade, significant theoretical frameworks and empirical studies have been established in human visual search behaviors. Several theories have been proposed regarding the nature of the visual search processes. The pioneer work from Treisman and her colleagues (1988) proposed feature integration theory which involves two distinct stages of visual processing.

Preattentive stage involves distinctions between disparate features on a particular dimension. Consider a search for vertical line among horizontal lines (Figure 2.2), the resulting RT x set size slope is virtually flat near zero ms/item (Figure 2.3). The pattern of the results is usually called *parallel search*. Triesman (1988) proposed that many *feature searches* were parallel searches. Feature searches are searches where the target is distinguished from distractors by a single basic feature like color (Julesz & Bergen, 1983), size, form and line orientation (Duncan, 1989; Duncan & Humphreys, 1992; Treisman & Gormican, 1988; Wolfe et al., 1992). Apparently, all items can be processed at once to a level sufficient to distinguish targets from distractors. The horizontal line, if present, "pops out" and makes its salient.

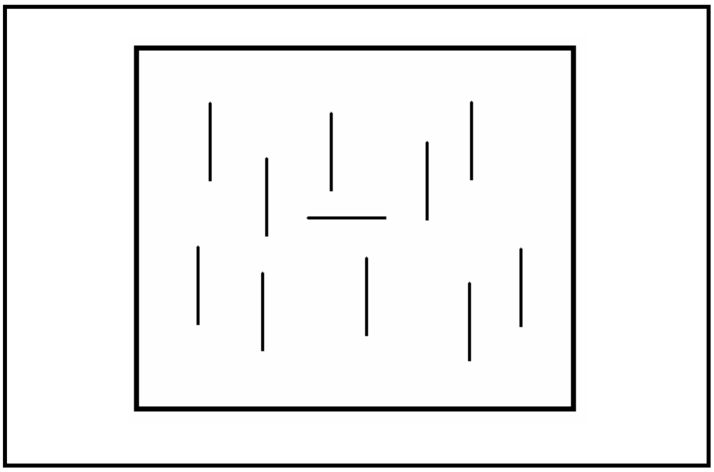


Figure 2.2
Parallel search for a horizontal target among vertical distractors: the target seems to “pop out” of the display.

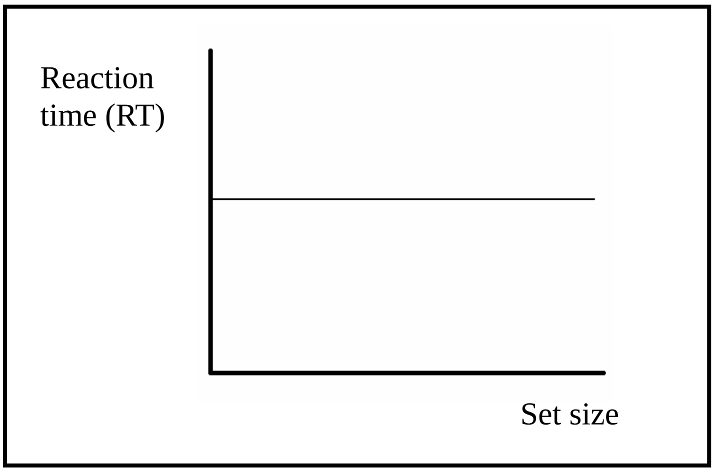


Figure 2.3
A plot of RT x set size slope in search for vertical line among horizontal lines: the slope of the RT plotted against the set size is 0 ms/item

The second stage was attentive stage which is a subsequent serial-processing stage that allows for finer discriminations among the stimuli presented. Consider a search for character “T” among characters “L” (Wolfe *et al*, 1989) as shown in Figure 2.4a and b, the RT increases with set size, the resulting RT x set size slope turned out in a steep function for about 40-60 ms/item in target absent trial (Figure 2.5). The pattern of the results reflects an underlying *serial search*, which occurs in *conjunction search* when the target is defined not by any single visual feature, but by a combination of two or more features. In this example, both “T” and “L” compose of horizontal and vertical line but with different spatial orientations.

The assumption of parallel search was that all stimuli were assumed to be processed simultaneously because highly disparate features could be identified rapidly and independently of the set size; whereas if the target was not identifiable immediately e.g. less disparate features, a sequential shift of focal attention across a scene in serial search of the array was required. The hallmark of feature integrated theory was that the perceptual analysis of complex visual objects depended on focal attention, and could only occur for one object at the time.

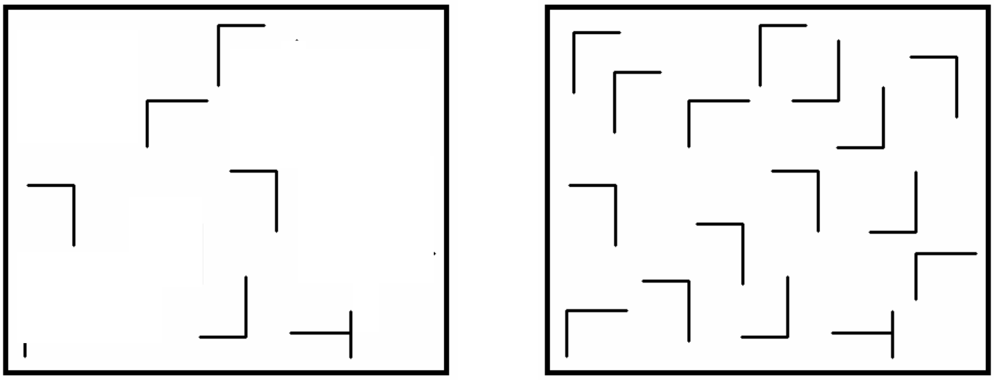


Figure 2.4a

Figure 2.4b

Figure 2.4

Serial search for character T among L., set size increases from 5 (Figure 2.4a) to 15 (Figure 2.4b)

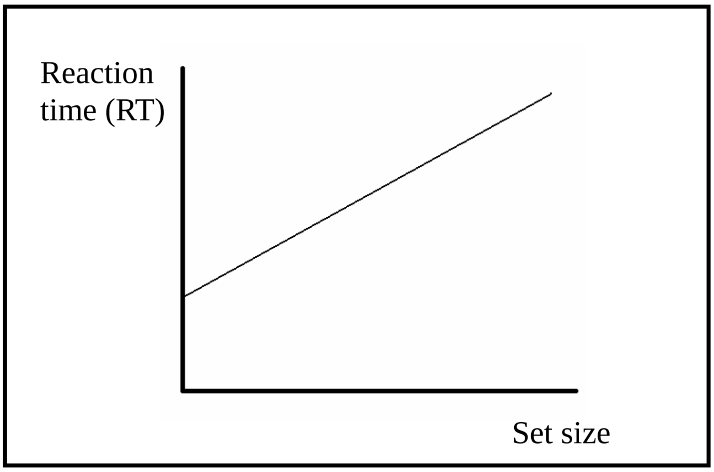


Figure 2.5

A plot of RT x set size slope in search for character “T” among characters “L”: the slope of the RT plotted against the set size is 40-60 ms/item

However, the notion of rigid serial-parallel dichotomy has come under question (Duncan, 1989; Duncan & Humphreys, 1992; Treisman & Gormican, 1988; Wolfe *et al.*, 1992). A number of experiments have shown that conjunction search can also be relatively efficient i.e. parallel search. For example, conjunctions of color and orientation can produce efficient search (Wolfe *et al.*, 1989). As the result were in conflict with the feature integration theory, revisions to the theory have been made by Treisman and Sato (1990) and some new theories have been proposed. Currently, one of the most inferential theories of visual search is the Guided Search Theory (Wolfe *et al.*, 1989; Wolfe, 1994). It accounts for several observed phenomena in visual search behavior, such as pop-out versus conjunction (Treisman & Gelade, 1980), target-distractor discriminability (Duncan & Humphreys, 1989; Nagy & Sanchez, 1990; Pashler, 1987; Treisman, 1991), and distractor heterogeneity (Duncan & Humphreys, 1989). Target-distractor discriminability is defined along two feature dimensions, so that the target differs from two types of distractors by a different feature dimension (e.g. red circle among red square and blue circle). Distractor heterogeneity, on the other hand, decreases the grouping of distractors and thus affects the visual search efficacy. According to this theory, both feature and conjunction search are basically similar, that is the underlying visual processing might be less distinct than originally assumed and two search modes demand focal attention both in serial and parallel search. The preattentive- and attentive-processing stages may not be autonomous, but rather, the initial preattentive stage informs or guides the subsequent attentive phase to the particular items in the array so that the most promising item are checked first. It is believed that when target–distractors similarity is high, increasing heterogeneity in the distractor stimuli would result in decreased search efficiency and vice versa. When a stimulus is presented, a parallel search is carried out across the array, and pre-attentive stage of visual processing generates an activation map that indicates likely target positions. The guided search model not only avoids the issue of efficient conjunction search in the feature integration theory but also makes underlying mechanisms explicit, thus allowing for successful computer simulations of a range of empirical data (Wolfe, 1994; Wolfe *et al*., 1989).

2.4 Enhancing visual search efficacy

One of the most important visual research areas is the extent to which visual attention can enhance the speed and accuracy with which the target is detected and analyzed (Baldassi & Burr, 2000). Visual search efficacy is a general term encompassing all processes involved in the performance of visual search task which includes the operation of both parallel and serial stage of visual processing (Carlin *et al.,* 1995). The common technique to study the searching efficacy is to ask the participants to make perceptual judgment about the target in the presence of a variable number of neutral distracters. By *efficient search*, the RT x set size slope is small e.g., 5 ms/item when the target is present, and *inefficient search* corresponds to a substantial search slope, e.g. 20 ms/item (Wang *et al.,* 2005).

2.4.1 Top-down and bottom-up approaches in visual search

In visual search efficacy studies, two types of mechanisms have been suggested for efficient visual search. Top-down and bottom-up factors are crucial which control search behaviors. Numerous behavioral evidence suggested that visual attention selection in everyday experience depends on the interaction of both components (Patel & Sathian, 2000). Top down factors include the search goal and strategies of the observer. Almost all visual search theories assume that pre-knowledge may generate top down activation that can guide the search process, allowing people to exert some voluntary control over the spatial allocation of attention. The top-down activation of an item increases with greater similarity of that item to the pre-defined target. For instance, when looking for the letter “E” on an English QWERT keyboard layout (Figure 2.6a), prior knowledge of the letter arrangement can guide the search process and ignore all other keypads.

On the other hand, bottom up factors include physical attributes of the visual array such as perceptual salience (e.g. unique color, form or motion) that determine which elements in an array are most likely to receive attention. When an element differs significantly from nearby stimuli on one or more feature dimensions, and is thus perceptually salient, it is referred to as a feature singleton (Pashler, 1988). Bottom up factors are said to operate in raw sensory input and capture attention involuntarily without intention, whereas top-down factors implement longer-term cognitive strategies which may or may not be under intentional control (Peterson & Kramer, 2001). The bottom-up activation increases with lower similarity to the distractors in its neighborhood. For instance, a sudden pop-up advertisement on the internet captures visual attention due to its bottom-up salience. Suppose the positions of the letter on the keyboard are rearranged (Figure 2.6b), finding the letter “E” can be less easy because of decreasing top-down influences. However, if the stimulus letter appears abruptly (i.e. as “popout”) in a display (Figure 2.6c), it may direct focal attention and guide the selection and identification processes of the visual system, by which the target properties are then easily recognized.

Figure 2.6a

Figure 2.6b

Figure 2.6c

Figure 2.6

English QWERT keyboard layout (Figure 2.6a). Rearrangement of letter on the standard English QWERT keyboard (Figure 2.6b). Stimulus letter “E” appeared abruptly in a display (Figure 2.6c).

2.4.2 Behavioral studies in visual search

In behavioral studies, whether the efficient detection of a singleton in visual search depends on stimulus properties, or depends on the observer's attentional set, is still controversial. While some researchers have found that cueing attention may or may not have any effect on both searching speed and accuracy (Baldassi & Burr, 2000; Grabbe & Pratt, 2004), a number of experimental studies on visual search among people with normal intelligence have reported that a visually salient element in a given environmental context is an important parameter in capturing attention. Color, motion contrast, change of luminance could produce efficient saliency effects that allow targets to be identified quickly and attracted focal attention for task target analysis and could even override the intended direction of an eye movement (Irwin *et al.*, 2000; Nothdurft, 1995, 2002; Turatto & Galfano, 2000). Yet it was debatable whether these physical attributes are functionally equivalent in the selection process (Grabbe & Pratt, 2004). By monitoring the overt attention using eye-tracker device, it was showed that abrupt onsets (i.e. new objects) were the most effective in capturing attention. It appeared to elicit reflexive and involuntary saccades whereas transient color change did not (Irwin et al., 2000). This is consistent with the hypothesis that two parallel pathways are involved in saccade generation: the subcortical pathway, i.e. superior colliculus that is responsible for generating reflexive, orienting saccades, and the cortical pathway, i.e. frontal eye field that is responsible for generating voluntary, goal directed saccades (Schall, 1995). Neurons in the superior colliculus appear not to discriminate color in primate studies (Marrocco & Li, 1977); therefore color distractors should be incapable of eliciting involuntary, reflexive saccades.

However, some studies suggest that capture of attention is dependent, not solely on singleton, but on the relationship between both stimulus properties and task demands. In most visual search studies of salient target, feature singletons were themselves the target of search, inducing a top-down activation of attentional readiness for them (Gibson & Kelsey, 1998; Patel & Sathian, 2000). Hence, salience does not necessarily instantiate complete dependence on bottom-up processes. Other evidences have demonstrated that knowledge of the specific task demands may guide attention to only those locations that match the target relevant feature. For example, Kaptein, Theeuwes & van der Heijden (1995) showed in their study that the participants could restrict search for a colour-orientation conjunction target to a colour-defined subset. Thus, when searching for a red vertical line segment between red tilted and green vertical line segments, participants searched serially among the red items while completely ignoring the green line segments. To conclude, salient target does not necessarily appear to reflect automatic, or strongly involuntary, attentional capture. An effective visual search does not occur on the basis of bottom-up factors alone, but it is also affected by the cognitive strategy of the observer (Patel & Sathian, 2000).

2.4.3 Neural studies in visual search

Numerous neural studies in the visual search literature have tried to characterize the neural basis and the relationship between the bottom-up and top-down processings in humans. Using fMRI, the activities in the parieto-occipital junction, superior parietal cortex and other areas of extrastriate visual cortex during a color/shape popout task were demonstrated, while conjunction search activated the same areas as well as the frontal eye fields (Miyauchi *et al.*, 1996). Another functional imaging technique is PET that measures the change in regional cerebral blood flow (rCBF). It was proposed that localized brain regions would be affected by manipulations of the balance between bottom-up and top-down activation during visual search. Corbetta & colleagues (1995) conducted a PET study on feature conjunction search and found that activation of a region of superior parietal cortex (in the dorsal stream) implicated in spatially shifting attention. It supported the notion that serial attentional shifts are involved in conjunction search. Another recent study conducted by Patel & Sathian (2002) has found that visual search does not necessarily depend on processing by the magnocellular visual sub-system and in fact, the neural processes underlying visual search are distributed over an extensive network of brain regions, with varying roles for different parts of the network as the dynamics of top-down and bottom-up influences shift. The conjunction of bottom-up processing with top-down attentional suppression of an irrelevant singleton could account for activity found in right primary visual cortex (V1). The conjunction of bottom-up processing with top-down attentional set could explain activity noted in the right superior temporal gyrus/insular cortex. The left lateral cerebellum appears to play a role in attention, either in signaling popout or in switching attention repeatedly between multiple visual attributes. Loci in left parietal cortex are implicated in attention-demanding search for a target shape. It was concluded that visual search is extremely flexible and subject to considerable specificity of top-down control, but such specificity is clearly not absolute.

To summarize, both behavioral and neural studies forward a notion that effective visual search relies on dynamic shift between top-down and bottom-up factors, however, impaired controlled attention and working memory commonly found in people with MH might impede the top-down processing and affect the visual search performance. Therefore this study focused on the role of different visual search strategies to enhance bottom-up processing and thus visual search performance using *behavioral research methodology*. It provided a theoretical foundation and research prototype for future neural studies in evaluating the visual search performance in people with MH.

2.5 Enhancing visual search efficacy for people with mild MH

Although it was difficult to differentiate top-down and bottom-up factors in human visual search, in the context of the guided visual search method, it was assumed that knowledge of target feature (i.e. top-down activation) and various saliency effects (i.e. bottom-up activation) could facilitate the pre-attentive stage and guide the attention to the target in the visual array which is relevant to the search goal. It appeared that when both factors highlight the same element in the array, visual search will be efficient. The question remained was whether people with MH could also demonstrate the efficacy in preattentive and attentive-processing search manner. However, the development of the literature on visual search processes in individuals with mild MH has been inadequate. Obviously, it was difficult for people with MH to exert voluntary control in a complex visual array because of impaired executive function and the lack of long-term cognitive strategies. Therefore, visual strategies that could increase bottom up activation would be one of the critical factors to enhance effective visual search.

Little has done in previous studies to address the visual search behavior and the searching strategies in people with MH. In the past decades, several researchers have attempted to compare the visual search in unidimensional arrays such as color, form, size and line orientation among people with and without MH (Carlin *et al.*, 1995). Their results showed group by set size interactions for the dimension of form and size, indicating intelligence-related differences in search efficacy for these dimensions. However, there was no difference in efficacy of search between the two groups for the dimensions of color and line orientation. It was found that at times, individuals with MH performed serial searching for target stimuli in which people with normal intelligence identified the target rapidly and independently of the number of objects in the array (i.e., parallel search). Carlin & colleagues (2002) further studied whether people with MH could benefit from guided visual search. They conducted the initial assessments of visual search efficacy to identify pairs of feature for the form and size dimensions for which the participants demonstrated serial search. Subsequently, color was added as defining feature that could guide search to a subset of the elements in the visual array. Their result showed that all the participants with MH were able to limit attention to the task-relevant items on the guided search task, thus greatly reducing overall target identification time. This supported the idea that people with MH could demonstrate sophisticated visual selection attention skills when the visual arrays are structured appropriately. Therefore, the application of the general methodological framework to further study visual search behavior can provide theoretical importance for understanding the visual search performance in MH and, thus adding relevance for the design of effective training procedures.

2.6 Definition of Computer Assisted Instruction (CAI)

Burke (1982) defined computer-assisted instruction (CAI) as a method of learning in which a computer is the primary delivery system which allows direct and interactive instruction to the learners. Gagne, Wagner & Rojas (1981) differentiated three types of CAI. The most common one is drill and practice, whereby the computer responds to the question or problem, and if participant answers incorrectly, the computer repeats question until the right answer is arrived, and immediate and responsive feedback is rewarded afterwards. The second type of application is simulation; participants are given feedback that helps them decide on an acceptable answer through drill and practice in a life-like or fantasy situation. Tutorial, the third type, provides step by step presentation of new information through the various stages of learning: presenting a concept to be learned, prompting for answers to questions, and offering feedback on responses.

While research shows that people with MH usually benefit from one-to-one tutoring rather than group instruction; it is apparently not effective for teacher to work individually in school medium. One possible solution would be, to develop CAI as a teaching aid that simulates potential learning environment and serves for individualized instructional purpose. However, Conners & Caruso (1986) highlighted that CAI for people with MH should not be a stand-alone activity. Findings overwhelmingly support the role of teacher in both practical (loading disks, accessing programs and in some cases interpreting program instruction) and pedagogical (interpreting program behavior and output) points of view (Nicol & Anderson, 2000). Therefore, it has almost always been evaluated as a supplement to, rather than a replacement of conventional classroom instruction.

2.7 Effectiveness of CAI

2.7.1 CAI in mainstream education

With the advance of computer technology, it continues to improve in size, speed, cost, and durability, and these trends are likely to continue. In the past few years, there has been increasing emphasis placed on CAI that has been widely used in a range of educational and industrial sectors (Chandler, 1995). The meta-analysis reported by Flinn & Gravatt (1995) provided solid evidence on the effectiveness of CAI in mainstream education and the overall positive effect size demonstrated that CAI could be even more effective than traditional instruction. An extensive amount of research has compared CAI with various pedagogical methods. Usually, researchers compared the performance of learners with and without computers, using a "traditional instruction" comparison group (Fitzgerald & Koury, 1996). In some studies, CAI teaching was found to be at least as effective as conventional instruction. However, the number of subjects in most studies tended to be small and often there were no control groups (Nicol & Anderson, 1997; Nicol & Anderson, 2000).

2.7.2 CAI in Special Education

There has been growing literature on the training of people with MH using CAI nowadays. Empirical findings showed that there was a relatively greater amount and diversity in the use of computer technology with people who have mild to moderate MH than those who with more severe MH (Lacono & Miller, 1989). Generally, CAI for people with MH has been developed in two main areas: the basic skill areas of reading (Baumgart, 1987; Lin *et al.*, 1991; Wise & Olson, 1994; Woodward & Carnine, 1988), written expression & language (Brewer *et al.*, 1990; Brewer & White, 1994) and mathematics (Dunlap & Dunlap, 1989; Lin *et al.*, 1994; Nicol & Anderson, 2000; Podell *et al.*, 1992), as well as in the content areas of social and community living skill training such as budgeting, money handling and purchasing skills (Browder *et al.*, 1988; Haring *et al.*, 1995; McDonnell *et al.*, 1984;

Nicol & Anderson, 1997; Wissick *et al.*, 1992). Podell, Tournaki-Rein and Lin (1992) found that CAI was more effective in promoting automatization of mathematics skills when compared to paper-and-pencil practices in people with MH. Nicol and Anderson (2000) also showed improved numeracy scores in CAI and teacher-directed teaching groups when compared to control group after three months training on numeracy in people with learning disabilities. Dube, Monitz and Gomes (1995) conducted discrimination training by comparing computer- and teacher delivered prompts in people with MH. Results suggested that the both types of instruction were effective with some subjects, and neither was effective with all subjects. Therefore, most of the studies pictured a positive evidence for the effectiveness, particularly on immediate transfer tasks, but the effects on retention are still questionable (Conners *et al.*, 1986).

2.8 Theoretical Framework for CAI

Previous research studies from visual search and cognitive psychology have provided important practical implications for the instructional design and learning condition that may impact the outcome in CAI studies, in which the strategies to enhancing top-down and bottom-up activations were focused. The design of CAI was based on the Stages of Learning Model as initially described by Gagne (1981), where the three main stages of learning can be further segmented into nine-step instructional events which are correlated to the mental conditions for learning (Fig. 2.7). At the acquisition stage, the instructional overlay focuses on the knowledge of basic skills and facts through tutorial and procedural simulation. After a learner has achieved acquisition, in the fluency stage of drill and practice, mastering a procedure often require automatization that reduces conscious cognitive processing requirements during the tasks and ensures sufficient speed of performance. This is mainly achieved through repetition of practice. In the final stage of generalization, it focuses on the skill transfer from simulated situation to real performance; the instructional overlay is used with high fidelity to provide more similar environment to reality. The nine levels of instructions are introduced as follows.

Level 1: Gaining attention

Gaining attention is critical for any task engagement in the initial stage of learning. Distraction is a common problem which affects the ability to focus on the desired target among people with mild MH. Some researchers reported that cluttered interfaces and animation in remediation software might cause distraction to people with learning disabilities (Larsen, 1995). With proper design of CAI program, it provides a cognitively guided and physically integrated form of instruction. The use of various visual strategies to attract and maintain attention i.e. guided cue to the critical elements in the arrays can be incorporated in design of CAI, but the empirical evidence was relatively limited.

Level 2: Informing learning objectives

Introducing learning objectives in each session can provide internal process of expectancy and help motivate to complete the session. The learning objectives are presented in the form of “Upon completing the session, you will be able to … …”

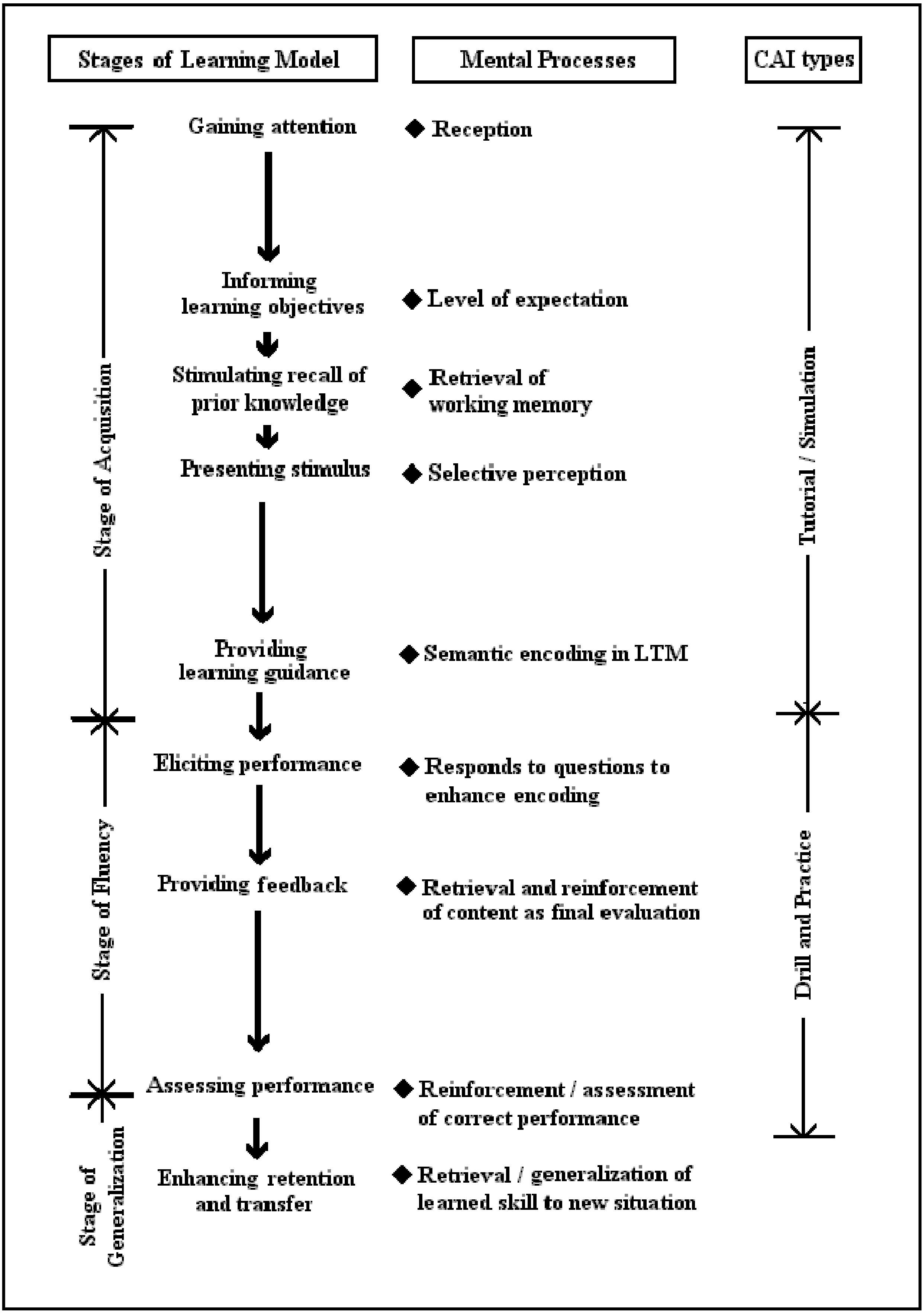


Figure 2.7

The instructional events and the associated mental processes incorporated in CAI

Level 3: Stimulating recall of prior knowledge

In this event of instruction, new information is associated with prior knowledge that facilitates encoding learning process in long term memory when there are links to personal experience and knowledge. This is mainly achieved by stimulating recall about previous training modules and the learned concepts.

Level 4: Presenting stimulus

This instructional event focuses on the information that enters the short-term memory and is coded for long-term storage. However, some studies have suggested that people with MH showed shorter memory span than normal individuals with chronological age and mental age (Marcell *et al.*, 1988, 1995). The impaired memory processes have been found to affect higher-level cognitive functions including long-term learning (Numminen *et al.*, 2000).

In view of the limited working memory which is commonly found in people with MH, current cognitive and instructional theories have provided a general foundation to support the remediation strategies via CAI. With the use of appropriate visual search guided strategies, the target in the visual arrays is highlighted so that the loading on the visual working memory is minimized, thus potentially enhancing retention and recall. Moreover, the empirical results suggest that the possible factors of game format and creation of fantasy contexts in simulation program had a more positive attitude and provided motivation for continued practice (Nicol & Anderson, 1997, 2000).

Level 5: Providing learning guidance

To help learners encode information in long-term memory, additional guidance would be provided along with the presentation of new content. Guidance strategies include the graphical representations.

Level 6: Eliciting performance

In this event of instruction, the learner is required to practice the skill or behavior. At the Stage of Fluency, drill and practice is vital to attain accuracy within a time frame. Automatic processing was defined as a rapid, accurate type of processing that requires minimal awareness and attention (Shitffrin & Schneider, 1977). In general term, it allows information to be processed automatically, with little or no conscious effort. This could reduce the mental load on working memory and permit the execution of higher-order processes and thus increased the performance (Podell *et al.*, 1992). Usually, automatization of basic skills is generally achieved through extended practice. In CAI, it could provide repetitive practice which in turn promoted the long-term retention and generally automatized the basic skills (Pellegrion & Goldman, 1987). On the other hand, researches on spaced practice suggested that short, spaced periods of practice were more effective than massed practice and promoted initial learning (Salisbury, 1990). A paced delivery that the program should be response controlled rather than time controlled, allowed learners to work at individualized pace (Nicol & Anderson, 2000).

Level 7: Providing feedback

During the drill and practice, immediate feedback is given contingent on the responses. According to Surber & Leeder (1988), “feedback” refers to an event that provides information about the correctness of the response and an event that increases the frequency of response. Surber & Anderson (1975) reported that information feedback primarily functioned to correct mistakes. The simplest type of feedback is knowledge of response feedback, in which “right” or “wrong” is stated. On the other hand, the motivational value of the feedback for correct responses is crucially important for people with MH, due to the beliefs about their low expectancy for success and motivation problem resulting from frequent failure experiences (Wong, 1980).

As described by Gage & Berliner (1998), motivation is defined as the forces that account for the arousal, selection, direction, and continuation of behavior. From the behavioral view of motivation, operant learning theory emphases the role of reinforcement in learning that has been widely applied to the development of CAI (Skinner, 1968). Based on the results of the above review, correct and incorrect responses should be indicated clearly; a response-by-response KR feedback (immediate reinforcement) is given to facilitate learning in drill and practice program. Further, reinforcement in the form of verbal praise is provided which has been found to be particularly useful in increasing task performance and sense of achievement for people with MH (Conners *et al.*, 1986).

Level 8: Assessing performance

Assessing performance and feedback mechanism are interlocking components at the Stage of Fluency. Upon completing teaching modules, the performance test will be administered to evaluate the level of competency and mastery of skills. In addition, continuous assessment i.e. onscreen scoring system is included with the program, in which the progress of the performance is monitored and the learners are often motivated to improve their scores.

Level 9: Enhancing retention and transfer

Generalization has been an especially difficult stage for people with MH (Gaylord-Ross & Holvoet, 1985). Learners have to select, organize and integrate the relevant information from long-term memory and apply in real-life situation. According to Alessi (1988), fidelity refers to how closely a simulation imitates reality. However, maximum fidelity does not necessarily provide the most effective instruction because it may in fact create overload on mental processes, which impedes learning and motivation. Research studies in computer simulation suggested that near transfer of learning for procedural knowledge could be enhanced by increasing fidelity of presentations progressively by levels to high fidelity at the end of the instruction (Clark & Voogel, 1985; Cronbach & Snow, 1977).

To conclude, based upon the instructional events and associated mental processes incorporated in CAI design, gaining visual attention through various visual search strategies is one of the critical aspects of CAI that are particularly important for people with MH. The ability to attend to complex display is the pre-acquisition of any fundamental skills in learning. Therefore in the Phase II of the study, it would mainly focus on the effect of these cueing strategies in CAI as cognitive anchor for the instruction.

CHAPTER III

METHODOLOGY

This chapter describes the methodology of the study. Phase I of the study includes the selection criteria; setting and apparatus; experimental stimuli; and experimental procedure. While phase II presented pilot test; selection criteria; setting and apparatus; CAI interface; data collection procedure; outcome measure and method of data analysis.

3.1 Phase I of the study

In phase I of the study, a series of experiments were conducted to investigate the efficacy of two cueing strategies on visual search behavior. The hypothesis was that the visual search efficacy (speed and accuracy) should be significantly different between two visual search strategies (i.e. guided motion and guided cue) when compared to no cueing condition (i.e. basic search).

3.1.1 Sampling

Twenty-two people with mild MH from local service agencies serving people with MH (experimental group) and another eighteen age-matched subjects with normal intelligence (control group) were recruited using the convenient sampling strategies. The inclusion criteria for the experimental group were:

(1) age 15 – 30;

(2) mild MH (IQ between 50 – 70);

(3) able to follow one-step instruction or above;

(4) no visual or hearing deficits reported by caregivers; and

(5) able to discriminate between circle and hexagon.

The exclusion criteria for the experimental group were:

(1) sensory-motor problems that affect computer operation;
(2) severe behavioral problems (e.g. self-harm or aggressive behaviors);
(3) failed in the screening test (see below).

All participants were provided with a set of trials for practice prior to the experiment. The practice would be ceased when their response rate reached 90% accuracy. This allowed the participants to familiarize the visual search tasks and to understand task demand reliably. Those who could not achieve 90% accuracy for 20 trials would be excluded from the study. Four people with MH failed the initial screening. Therefore, 36 participants including 18 with MH and 18 with normal intelligence finally participated in the experiment. This sample size could achieve 81% power as calculated based on PASS 2000 when F test was used to test the interaction effect at a 5% significance level (Hintze, 2006). Ethics approval was obtained prior to the study. The purpose of the study and procedures of the experiment were explained to the participants and parents/caregivers prior to their consent (Appendix I) to join the study.

3.1.2 Setting and apparatus

A series of experiments was conducted on an IBM ThinkPad® T series computer running Windows XP (Chinese Version). Participants were seated approximately 70 cm from the 14 inches computer screen at eye level, with head rested on a chin rest device and the mouse placed within arm’s reach. The chin rest device (Figure 3.1) was used to strictly control the viewing distance and minimize the potential distraction from the environment.

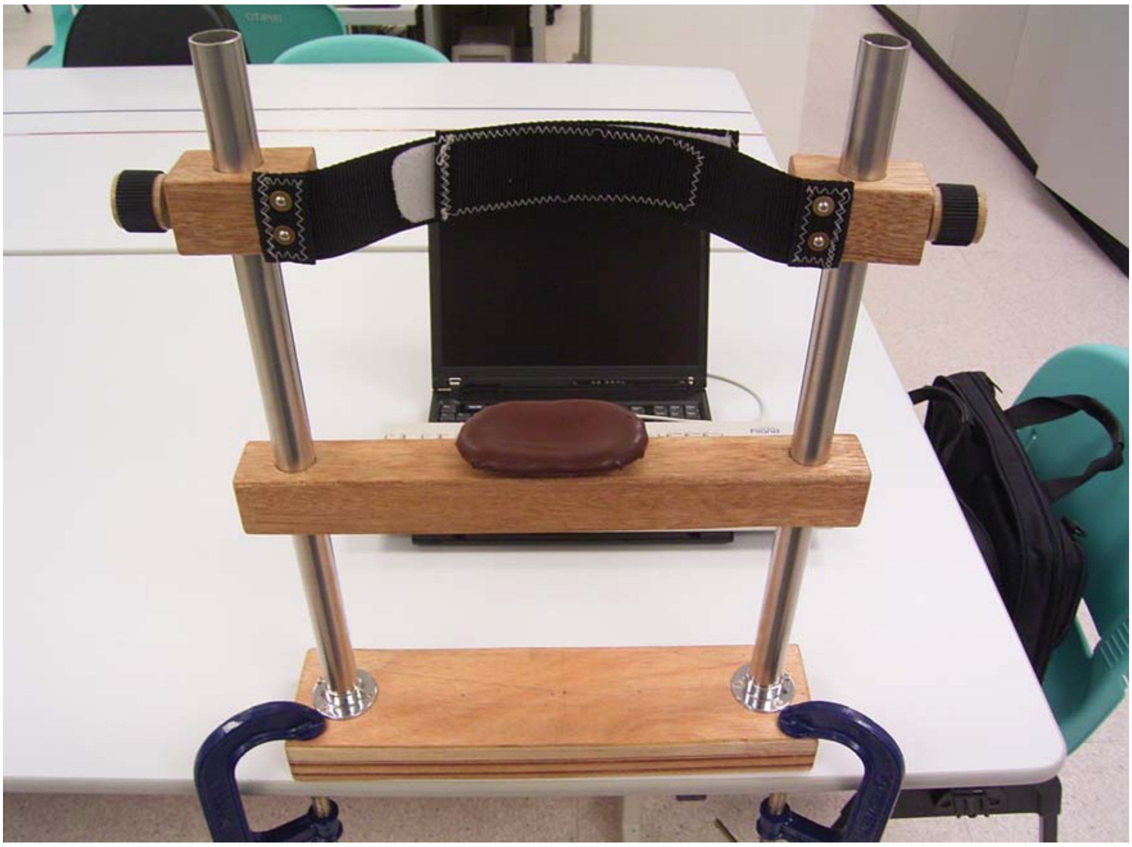


Figure 3.1
The chin rest device was used to strictly control the viewing distance.

3.1.3 Experimental stimuli

Each trial was started with a one second presentation of a 5 mm x 5 mm fixation cross placed at the center of the screen before the stimulus pattern was switched on. Visual array was presented at the center of the computer screen with a dark background. The array was comprised of an imaginary 10 x 8 grid with the lines and borders of the grid not appearing on the screen (Figure 3.2). Stimuli were placed in each cell of the grid such that they were aligned both horizontally and vertically. The gap between the stimuli in adjacent cells of the grid was approximately 5mm. Prior to each experimental trial, the participant was introduced to a pre-defined stimulus (i.e. hexagon) for the search task and required to identify the target along "form" dimension. The relatively high target-distraction similarity stimuli were used for the feature based search where the pre-defined target was a hexagon (side = 1cm) embedded in the subset of circle (radius = 1.2cm). The set of stimuli was randomly assigned to each cell. The entire predefined targets would be randomly assigned and spaced equally in each trial. In basic visual search task, given a predefined search goal (e.g. "find a hexagon"), participants were to focus on a goal-related subset of items and limit attention to distractor items (Figure 3.3a).

For the guided visual search task, the predefined target was made salient either by guided motion, i.e. the item appeared abruptly which flashed at the rate of 5Hz (Figure 3.3b), or by guided cue, i.e. the item was surrounded by a ring with 1.6cm diameter (Figure 3.3c). These exogenous cues were located close to the target and presented at the 100ms after the stimulus onset. Previous research showed that when the delay between cue and target onset was 100ms, the cueing effect on RT was the strongest in most cases; whereas if the delay was increased to 200ms, cue

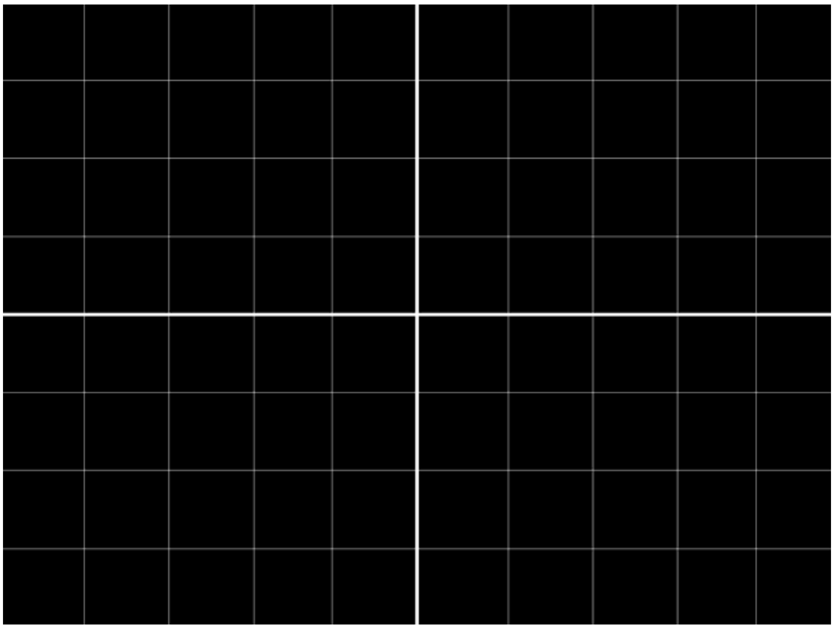


Figure 3.2

Visual array was comprised of an imaginary 10 x 8 grid with the lines and borders of the grid not appearing on the screen

Figure 3.3a

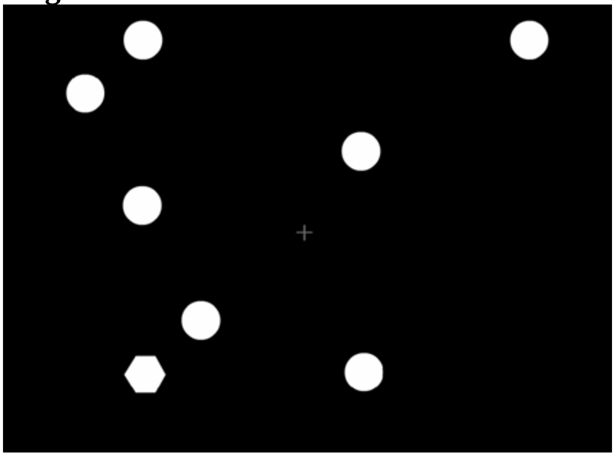
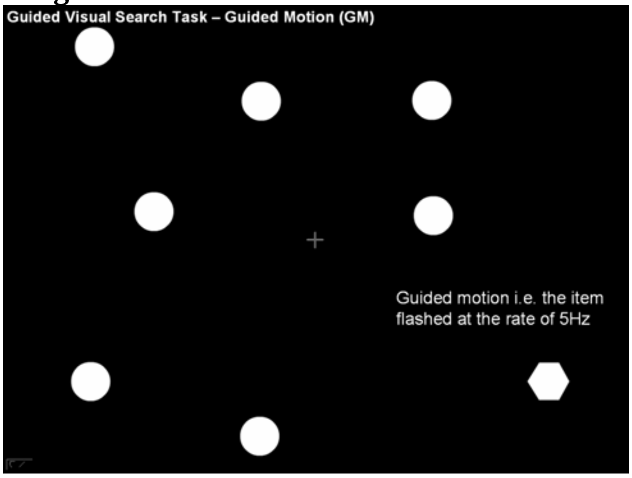


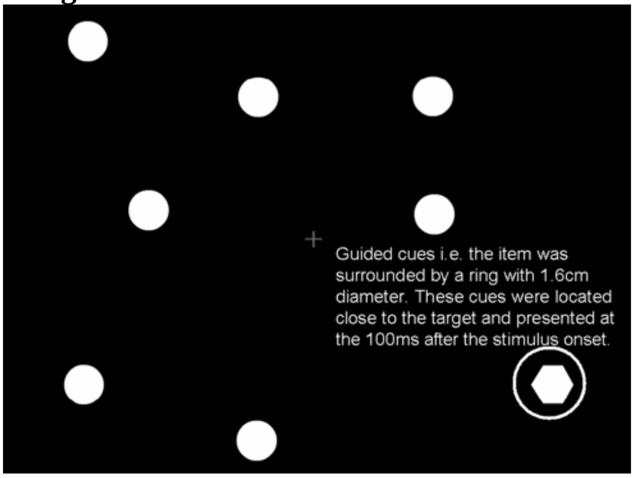
Figure 3.3b



Guided Visual Search Task – Guided Motion (GM)

Guided motion i.e. the item flashed at the rate of 5Hz

Figure 3.3c



Guided cues i.e. the item was surrounded by a ring with 1.6cm diameter. These cues were located close to the target and presented at the 100ms after the stimulus onset.

Figure 3.3
Three visual search tasks: Basic visual search task (Figure 3.3a), guided visual search task – motion contrast (Figure 3.3b) and guided visual search task – additional cues (Figure 3.3c)

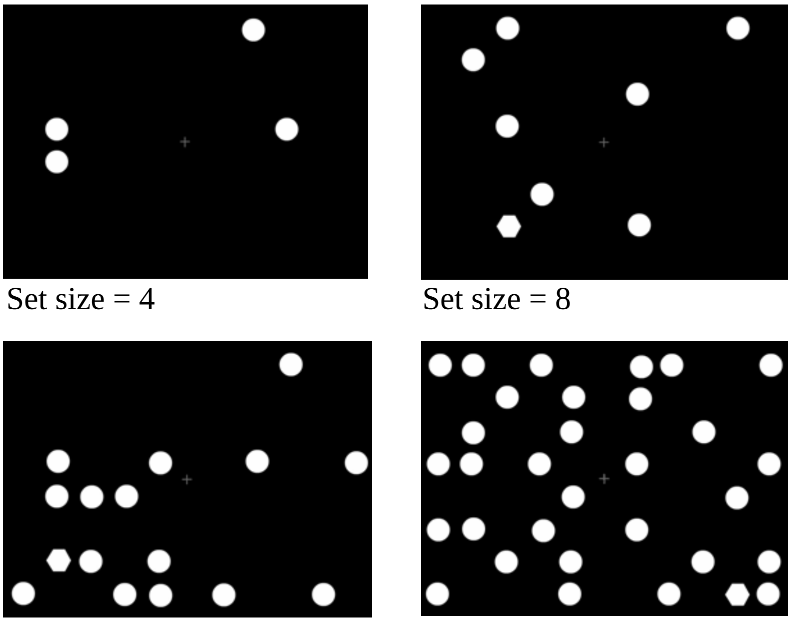
effectiveness attenuated eventually (Muller & Findlay, 1988; Muller & Rabbit, 1989; Shepard & Muller, 1989; Weichselgartner & Sperling, 1987). Both the accuracy and speed were emphasized. Thus, if the salient elements were to guide the selection and identification processes of the visual system, by which the target was then recognized, the time taken for target detection would be shorter.

3.1.4 Experimental procedure

The experiments for the experimental group were conducted in a computer laboratory, while the control group performed the field test at their study or home settings for convenience. To minimize the variation of environmental difference and allow the participants to focus on the stimuli given at the computer monitor, quiet environments were arranged with flat walls and dim light in both laboratory or field tests. Also, a standardized procedure (Appendix II) for conducting visual search experiments was employed to ensure consistent administration of experimental trials. The assessor sat at the right side of the participant and initiated the trials by pressing the control key when the participant was ready to proceed. This arrangement was designed to minimize the physical and eye contact between the assessor and the participants during testing. The software program automatically measured the accuracy and reaction time (from stimulus onset to the participant's response in millisecond) in each visual-search task and the assessor would record the results on the response data sheet manually (Appendix III). The RT was used for the primary dependent variable if the response was correct in target-present trials, whereas the response error rate would be recorded to show some unexpected events which might influence the decision processes and in turn affect response latencies.

A total of 240 trials (4 set sizes x 3 testing conditions x 20 trials) was completed in a single testing session for 30 to 60 minutes. Participants were asked to complete two consecutive blocks of 120 trials for three testing conditions, i.e. basic visual-search task and guided visual-search tasks using motion contrast or additional cues. Twenty trials of set size (i.e. 4, 8, 16 and 32) in each testing condition were included in each block of assessment. There was a five-minute short break between each block in consideration of physical and mental fatigue. Figure 3.4 showed the stimulus patterns in various set size. Previous studies (Carlin *et al*., 2002; Carlin *et al*., 1995) have indicated the majority of individuals with MH were unable to adhere to task demands involving binary decision (i.e. “target present” or “target absent”). Therefore, in this study, the task was modified such that the participants only needed to press on the button if the target was present in the given stimulus array and the other if it was absent. If the target was not present on a given trial, the display was automatically removed after a 3-s interval.

Each participant was assigned to one of three testing orders of stimulus dimension in quasi-randomization by the computer prior to each block. The RT was calculated based on the performances across the 20 trials in each of the 12 conditions formed by a factorial combination of three stimulus dimensions and set size (4, 8, 16 and 32). It was assumed that the visual search time would be much shorter for the guided search tasks than that of the basic search task, and searching time in guided search tasks would be independent of set size.



Set size = 4

Set size = 8

Set size = 16

Set size = 32

Figure 3.4
Stimulus patterns in various set size (4, 8, 16 and 32)

3.1.5 Data analysis

A boxplot is used to provide the variation information in data sets, particular for detecting the outlier and extreme cases. Any data observation which lies more than 1.5 * interquartile range (IQR) lower than the first quartile or 1.5 * IQR higher than the third quartile is considered as outlier which would be deleted from the data analysis (Tukey & Iglewicz, 1989). Descriptive analysis was conducted for patient demographic data (i.e. sex, gender, chronological age, education level and occupations). Chi-square tests on categorical data would be used to compare the baseline differences between groups. Response error rate was calculated in each search task.

Two separate two-way analysis of variance (ANOVA) were conducted to compare the RT among three search tasks in each group. Therefore, the alpha level was adjusted that the result was interpreted somehow conservatively with an appropriate statistical correction i.e. $\alpha = 0.01$. A RT x set-size slope was plotted to examine the relative visual search behaviours i.e. serial search or parallel search among the three different search tasks. Furthermore, two-way ANOVA was conducted to compare RT between the two groups in each visual search task. Again, a RT x set-size slope was plotted to compare the relative visual search behaviours i.e. serial search or parallel search between the two groups.

3.2 Phase II of the study

Based on the results in Phase I of the study and pilot test, an innovative CAI program for typing was developed, which was culturally appropriate and specific to people with MH. The effect of visual search strategies incorporated in CAI on the typing performance was examined. The hypothesis was that the typing efficacy in terms of speed and accuracy would be significantly different between visual cueing (i.e. guided motion) and no cueing conditions in CAI.

3.2.1 Pilot test

A pilot test for phase II of the study was conducted in order to identify the logistic feasibility of the procedures, to test the prototype of CAI typing program and provide estimation about variances needed for sample size analysis in later full-scale study. Convenient sampling was adopted and 6 participants were recruited. The preliminary draft of CAI typing program was examined on the visual search efficacy and accuracy in three searching conditions, i.e. basic search and guided searches with additional cue or motion contrast. The result of the pilot study further substantiated the use of appropriate visual search strategies that would be incorporated in full-featured CAI typing program in the main study.

3.2.2 Selection criteria

Based on the result of the pilot test, phase II of the study targeted recruitment of a total of 40 patients. Criteria for inclusion were:

(1) age 15 – 30;

(2) with mild MH (IQ between 50 – 70);

(3) able to follow one-step instruction or above;

(4) with no visual or hearing deficits reported by caregivers; and

(5) able to identify the 26 alphabets in upper and lower cases.

The exclusion criteria included:

(1) those presented with sensory-motor problems that affect the computer operation

(2) those presented with behavioral problems (e.g. self-harm or aggressive behaviors)

(2) those with comorbid autism and psychiatric diagnoses. They were excluded from the study in an attempt to minimize confounding of data.

3.2.3 Research design

A two group (i.e. Group I and Group II) repeated measure experimental design was employed in this study. The purpose of the study and procedures of the experiment were explained to the participants and parents/caregivers prior to their consent to join the study. After collection of the informed written consents (Appendix IV), participants were randomly allocated to either Group I i.e. *CAI typing without cue* or Group II i.e. *CAI typing with visual cue*. Randomized block was adopted to keep the numbers of participants in each group similar and minimize the potential differences of participants' characteristics at post-tests during the study. If group sizes vary a lot, statistical power diminishes. The random sequences of allocation were generated by means of dice rolling. A block of sequence was constructed and the sizes of block correspond to a multiple of the number of groups in this study (Appendix II).

As reported in phase I and pilot study, motion contrast was used as cueing strategies. The training program was conducted in the computer laboratory of The Hong Kong Polytechnic University (PolyU). Three 90-minute sessions were conducted in consecutive weeks and led by researcher to provide support of computer use (e.g. loading disks, accessing programs and in some cases interpreting program instruction). According to Nicol & Anderson (1997), four participants to be assigned in each group might apply this to be a satisfactory arrangement. The researcher verified participants with all selection criteria in the first session and subsequently, collected demographic data and baseline values of the outcome measures (Pretest). The CAI program focused on English typing rather than Chinese character because it is believed that English typing is a prerequisite in basic typing skill prior to typing in Chinese and mastering proficiency. Moreover, people with mild MH should be familiar with the English alphabets which were taught in school curriculum. Letter drill practice was provided in the first training session whereas word and sentence drill were focused in the second session. In the last session, participants were required to type a long paragraph. Ten minutes break was given at 30-minute interval. In consideration of potential mental and physical fatigue after prolonged computer usage, post test assessment (Post-test-1) was conducted within one week after the training program was completed. All the participants were reassessed after 4 weeks (Post-test-2) to examine the potential fading effect of the acquired typing skill after the training program. Individual interview on the program content and satisfaction would be conducted in the last session of the training program.

3.2.4 Setting and apparatus

The training program was conducted in the computer laboratory of Department of Rehabilitation Sciences of PolyU. Four IBM T-series computers running Windows XP (Chinese Version) were prepared. Marcomedia Flash Player 5 was installed to present the CAI typing program.

3.2.5 CAI interface

The typing program was written using Multimedia software application – Macromedia Flash 5.0, which offers great interactivity and provides integrated multimedia elements. It also supports web page presentation, making the teaching materials accessible to users through internet. Based on Stage of Learning Model described by Gagne (1985), some of the instructional principles were adopted in designing the CAI typing program. The program was designed to provide drill and practice and simulation through high fidelity of the instructional overlay that was closely similar to real environment.

The layout of the program was shown in Figure 3.5. It consisted of a Standard English QWERTY keyboard and a 15cm x 25cm display monitor. The background of the display monitor was in dark blue and the text was in white. Light letters on a dark background could make the text more easily to read. In the display monitor, the letter which was 22Hhz2that isisiicurrently being typed was highlighted by yellow color and moved along with the sequence of the text. The font text "Courier New" was used to have clear differentiation between upper and lower cases of "i" (`I` and `i`) and "l" (`L` and `l`). The keyboard was displayed at the bottom of the layout which composed of 12 function keys, 16 numeric keypads, 4 cursor control keys, 2 enter keys, 60 typewriter keys and others (i.e. Print, Scroll Lock, Pause, Insert, Delete, Home, End, Page Up and Page Down).

Participants were instructed to type the key which was highlighted in sequence; no correction could be made. The program consisted of two search modes and 4 training modules. In guided search mode, the key to be typed flashed at a rate of 5Hz (Figure 3.6b) whereas in the basic search mode, no cue to the key (Figure 3.6a) would be given. There were four training modules includes 50 letters (Figure 3.7a), 50 words (Figure 3.7b), 30 sentences (Figure 3.7c) and 5 paragraphs (Figure 3.7d) drill (Appendix V). The concept was basically similar among these four modules but the type of training was increasingly demanding which allows grading of the training. All the alphabet keys and some relatively common punctuation keys (i.e. . , ’) would be practiced.

Figure 3.5
The layout of the CAI typing program

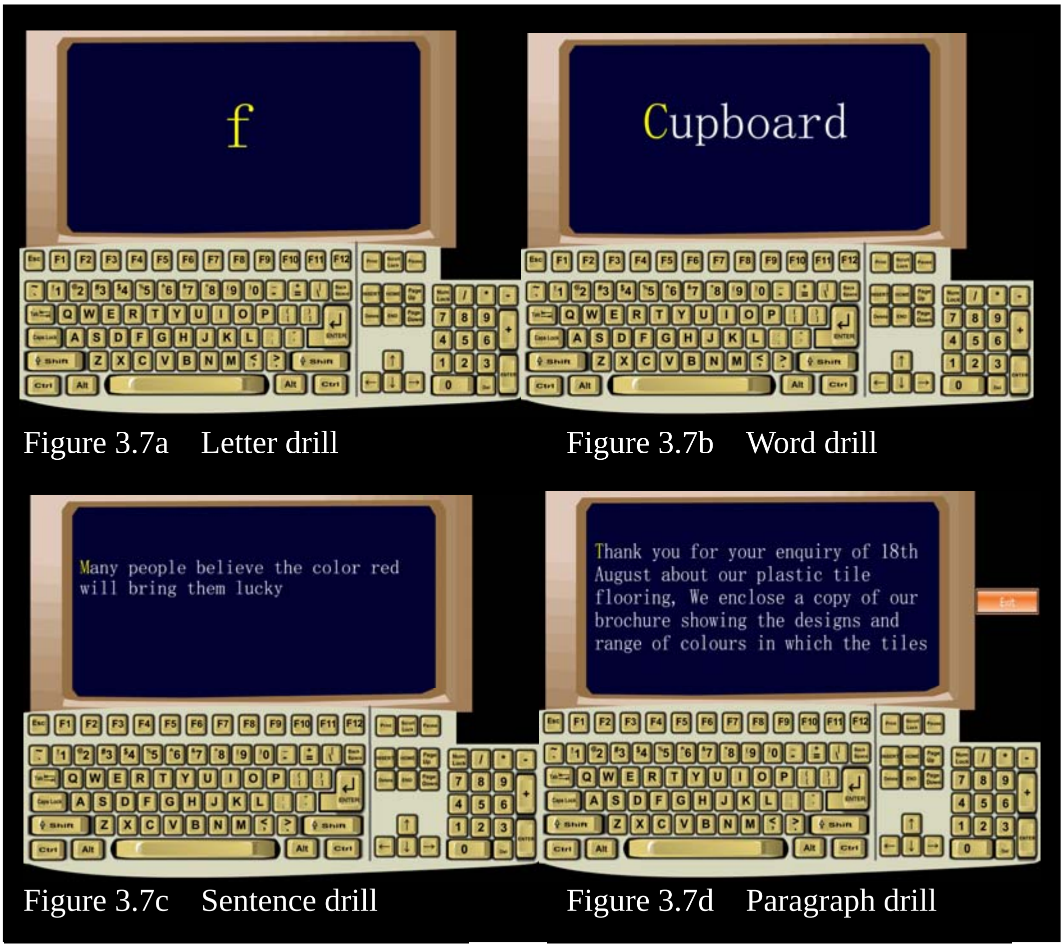
Face

Evening

Figure 3.6a Figure 3.6b

Figure 3.6

CAI typing program in basic search mode (Figure 3.6a) and guided search mode (Figure 3.6b)



f

Cupboard

Many people believe the color red will bring them lucky

Thank you for your enquiry of 18th August about our plastic tile flooring, We enclose a copy of our brochure showing the designs and range of colours in which the tiles

Figure 3.7a Letter drill

Figure 3.7b Word drill

Figure 3.7c Sentence drill

Figure 3.7d Paragraph drill

Figure 3.7

Four training modules: Letter drill (Figure 3.7a), word dill (Figure 3.7b), sentence drill (Figure 3.7c), paragraph drill (Figure 3.7d)

3.2.6 Outcome measure

Although there were no standardized tests in assessing typing performance, especially for people with MH, typing speed and accuracy were considered as the basic and valid outcome measures commonly used in commercial typing programs and research studies on typing (Majaranta *et al.*, 2006; Salthouse, 1984). Therefore, in this study an unseen paragraph which constituted >90% alphabet keys was administered. The assessment would last 10 minutes. The main outcome parameters – typing speed and accuracy were recorded through the CAI program to provide accurate and reliable data measurements. Word per minute (WPM) is commonly used to measure typing speed. Word was standardized to five keystrokes including spaces e.g. 50 keystrokes per minute means a typing rate of 10 wpm. The other outcome measure accuracy was used which measured the percentage of corrected key strokes (i.e. number of correct keystrokes over the total number of keystrokes). If wrong key was pressed, the program would give a signal sound to provide an immediate feedback. A final score indicating the accuracy was shown at the end of each training module. Positive reinforcement included refreshment and verbal praise was given to enhance their learning motivation and participation in training.

3.2.7 Data analysis

Demographic data of the participants were compared between control and experimental groups using Chi square test and t-test according to the sex, chronological age, education, occupation and computering experience. Baseline comparisons on the two outcome parameters (i.e. WPM and accuracy) between the two groups were performed using independent t-test.

To test the significance of the difference in the outcome measures between and within the Group I and Group II, two-way repeated measure of multivariate analysis of variance (Two-way repeated measure MANOVA) was used in the data analysis that controls the experiment-wide error rate and differentiates a set of dependent variables most sensitive to detect the change. The group (i.e. Group I and Group II) and time (i.e. pretest, post-test-1 and post-test-2) serve as independent variables whereas the typing speed and accuracy act as dependent variables. One of the assumptions for the multivariate approach is the vectors of the dependent variables follow a multivariate normal distribution, and the variance-covariance matrices are equal across the cells formed by the between-subject effects. Box's test statistics would be performed to test the homogeneity of covariance across group. If significance level < 0.001, then there is significant difference in the covariance matrices, and the null hypothesis is rejected and the assumption is violated. However, F test is quite robust even when these are departure from this assumption. Sphericity assumption was tested by Bartlett's test of sphericity to examine whether the residual covariance matrix is significantly different from an identity matrix. If significance level < 0.05, then the null hypothesis was rejected and the dependent variables were correlated. This is to avoid the probability of Type I error inflation. Post-hoc multiple univariate F tests for each dependent variable would be conducted with modified Bonferroni adjustments to interpret the respective effect. It controls the Type I error rate while maintaining statistical power. The multivariate normal distributions were assumed since MANOVA is robust to modest violations of this assumption if df = 20 for equal sample size. Multivariate test was done with reference to Wilks' Lambda statistical test if the assumption of variance-covariance was not violated, otherwise Pillai's Trace test would be adopted which was relatively robust and not highly linked to assumptions about the normality of the distribution.

Regarding the missing data in follow-up assessment, there were several methods in clinical trials. According to Streiner & Geddes (2001), one of the methods is called the Growth Curve Analysis which calculates the trajectory of change over time based on whatever data are available. Another method is called Last observation carried forward (LOCF) which would be adopted in this phase II of the study. The advantages of this approach are that (a) it minimises the number of subjects who are eliminated from the analysis and (b) it allows the analysis to examine trends over time, rather than focusing simply on the endpoint. However it assumes that no improvement will occur outside of treatment and ignores the trajectory of the change prior to the final value. Yet it is an improvement over eliminating subjects from the analysis.

CHAPTER IV

RESULTS

This chapter presents the results of the studies. Phase I of the study reports the results of the visual search performance in people with MH and people with normal intelligence in three experimental trials. Phase II of the study gives the treatment effectiveness of the 3-week CAI typing program for people with MH.

4.1 Phase I of the study

A 2 (Group: Control, Experimental) × 3 (Search Task: Basic search, guided cue, guided motion) × 4 (Set Size: 4, 8, 16, 32) mixed design was employed. The outlier, which is numerically distant from the rest of the data, can be identified using boxplot. Two data observations in experimental group were 1.5 * IQR higher than the third quartile as shown in the boxplot (Figure 4.1). Therefore they were eliminated from subsequent data analysis.

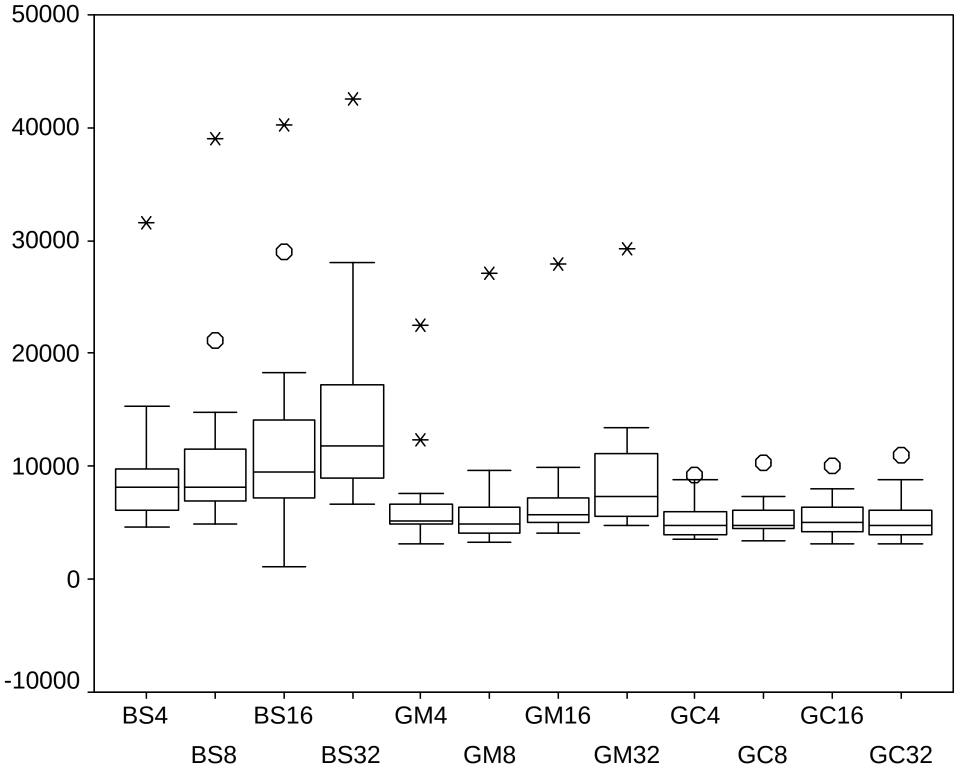


Figure 4.1
A boxplot of each dependent variable in the experimental group.

4.1.1 Demographic data

Descriptive statistics on the demographic characteristics of the 34 participants were reported. 16 (50%) were male and 18 (50%) were female. X^2 test revealed no significant difference in gender composition (x^2 = 0.44, df = 1, p > 0.05). The mean chronological age of participants in the control group and the experimental group was 22.6 years (SD = 2.6 years) and 20.7 years (SD = 2.7 years) respectively. The result of independent t-test showed insignificant difference in participants’ age between the two groups (t =1.498, df = 34, p > 0.05). The participants in control group were university students of the PolyU. All participants in the experimental group were diagnosed having mild grade MH based on the medical record provided by local service agencies serving people with MH. Among them, 11 (61.1%) were studying in secondary schools for the mentally handicapped, 4 (22.2%) from shelter workshop, and another 3 (16.6%) from the day activity centre.

4.1.2 Response error rate

The response error rate was only observed in the experimental group while no error was made in the control group (Table 4.1). Higher error rates of false negative (i.e. responded incorrectly in the target present condition) were noted when compared to the error rates of false positive (i.e. responded incorrectly in the target absent condition) among people with MH. No error was made at set size of 4 and 8 for all these search tasks; but when the set size increased, the overall error rates increased. Moreover, the overall error rate was higher in basic search task (10.4%) when compared with guided cue (2.7%) and guided motion (6.0%).

Search task	Set Size								Overall
	4		**8**		**16**		**32**		
	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	
Basic Search	0	0	0	0	1.6%	3.3%	0	5.5%	10.4%
Guided Cues	0	0	0	0	0	0	0	2.7%	2.7%
Guided Motion	0	0	0	0	0	0	2.2%	3.3%	6.0%
Overall	0%		0%		4.9%		13.7%		

Notation: (+) represents the error rate of false positive in the target absent condition
(-) represents the error rate of false negative in the target present condition

Table 4.1
Response error rate for target present and absent trials by set size in MH group_

4.1.3 Comparison of different visual search tasks

Two-way ANOVA for each group was conducted to evaluate the effectiveness of visual search strategies. The alpha level was reduced to 0.01 that prevented the possibility of increasing Type I error when multiple tests were performed (Carlin *et al*., 1995). The *RT x set size slope* was plotted to examine the relative visual search behaviors. The data analysis was conducted with SPSS for Windows 12.0 version (SPSS, 2003).

(A) Control group

Comparison of the results between the two groups (i.e. control group and experimental group) was made and shown in Figure 4.2a and b respectively. It was found that the performance was better for guided cue or guided motion task than that of basic search task for participants of both groups. There were significant differences in main effect of search tasks (F(2, 51) = 21.38, $\underline{p}$ <.0001) and main effect of set size (Pillai's Trace = 25.83, $\underline{p}$ < .0001) in the control group. However, no significant difference was shown in interaction effect between search task and set size (Pillai's Trace = 2.18, $\underline{p}$ = 0.051). It appeared that participants in the control group could demonstrate parallel search in all search tasks efficiently independent of the set size.

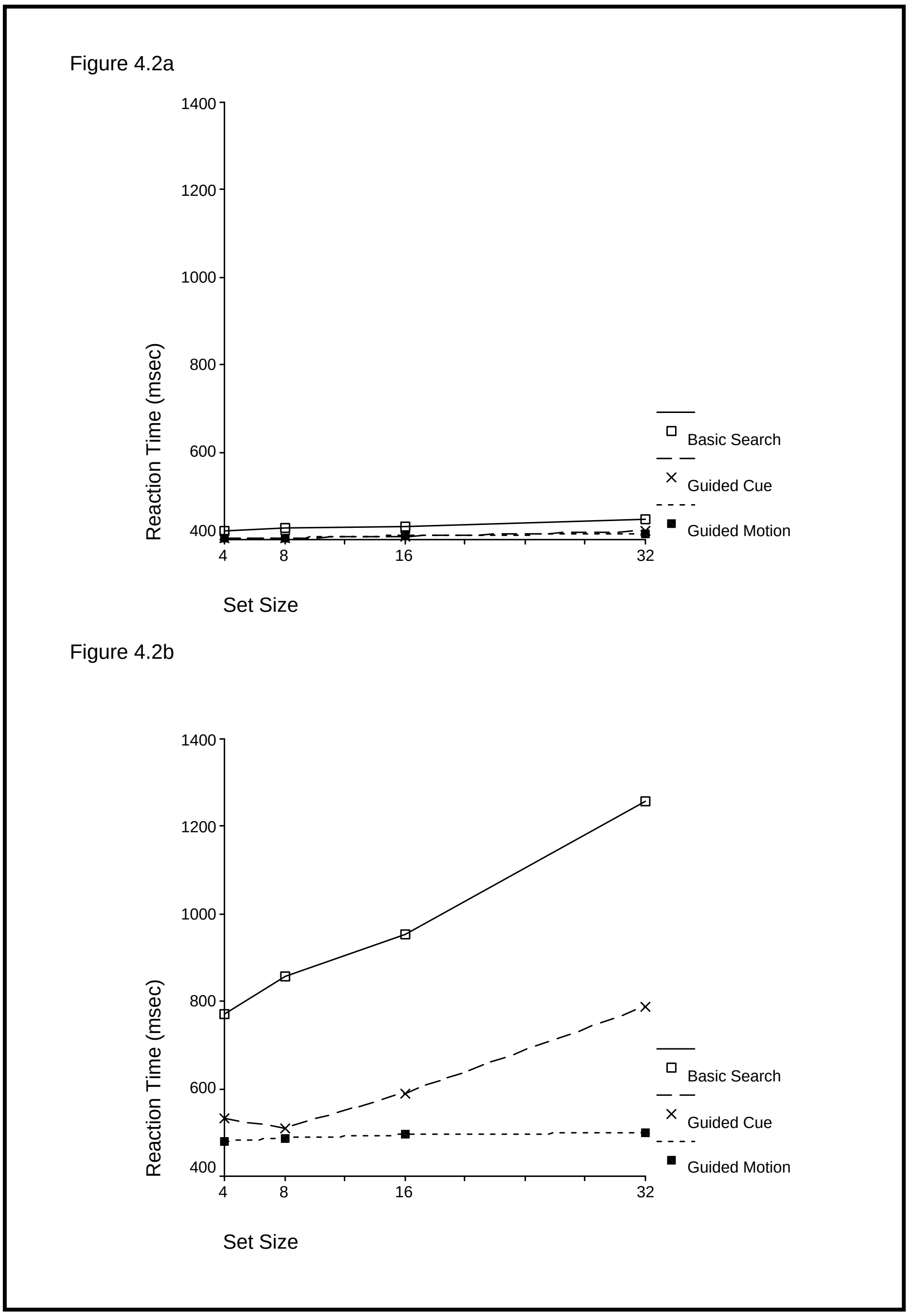


Figure 4.2
Mean RT for control group (Figure 4.2a) and experimental group (Figure 4.2b) by set size

(B) Experimental group

Similar to the control group, analysis in the experimental group also indicated significant main effect of search task (F(2, 45) = 21.89, p < 0.0001), and set size (Pillai’s Trace = 23.23, p < .0001). And the interaction between search task and set size was also found significant (Pillai’s Trace = 5.99, p < 0.0001). Post-hoc multiple comparison test (Tukey HSD) indicated significant differences in the RT between guided cue and basic search condition (p < 0.001), and between guided motion and basic search condition (p<0.001). However, no significant difference was found in the RT between guided cue and guided motion (p = 0.281).

4.1.4 Comparison between the two groups

Two-way ANOVAs for each search task was also conducted in order to compare the visual search efficacy between the control and experimental groups. Again, the results were interpreted somehow conservatively with the alpha level adjusted to 0.01. Moreover, the set size was plotted against the RT for the three different search tasks.

(A) Basic search task

With respect to the basic search task, the 2 (Group) × 4 (Set Size) ANOVA showed a significant main effect of group (F (1,32) = 55.55, p <0.0001), and also a significant set size effect (Pillai’s Trace = 19.84, p <0.0001). Figure 4.3a depicts the significant group × set size interaction (Pillai’s Trace = 17.59, p = <.0001. The mean RT for control and experimental groups was 431ms (SD = 19) and 677ms (SD = 331) respectively (Table 4.2a). The RT of the experimental group increased as the set size increased but that of control group was virtually unchanged. The *RT x set size slope*

Figure 4.3a

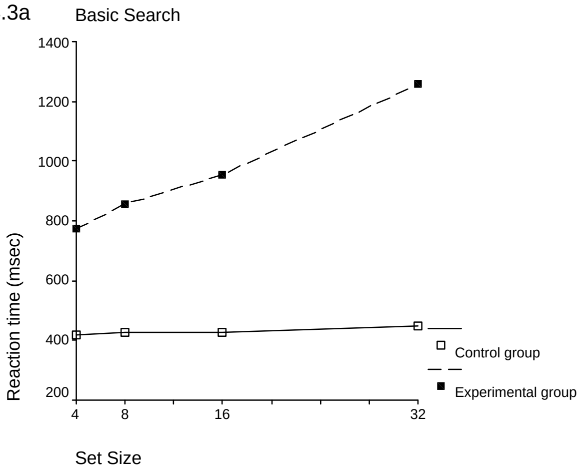


Figure 4.3b

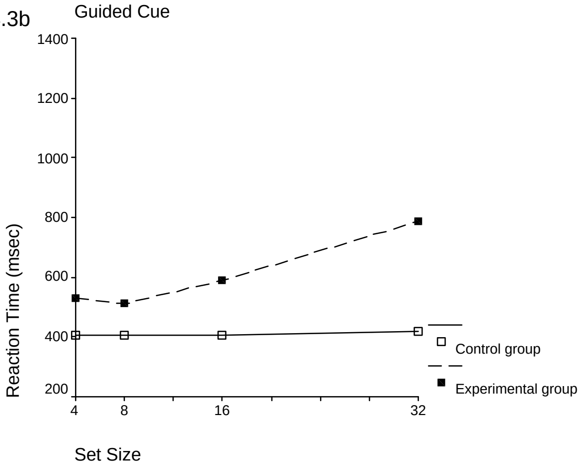


Figure 4.3c

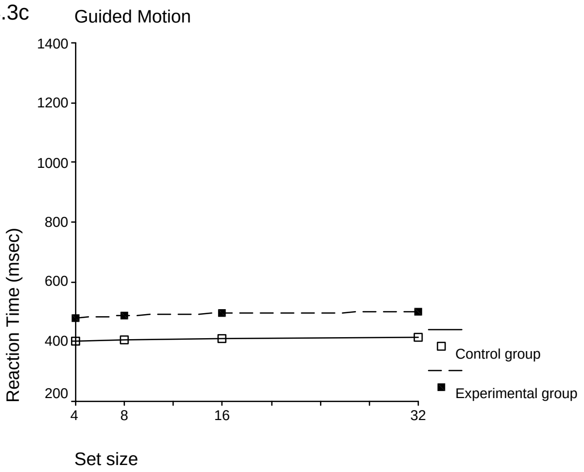


Figure 4.3

Mean RTs for the basic search task (Figure 4.3a), guided cue task (Figure 4.3b) and guided motion task (Figure 4.3c) by set size function for the control and experimental groups.

in control and experimental groups was 0.93 ms/item and 34.12 ms/item, which meant the participants in the experimental groups performed serial search for target stimuli.

(B) Guided cue search task

The mean RT for the guided cue search task for the control and experimental groups was 409 ms (SD = 9) and 605 ms (SD = 181) respectively (Table 4.2b). There was a significant main effect of group (F (1,32) = 25.16, $p < 0.0001$), and also a significant set size effect (Pillai's Trace = 21.08, $p < 0.0001$). The group x set size interaction was significant (Pillai's Trace = 17.36, $p < 0.0001$) as shown in Figure 4.3b. Although the overall RT of the experimental group was longer than that of the control group, the corresponding *RT x set size slope* was 0.42ms/item and 9.9 ms/item for the control and experimental groups respectively, which demonstrated the participants in both groups could perform parallel search of array.

(C) Guided motion search task

For the guided motion search task, the mean RT for the control and experimental groups was 407ms (SD = 17) and 490ms (SD = 123) respectively (Table 4.2c). Statistical analysis showed that the main group effect (F (1, 32) = 9.277, $p > .05$) and set size effect (Pillai's Trace = 0.518, $p= .518$) were not significant. The group × set size interaction was also insignificant (Pillai's Trace = 0.08, $p = 0.969$) as presented in Figure 4.3c. The *RT x set size slope* in control and experimental groups was 0.64 ms/item and 0.42 ms/item, respectively, showing that both groups could identify the target rapidly, independent of the number of the distractors in the array. It appeared that the visual search efficacy of the experimental group was comparable to that of people with normal intelligence if the target was made salient using guided motion strategies. Also, the superiority of guided motion over guided cue was demonstrated with a smaller RT x set size slope that implied better visual search performance. This provided significant implication on the incorporation of visual search strategies in CAI typing program design in phase II of the study.

Table 4.2

Mean and standard deviation of the RT in basic search task (Table 4.2a), guided cue task (Table 4.2b) and guided motion task (Table 4.2c) in control and experimental groups

Table 4.2a

Set size	Control (n=18)		Experimental (n=16)	
	Mean (ms)	SD	Mean (ms)	SD
4	420	17	772	208
8	427	19	856	271
16	429	19	954	429
32	448	19	1260	414
Overall Mean	431	19	677	331

Table 4.2b

Set size	Control (n=18)		Experimental (n=16)	
	Mean (ms)	SD	Mean (ms)	SD
4	405	9	531	119
8	404	9	511	162
16	407	9	590	146
32	419	9	787	296
Overall mean	409	9	605	181

Table 4.2c

Set size	Control (n=18)		Experimental (n=16)	
	Mean (ms)	SD	Mean (ms)	SD
4	402	17	480	107
8	404	19	487	108
16	409	19	495	130
32	414	13	499	148
Overall mean	407	17	490	123

4.2 Phase II of the study

4.2.1 Pilot test

Six people with MH were recruited in the pilot test. All participants were diagnosed with MH and met the selection criteria in the main study. The results of typing speed and accuracy were summarized in Table 4.3. Although the proficiency in terms of speed and accuracy of typing were enhanced in both guided cue and guided motion tasks when compared with basic search, participants showed even better performance in guided motion than guided cue conditions. This finding was in line with the results obtained in Phase I of the study, showing the superiority of guided motion over guided cue. It was suggested that people with MH may benefit from the guided motion strategies in searching the keyboard key during typing. Therefore, guided motion strategy was incorporated in CAI typing program and its effect was compared with no cue condition in the main study.

Table 4.3

The result of typing speed and accuracy in each participant

	Basic Search		**Guided Cues**		**Guided Motion**	
	Typing speed (wpm)	Accuracy (%)	Typing speed (wpm)	Accuracy (%)	Typing speed (wpm)	Accuracy (%)
Participant A	4.83	92.0	5.03	94.0	5.14	96.0
Participant B	5.10	92.0	5.25	92.0	5.22	94.0
Participant C	5.36	94.0	5.53	96.0	6.04	98.0
Participant D	8.31	96.0	8.46	98.0	8.61	98.0
Participant E	4.54	80.0	4.92	90.0	5.44	92.0
Participant F	6.37	94.0	6.48	94.0	6.77	96.0
Mean (SD)	5.75 (1.40)	91.3	5.95 (1.35)	94.0	6.2 (1.32)	95.7

4.2.2 Main study

Forty persons with MH were contacted from local service agencies serving people with MH. The researcher then verified all selection criteria, four persons were not eligible and excluded from the study as three of them could not identify upper and lower cases from A – Z, and the other one refused to participate in the study. Therefore, thirty-six persons with mild MH were randomly allocated to either Group I (n=18) or Group II (n=18) based on random sequences of allocation generated by means of dice rolling (Appendix VI). All the participants had completed the post-test-1 assessment, but two of them in Group II missed post-test-2 assessment for the reasons of lack of time and loss of contact. Two-way repeated measure MANOVA was performed for the outcome measure typing speed and accuracy, using last observation carried forward for the patients who withdrew from the study. The process of the study was shown in Figure 4.4.

4.2.3 Demographic data

Descriptive statistics on the demographic characteristics of the 36 participants were reported. All participants were diagnosed with mild MH. 19 (52.7%) were male and 17 (47.2%) were female. X^2 test revealed no significant differences in gender composition ($\underline{x}^2 = 0.11$, df = 1, $p > 0.05$). The mean age of the Group I and Group II was 22.4 years (SD = 1.46 years) and 22.9 years (SD = 1.10 years) respectively. The results of independent t-test showed insignificant differences in participants' age between the two groups ($\underline{t} = -1.15$, $\underline{df} = 34$, $\underline{p} > 0.05$). Moreover, X^2 test on education level; occupation and past experience in computer usage also showed insignificant between two groups (Table 4.4)

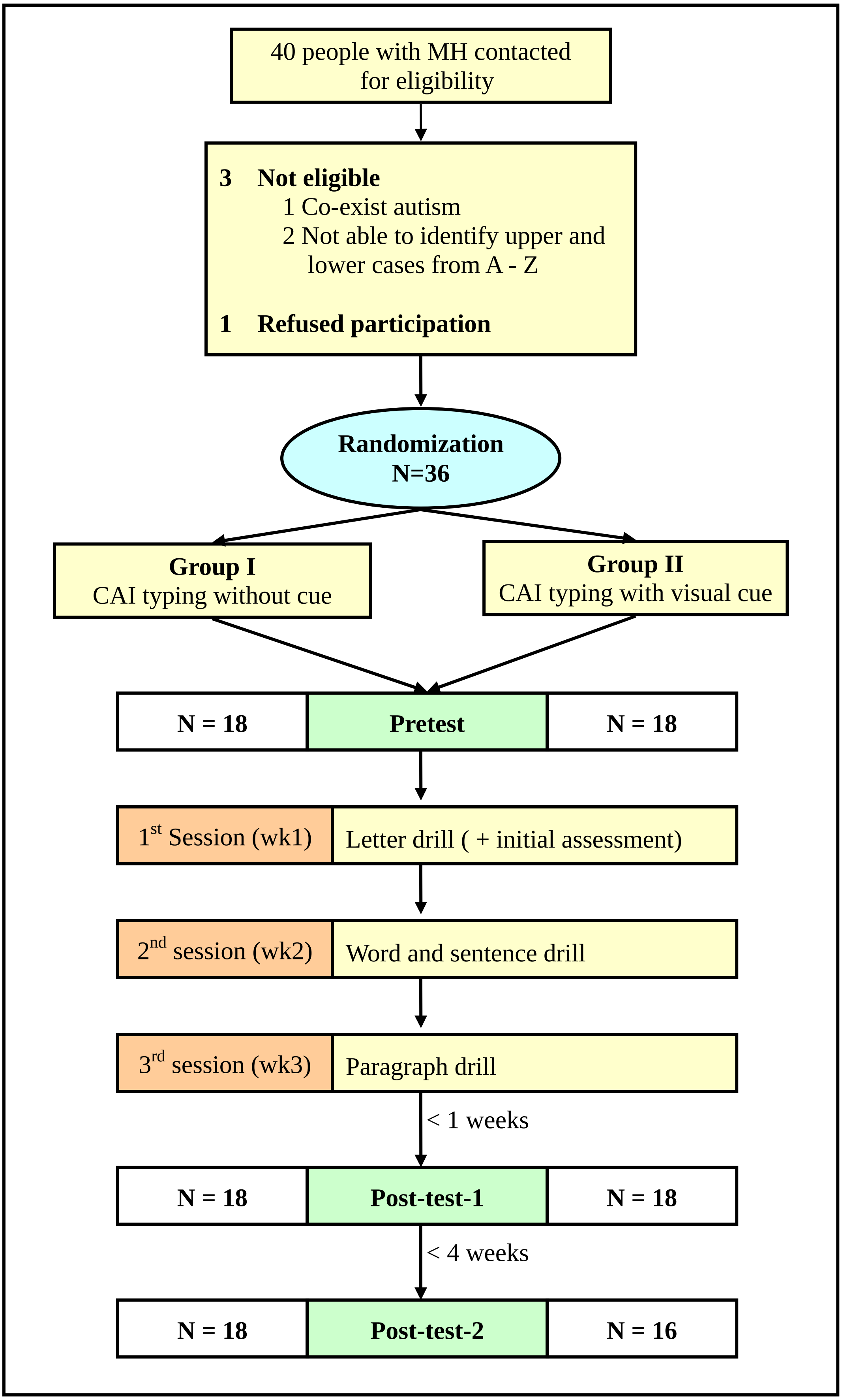


Figure 4.4
Process of the study

Table 4.4
Demographic data of participants

	Group I (n=13)	Group II (n=14)	Total (n=27)	Chi-square / t-test	p-value
Sex				Chi-square =0.11, df = 1	> 0.05
Male	9 (50.0%)	10 (55.6%)	19 (52.5%)		
Female	9 (50.0%)	8 (44.4 %)	17 (47.2%)		
Age	Mean: 22.4 SD = 1.46	Mean = 22.9 SD = 1.11		t-test = -1.15, df = 34	>0.05
Education				Chi-square = 0.11, df = 1	> 0.05
F.1 – F.3	8 (44.4%)	9 (50.0%)	17 (47.2%)		
F.4 – F.5	10 (55.6%)	9 (50.0%)	19 (52.8%)		
Occupation				Chi-square = 2.511, df = 3	> 0.05
Student	2 (11.1%)	0 (0.00%)	2 (5.6%)		
Shelter workshop	9 (50.0%)	11 (61.1%)	20 (55.6%)		
Supported employment	5 (27.8%)	4 (22.2%)	9 (25.0%)		
Open employment	2 (11.1%)	3 (16.7%)	5 (13.9%)		
Experience				Chi-square = 0.131, df = 1	>0.05
1 – 3 years	13 (72.2%)	12 (66.7%)	25 (69.4%)		
3 – 5 years	5 (27.8%)	6 (33.3%)	11 (30.6%)		

Note: * p-values ≤ 0.05 were considered statistically significant

To test the assumptions for the multivariate approach, Box's test was used to indicate whether sampling error explained the variability. Result was not significant (F=2.27, df = 21, p>0.001) and the assumption was not violated. Therefore, Wilk's Lambda would be an appropriate test to use in subsequent multivariate result interpretation. Barlett's Tests of Sphericity was performed to test whether the variance/covariance matrix of the dependent variables was correlated. It showed significant result ($\underline{X}^2$=79.88, df=2, $\underline{p}$<0.001) that the sphericity assumption was violated and therefore multivariate approach would be adopted, Post-hoc multiple univariate F tests with modified Bonferroni method would be used to interpret the respective effect of each parameters.

4.2.4 Treatment efficacy of the CAI typing program

Table 4.5 showed the results of typing speed and accuracy at three occasional assessments in Group I and Group II. Two-way repeated measure of MANOVA was used to test the "Group" and "Time" main effect as well as Time by Group interaction on typing speed and accuracy, and the statistical result was summarized in Table 4.6. The significant intercept suggested that both Group I and Group II showed an upward trend across different assessment occasions, Wilk's Lambda = 0.001, F(2,33) = 16461.18, p <0.001. The overall model was significant for the difference on a linear combination of the two dependent variables (i.e. typing speed and accuracy) between the Group I and Group II (Wilk's Lambda = 0.456, F(4,31) = 9.248, $\underline{p}$ <0.001). The Group II demonstrated significant improvement in typing efficacy after 3-week CAI typing program when compared with Group I. Multivariate η^2 = 0.54 indicated that approximately 54% of multivariate variance of the dependent variables was associated with the group and time factors. The main effect of group was significant (Wilk's Lambda = 0.83, F(2,33) = 3.30, $\underline{p}$ = 0.049), together with a significant effect of time (Wilk’s Lambda = 0.14, F(4,31), $p < 0.001$).

Table 4.5

Results of typing speed and accuracy in pretest and post-tests

	Group I	Group II
Typing speed (wpm)		
Pretest	4.26 (SD=0.72)	4.31 (SD=0.97)
Post-test-1	4.67 (SD=0.71)	5.89 (SD=1.49)
Post-test-2	4.25 (SD=0.57)	5.12 (SD=0.98)
Accuracy (%)		
Pretest	92.89 (SD=3.36)	91.67 (SD=5.31)
Post-test-1	95.50 (SD=2.09)	95.28 (SD=3.89)
Post-test-2	95.83 (SD=1.72)	96.06 (SD=2.31)

Table 4.6

Results of two-way repeated measure MANOVA

	F-values	Hypothesis df	Error df	p-value	η^2
Intercept	16461.18	2	33	<0.001***	0.99
Group effect	3.29	2	33	0.049 *	0.17
Time effect	46.36	4	31	<0.001***	0.86
Time * Group effect	9.24	4	31	<0.001***	0.54

Notes: *p-values < 0.05 were considered statistically significant
*** p-value < 0.001 (highly significant)

4.2.5 Respective effect of typing speed and accuracy

Post-hoc univariate F tests were used to investigate the respective effect of two dependent variables - typing speed and accuracy (Table 4.7). To protect against Type I error, modified Bonferonni method for each ANOVA would be used. The significanct *p* values obtained from the univariate F tests were ranked from the smallest to the largest. New alpha was calculated by dividing the original alpha by the number of test in reversed order (Table 4.8). The obtained *p* values were then compared to the corresponding new alpha. Post-hoc univariate F tests revealed that typing speed was significantly different for the basic search in Group I and the guided search in Group II, $F(2,68) = 13.38$, $p < 0.025$; whereas no statistically significance was shown on accuracy between the two groups, $F(2,68) = 13.38$, $p > 0.05$).

4.2.6 Comparison of typing speed and accuracy at the three assessments

Figure 4.5 illustrated the pattern in the means of typing speed and accuracy across the three occasional assessments. There was a general increase in typing speed from Pretest to Post-test-1, but the speed dropped between Post-test-1 and -2 (Figure 4.5a). Similarly, there was an upward trend in accuracy from Pretest to Post-test-1 but it levelled off between post-test-1 and -2 (Figure 4.5b). Standard repeated measures analysis with simple contrast tests were conducted to compare the result of Post-test-1 and -2 with Pretest. Again modified Bonferonni method was conducted to maintain familywise error rate across multiple pairwise comparisons for the dependent variables (Table 4.9). There was a significant difference in tying speed between Pretest and Post-test-1, $F(1, 34) = 16.11$, $p < 0.0125$. However, there were no significances for typing speed when compared Pretest to Post-test-2 and for accuracy at each level of comparisons (Table 4.10).

Table 4.7

Result of post-hoc univariate F test on each dependent variables

	Type III Sum of Squares	df	Mean Square	F	*p*
TIME * GROUP					
Typing speed	6.421	2	68	13.38	0.0001*
Accuracy	9.852	2	68	1.89	0.174

Note: * p-value < 0.025 was considered statistically significant

Table 4.8

Modified Bonferonni method for each ANOVA

	Obtained Significance	Original alpha	Divisor	New alpha	Significant
Typing speed	0.0001	0.05	2	0.025	Yes
Accuracy	0.1740	0.05	1	0.050	No

Table 4.9

Modified Bonferonni method for each ANOVA in pretest and post-tests

	Obtained Significance	Original alpha	Divisor	New alpha	Significant
Typing speed					
Pretest vs. Post-test-1	0.0003	0.05	4	0.0125	Yes
Pretest vs. Post-test-2	0.1580	0.05	3	0.0167	No
Accuracy					
Pretest vs. Post-test-1	0.1438	0.05	2	0.0250	No
Pretest vs. Post-test-2	0.3563	0.05	1	0.0500	No

Table 4.10

Comparison of typing speed and accuracy between pretest and post-tests

	Type III Sum of Squares	df	Mean Square	F	*p*
TIME * GROUP					
Typing speed					
Pretest vs. Post-test-1	6.066	1	6.066	16.106	0.0003*
Pretest vs. Post-test-2	1.046	1	1.046	2.087	0.1577
Accuracy					
Pretest vs. Post-test-1	18.778	1	18.778	2.238	0.1438
Pretest vs. Post-test-2	1.778	1	1.778	0.875	0.3563

Note: * p-value ≤ 0.0125 was considered statistically significant

Figure 4.5a

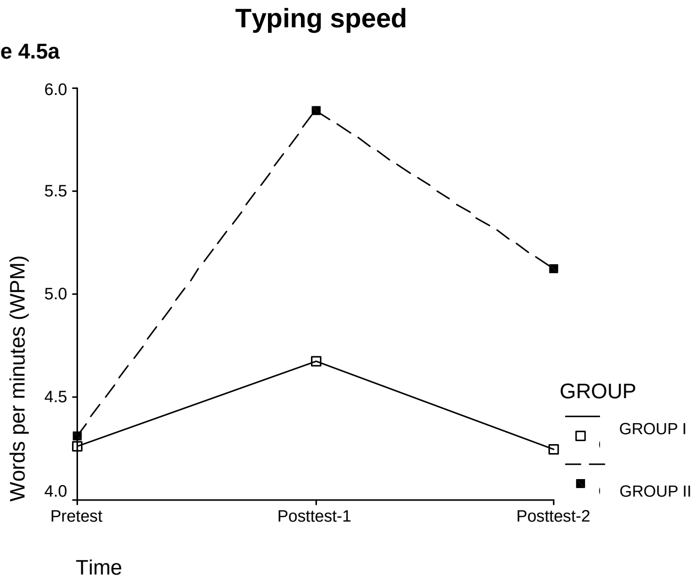

Typing speed

Figure 4.5b

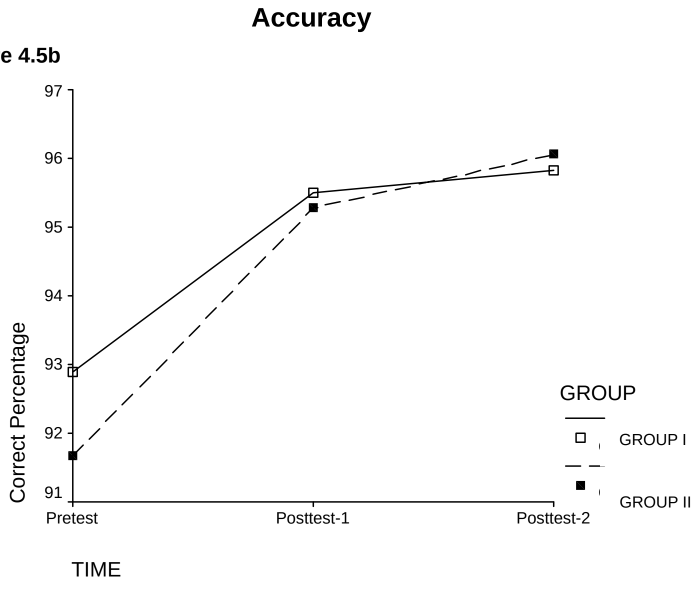

Accuracy

Figure 4.5

Results of typing speed (Figure 4.5 a) and accuracy (Figure 4.5b) for the Group I and Group II in pretest and post-tests

CHAPTER V

DISCUSSION

5.1 Phase I of the study

5.1.1 Visual search mechanism in people with MH and normal intelligence

The purpose of phase I of the study was to compare the visual search efficacy of different guided search strategies between people with MH and those with normal intelligence. To the best knowledge of the researcher, this study was first to examine the visual search efficacy and the effect of different visual search strategies in capturing focal attention in people with MH. The results showed that relatively high target-distraction similarity in "form" dimension array (i.e. searching target "hexagon" among distractor "circle") could yield non-flat set size slopes (i.e. > 10 ms/item) in people with MH. However for people with normal intelligence, the mean RT was virtually unchanged with set size slope < 10ms/item, demonstrating that those with normal intelligence could parallel search efficiently independent of set size. This could be accounted by the stronger influences of top down activation in people with normal intelligence. The specification of the target and knowledge of array characteristics could have positive influence on the top-down processing, thus increasing the visual search efficiency. People with normal intelligence may utilize other performance strategies based on mismatch detection rather than pre-defined target feature detection in unidimensional arrays with homogeneous background that requires attentional/perceptual processing (Duncan & Humphreys, 1992). Therefore search efficacy might be increased by adopting these strategies to detect heterogeneous background.

5.1.2 Effect of visual search strategies for people with MH

Interestingly, visual search efficacy could be significantly enhanced when guided search strategies i.e. guided motion and guided cue were provided for people with mild MH. An efficient parallel search (i.e. set-size slope < 10 ms/item) was demonstrated when the target was made salient. The searching time for people with MH was actually comparable to that of people with normal intelligence in guided motion search task (Pillai's Trace = 0.08, $\underline{p}$ = 0.969). Both groups could identify the target rapidly, independent of the number of the distractors in the array. It implied that the RT for visual searching was independent of the set size, thus it was evident of parallel search for the features. Better performances in guided search tasks when compared to basic search task could be explained by the model that "pop-out" targets were detected quickly, as the salience attracted focal attention and brought it right to the location where target properties were represented. Based on the Posner's theory of selective visual attention, when the predefined item was made salient, it might facilitate the disengaging process by which attention would be directed to a new location.

Although different saliency mechanisms have demonstrated functionally similar effects that confirmed the non-specific character of salience (Nothdurft, 2002), guided motion search was shown more superior compared with guided cue search in our study. The major differences between guided motion and guided cue were that the target was made salient by abrupt onset and enhanced with flashing features in guided motion search, whereas a static circular cue was presented close to the target in guided cue search. Functionally, both guided motion and guided cue search strategies produced similar effects, such that the target in visual search could be detected fast and independent of set size when the salience was produced on the same spatial scale and at the same location in the visual field where target properties were encoded (Nothdurft, 2002). In this study, by comparing set size slopes and mean RT, it was demonstrated guided motion search had even better visual search performance than guided cue search task. Since the task was the same for all visual search strategies, these differences should reflect the physical properties of different cueing effects. According to Nothdurft (2001), several properties might have affected performance in guided search tasks: (1) the speed of encoding salience in the brain, (2) the perceived strength of a given saliency effect, (3) differences in stimulus duration, (4) the dissimilarity of cue and target objects and (5) size and location of the cue. In contrast to static feature in guided cue task, the dynamically and constantly flashing features in guided motion search enhance faster encoding process than salience from guided cue. It allowed faster and stronger attraction of focal attention that resulting better performances in the search tasks.

5.1.3 Feature visual search in people with MH

In an earlier study by Carlin and colleagues (1995), people with and without MH were compared in feature-defined search for color, form, size and line orientation. Their results were not consistent across all dimensions tested. Although there were individual differences in searching performances among people with MH, it was evident that some of them actually searched the visual array serially whereas people without MH could demonstrate efficient parallel search. They found no differences in efficiency of search between groups for the dimensions of color and line orientation, but significant results were showed in form (i.e. circle and triangle) and size (i.e. large and small circle) features. The latter result agreed with what we found in this study that inefficient search for “form” dimension in unidimensional visual arrays. This study employed a variation of the paradigm to examine the effect of visual strategies using visually salient elements in feature-defined search. The unidimensional array feature search task was used, as there was evidence of poor accuracy during conjunction search in people with MH (e.g. blue circle among blue triangle and green circle). Therefore, designs of relatively high target-distractor similarity of the array intentionally demanded their focal attention and prevented participants with MH from parallel search, such that the role of various visual strategies in enhancing attention could be better examined.

5.1.4 Error rate in people with MH

There was an increasing overall error rate as the set size increased in people with MH. However, the overall error rates decreased when the target was made salient by either guided cue and guided motion. Another finding was that the error rates of false negative tended to be higher than the error rates of false positive in people with MH. In another words, the participants tended to miss the target in target present condition instead of false response in target absent condition. This could be explained by an inefficient visual search of the arrays resulting in higher error rates in target present condition. On the other hand, if the participants responded early in a trial rather than waiting to confirm the presence of a target, this could raise the possibilities of speed-accuracy tradeoffs (Carlin *et al.*, 2002). Yet this was not shown in our data as the error rates were low and consistent across the search tasks.

In conclusion, the results of this study provided a theoretical understanding of the visual searching behavior in people with MH. It was suggested that the visual search efficacy of people with MH would be greatly improved if the target was made salient using guided motion. Our results supported the hypothesis that visual search strategies were able to capture focal attention in an automatic manner for people with MH as well. Practically speaking, people with MH might benefit from these cueing strategies to enhance the ability in guiding the selection and identification processes of the visual system, by which the target is then recognized. For example, gaining visual attention through various visual search strategies is one of the critical aspects of CAI that are particularly important for people with MH. The ability to attend to complex display is the pre-acquisition of any fundamental skills in learning. It is believed that the use of appropriate cueing strategies could attract attention to the critical elements in the arrays and minimize the loading on visual working memory, and thus potentially enhance the learning process. This study provided an important practical implication and rationale for incorporating the visual search strategies in CAI typing program design in phase II of the study.

5.2 Phase II of the study

5.2.1 Foundation skill and functional skill training

While the foundation skill training emphasized remediating the performance components e.g. visual attention; functional skill training focused on the task performance and often utilized various strategies to manage the daily tasks more effectively. In studies of foundation skill approach, Wang and colleagues (1997) investigated whether eye-movement strategy in visual search could be enhanced by search strategy training. The search strategy was typically defined as either random search or systematic search, where random search meant that fixation locations were sampled from the visual field with replacement while systematic search used sampling without replacement. While the systematic search strategy would yield better performance than random search, it showed that people with normal intelligence could improve the search strategy using practice with performance feedback and eye movement monitoring. However, the effectiveness of these performance-based trainings in people with MH remained uncertain.

Moreover it appeared that the evidence of generalization of acquired skills to real-life situation was limited. Therefore, functional skill training (e.g. CAI program through simulation) was suggested in life skills acquisition for people with MH.

5.2.2 Role of cueing strategies in designing CAI program e.g. typing

Current research generally supported that CAI could remediate specific areas of learning through repeated drills and interactive simulation. However, there was lack of commercially available educational software which was empirically supported and specifically developed for people with MH. Therefore in this study we aimed to develop an innovative CAI which was culturally appropriate and specific to people with MH. Furthermore, based on the result of Phase I of the study and pilot test, the effect of visual search strategies (i.e. guided motion) and their roles in CAI typing program were demonstrated. In this phase of the study, participants were randomly assigned to either Group I without cue or Group II with cueing. Typing speed and accuracy were assessed and compared at three occasions (i.e. pre-assessment, 1-week and 4-week after training) after the three week CAI typing program was completed. Current literature provided little information regarding the optimal training intensity to acquire and master specific skills and thus, this study mainly focused on the immediate effect of the CAI program.

The main question of this study concerned whether typing efficacy would be significantly different between visual cueing and no cueing conditions in CAI. Our findings showed that there was significant difference on a linear combination of the typing speed and accuracy between the two groups. In other words, CAI program with visual search strategies (i.e. guided motion) was found to be more effective in improving the typing efficacy. The results further indicated that the program was more effective in promoting the typing speed when compared to the accuracy improvement.

Typing could demand controlled processing for people with MH as it involves dynamic shift of attention between keyboard, computer display and typing material. Controlled processing tends to be slow, serial and under the conscious control of the individual. However, when the typing keys were identified efficiently through visual cue, the typing performance could be enhanced with drills and turned into automatic processing. The key differentiation between controlled and automatic processings is that, controlled processing relies heavily on conscious attention to the given task, whereas automatic processing occurs with little or no conscious attention. Therefore, unlike automatic processes, multiple controlled processes generally cannot be performed efficiently especially for people with MH.

In this study, the high levels of accuracy and significant improvement in typing speed with visual cue might indicate that automatic processing might have occurred. When target key detection was performed, cueing strategies by flashing at the target location incorporated in CAI typing program might facilitate response times. This could be accounted by the notion that the effective search strategies encode the target key location and facilitate spatial memory process. The skill automatization might occur and mediate search performance that required minimal conscious control or effort, so that the cueing strategies could then be faded out. However, it was noteworthy that the optimal training intensity to achieve the stage of skill automatization was not determined in this study. It might be reflected by the learning curve referring to the relationship between the duration of learning and the resulting progress (Ritter & Schooler, 2002). It was characterized by a a rapid improvement during the initial stages followed by ever lesser improvements with further practice. However, this could not be shown in our data as it required extensive practice and continuous assessment until the performance achieved plateau.

5.2.3 Comparison of accuracy and typing speed between the two groups

With regard to the accuracy, no statistically significant difference between the two groups was observed ($p > 0.05$). In fact, the mean accuracy was all above 90% in both groups which means most of the participants could attain near upper limit for the test. This usually resulted in distortion of normal distributions with little variability that limits the possibility of finding significant effects. The search performance in term of typing speed was significantly higher with visual cues ($p < 0.001$), although the Group I also demonstrated increasing speed with practice as the participants might have become familiar with the task requirements and the particular target-detection task. The tying speeds were significantly improved in both groups after completing the 3-week program as measured in Post-test-1. However, when they were reassessed after one month, both typing speed and accuracy decreased and became insignificant when compared with Pretest. The rate of deterioration was very similar for the two groups. These findings could be attributed to the fact that people with MH have always demonstrated poor performance in long term retention that is related to the cognitive deficit. It might be reflected by the forgetting curve referring to the decline of memory retention in time (Ruger & Bussenius, 1913). Therefore, it was suggested that repeated drills and practice (e.g. booster program) could increase the strength of memory.

5.2.4 Comparison of typing speed between people with and without MH

It was worth to note that the average speed of typing in people with MH was about 4 – 5 wpm, indicating that people with MH perform very slowly in typing when compared with normal people. In one study on average computer users, the average speed for transcription was 33wpm (Karat *et al.*, 1999). In the same study, where the subjects were divided into "fast", "moderate" and "slow" groups, the average speeds were 40wpm, 35wpm, and 23wpm respectively. Salthouse (1984) studied the factors responsible for skilled typing performance of the typist by examining time and accuracy of keystrokes in a variety of typing activities ranging in speed from 17 to 104wpm and ranging in age from 19 to 72 years. Typing skill was found to be related to (a) the temporal consistency of making the same keystroke, (b) the efficiency of overlapping successive keystrokes, (c) the speed of alternative-hand tapping, and (d) the number of characters of to-be-typed text required to maintain a normal rate of typing. In an earlier study on typewriting rate in skilled typists, Hayes and colleagues (1977) found that the typewriting rate was positively correlated with RT of the finger and RT to individual keys on the typerwriter. Obviously, motor skill deficit and inefficient search of keyboard keys in people with MH could be the factors that accounted for poorer typing performance. Ordinary computer users might demonstrate touch typing which meant using the sense of touch rather than sight to find the keys. It relied on the memorized position of keys. However, we found that most of the people with MH performed two-fingered typing in which they must find and press each key individually which is always considerably slower than touch typing.

5.2.5 Individual feedback

We have observed that most of the participants responded well to the training program. Those who were reported by caregiver as having short attention span and requiring individual attention could actually retain in the classroom situation and complete the program with minimal cognitive guidance. Although they were encouraged to stay for the duration of the program, they were free to drop out of the program at any time. In fact, the overall attendance rate was high and only two participants missed the follow-up assessment for the reasons of lack of time and loss of contact. Some of the participants and their caregivers reported that they found the training program was very useful and requested for further sessions. Therefore, when the post-test-2 was conducted after the training program, a software CD-ROM was given for practice at home.

Developing CAI program was no longer restricted to those with programming skills. The advent of multimedia authoring program such as FLASH has meant that the clinicians can create their own software programs. It was indicative of a move to develop software which would more specifically meet the needs of individuals with MH. This study provided a theoretical foundation for CAI program and implemented research into the effectiveness that could be extended to other CAI for community living skills or vocational trainings e.g. using ETC machine, money exchange, for people with MH.

CHAPTER VI

CONCLUSION

6.1 Significance of the study

Phase I of the study conducted a series of experiments to investigate the efficacy of two visual search strategies on search behavior. The main hypothesis was that the visual search efficacy in terms of speed and accuracy would be significantly different for the two visual search strategies (i.e. guided motion and guided cue) when compared to no cueing condition (i.e. basic search). The results obtained from phase I of the study provided theoretical understanding of the searching behavior of people with MH. It showed that people without MH could benefit from guided search, in which the saliency effects from guided motion could be used to facilitate visual search for a target stimulus. An efficient parallel search (i.e. set-size slope < 10 ms/item) was demonstrated when the target was made salient. The searching time in people with MH was actually comparable to that of people with normal intelligence across set-size in guided motion search task. The results supported the hypothesis that visual search strategies were able to capture focal attention in an automatic manner for people with MH. This could be explained by the dynamically and constantly flashing features in guided motion search that allow faster and stronger attraction of focal attention resulting a better performance in the search tasks. Phase I of the study provided significant implication on the use of visual search strategies (i.e. guided motion) that could be incorporated in CAI typing program design in phase II of the study.

Based on the results from Phase I of the study and pilot test, an innovative CAI for typing which was culturally appropriate and specific to people with MH was developed. Furthermore, the effect of visual search strategies (i.e. guided motion) and its role in CAI typing was examined in Phase II. The main hypothesis of Phase II study was that the typing efficacy in terms of speed and accuracy would demonstrate significantly different between visual cueing and no cueing conditions in CAI. Results showed that the overall model was significant for the difference on a linear combination of the typing speed and accuracy between the two groups. The typing performance in term of speed was significantly enhanced with visual search strategies ($p<0.001$), however there was no statistically significant difference on accuracy between the two groups. This study further supported the role of visual search strategies and pictured a positive effectiveness of CAI in enhancing functional performance among people with MH. While it is believed that the cognitive deficits in attention and working memory in people with MH might impede the learning process. By using appropriate visual search strategies, it could attract and maintain attention to the critical elements in the arrays, and thus promote the encoding process for long-term storage.

In conclusion, this study supported the use of visual search strategies for CAI program that could be extended to other CAI for community living skills or vocational trainings e.g. learning IT platform, using ETC machine. Moreover, the attention effect of visual search strategies could be applied in some functional applications. For example, to teach a person with MH to make outgoing call using telephone, several steps involved: (1) pick up the handset, (2) push the number buttons and (3) put down the handset to disconnect the telephone call. A built-in flasher could be applied to the handset and number buttons, such that the handset will flash to guide the user to pick up the phone, followed by a flashing number buttons to further guide the user to enter a phone number. These strategies could enhance the visual search process and automatize the steps involved, and the ultimate goal of the training was to fade out the cueing strategies after the skill automatization and generalization.

6.2 Limitations of this study and implications for future research

In phase I of the study, there was limitation in capturing the actual covert attention. The participant’s gaze could probably shift to target item but with delayed motor response, especially among people with MH. This delay could also be due to the decrease in fine motor dexterity to operate the key pressing or the impaired higher cortical functioning to execute the desired command. Therefore, it was suggested that the response time (i.e. time required to make a motor response by key pressing when a target was presented) should be measured prior to future visual search experiment in people with MH. Recent functional brain imaging and Tran-cranial magnetic stimulation (TMS) studies supported the notion of specific and critical involvement of right posterior parietal cortex in tasks requiring serial search. The investigation of neuronal mechanisms underlying visual search might help to facilitate the understanding of visual search behaviors among people with MH. A priority for follow-up study is the use of more rigorous research designs through utilization of eye-tracker technology that could provide real-time signals giving the direction of participant’s gaze to be aligned with the observed behavior. Future studies should also include analysis of visual search behaviors in real life situation so that the results of the data could be generalized and applied in daily living and educational contexts.

Phase II of the study has certain limitations and potential confounding variables. In this study, the use of computer at home was not controlled and this might be the confounding factor that might potentially affect the outcome measurement. Typing speed and accuracy were selected as the main outcome parameters; other standardized assessments to evaluate computer proficiency skill should be explored to reflect more valid measures of typing skill in people with MH. In fact, the mean accuracy was all above 90% in both groups which means most of the participants could attain near upper limit for the test. This usually resulted in distortion of normal distributions with little variability that limits the possibility of finding significant effects between the two groups (p>0.05). Moreover, the degree of skill generalization across different situations and the effects of maintenance still warrant further investigation, as generalization has been an especially difficult stage for people with MH (Gaylord-Ross & Holvoet, 1985). And the transfer of learning to real-life setting (e.g. word processing program) and over time (e.g. longer follow-up period) should also be evaluated in future research. To further explore the effectiveness of the CAI program, future studies should determine the training intensity in learning a specific new skill based on the learning curve. Furthermore, future research on what level of MH varies factorially is needed to confirm the effect of visual search strategies (i.e. guided motion) across both mild and moderate levels of MH.

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APPENDICES

Appendix I. Consent form for Phase I of the study

香港理工大學
康復治療學系
同意書

研究題目：

利用電腦輔助教學給予智障人仕學習電腦軟件應用的成效

研究目的

隨著電腦科技發展一日千里，智障人仕對學習電腦軟件的需求也不斷增加。閣下現被邀請參與一項由香港理工大學進行的研究。這項研究希望了解利用電腦輔助教學給予智障人仕學習電腦軟件應用的成效，從而有助發展有關電腦輔助教學的製作。

研究程序

閣下將被邀請接受一次利用利用電腦輔助進行視覺搜索（Visual Search）的測驗，歷時三十至六十分鐘。

得益與風險

你的參與將了解智障人仕視覺搜索的情況及其利用電腦輔助教學給予智障人仕學習電腦軟件應用有極大貢獻。本項研究不會構成任何風險；研究員都曾接受有關陪訓及具備進行有關測試的資格。

自願參與

閣下參加此項研究，完全是依閣下的意願為依歸。閣下可隨時退出而不會受到損害。閣下亦可拒絕參與而不會造成任何久遠的影響。

資料保密

所有於研究中獲得的資料都會絕對保密，而這些資料只供學術研究用途。閣下的身份亦不會於研究結果中公開。

副本

閣下將獲發此同意書的副本作為參考之用。

研究顧問

李曾慧平博士、蕭敏康博士、許雲影教授

研究員

黃啟傑先生

聯絡人

如有任何關於這個研究的問題，閣下可聯絡：

黃啟傑先生　xxxx xxxx
xxxxxxx@netvigator.com

簽署

本人簽署此同意書，表示本人同意參加上述的研究。

參加者簽署　　日期

研究人員已向參加者詳細解釋此同意書的資料，就本人所知，參加者已清楚明白此項研究的性質及所帶來的得益和風險。

研究人員　　日期

Appendix II. Standardized Procedure of Experimental Design on Visual Search

(1) Experimental setup:

- Subjects are seated approximately 50 cm from the computer screen with head resting on the chin rest, and the mouse placed within arm's reach.
- Prior to beginning of the experimental trial sets of each condition, subjects are introducing a predefined stimulus (hexagon) for the search task.
- Subjects had to respond only when the target (hexagon) was present by either pressing the keyboard spacebar or right click the mouse. (If the target was not present on a given trial, the display was automatically removed after a 5-s interval.)
- Trials are initiated by the experimenter pressing the control key when ready to proceed.

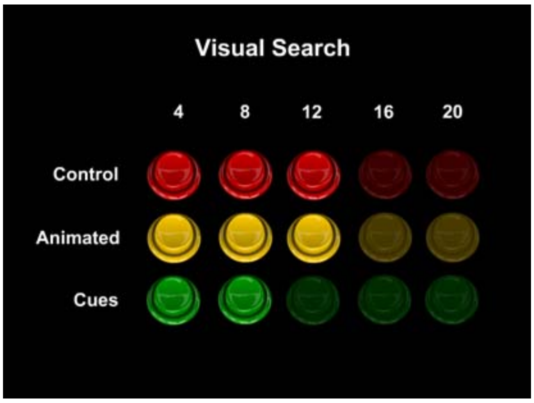
Practice of Trial [Open the file:]

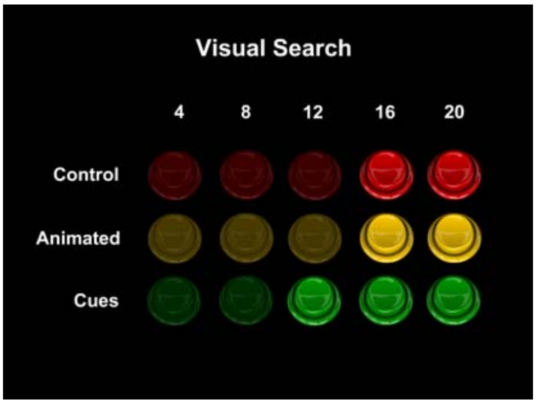
Subjects are provided with a practice set of trials which ceased at the point when the subjects are responding with 90% accuracy.

【你需要在螢光幕上搵出六邊形，當你見到六邊形既時候，就按一下鍵盤 (Spacebar) / 右擊滑鼠。如果沒有的話，你不用按動任何掣。你唔需要理會其他圖形，只需要見到六邊形既時候，盡快按一下鍵盤 (Spacebar) / 右擊滑鼠，我地而家練習一次。】

Experiments:

- The experiment is split into half, which allows 10 mins break in-between





File: VS1 - RUN (Modified - 6s)   File: VS2 - RUN (Modified - 6s)

- The instructor should follow the sequence of the testing order: ________
    - Control: no addition cue to the predefined target
    - Animated: animated prompt effects act on the predefined target
    - Cues: addition cues (a prompt of an additional circle) around the target
- Trials are initiated by the experimenter pressing the control key when ready to proceed.

  【你需要在螢光幕上搵出六邊形，當你見到六邊形既時候，就按一下鍵盤 (Spacebar) / 右擊滑鼠。如果沒有的話，你不用按動任何掣。記住你唔需要理會其他圖形，只需要見到六邊形既時候，盡快按一下鍵盤 (Spacebar) / 右擊滑鼠，因爲我會幫你計時的。】
- The program automatically records the accuracy and response time for each visual-search task. And the instructor records down the result in the scoring sheet.

Appendix III. Scoring sheet

Code: (N)___________

Experimental Design on Visual Search – Scoring Sheet

Name:______________ Date: _____________

---

(1) Demograpohic Data:

1. Age: __________
2. Sex: ○ M ○ F
3. UL functional limitation: _____________
4. Educational Level:

○ Special School (P.1 – 3)
○ Special School (P.4 – 6)
○ Special School (F.1 – 3)
○ Special School (F.4 – 7)
○ Normal School (Pri.)
○ Normal School (Sec.)
○ Normal School (Ter.)

5. Occupation:

○ None

○ Student

○ Day activity center

○ Shelter workshop

○ Supported employment

○ Open employment

(2) Result:

	Basic Search	**Guided Motion**	**Guided Cues**
4	ms	ms	ms
8	ms	ms	ms
12	ms	ms	ms
16	ms	ms	ms
20	ms	ms	ms

Remark:

Appendix IV. Consent Form for Phase II of the study

香港理工大學
康復治療學系
同意書

研究題目：

利用電腦輔助教學給予智障人仕學習電腦軟件應用的成效

研究目的

隨著電腦科技發展一日千里，智障人仕對學習電腦軟件的需求也不斷增加。閣下現被邀請參與一項由香港理工大學進行的研究。這項研究希望了解利用電腦輔助教學給予智障人仕學習電腦軟件應用的成效，從而有助發展有關電腦輔助教學的製作。

研究程序

閣下將被邀請接受四次利用電腦輔助進行輸入鍵盤的訓練和測驗。

得益與風險

你的參與將了解智障人仕視覺搜索的情況及其利用電腦輔助教學給予智障人仕學習電腦軟件應用有極大貢獻。本項研究不會構成任何風險；研究員都曾接受有關陪訓及具備進行有關測試的資格。

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副本

閣下將獲發此同意書的副本作為參考之用。

研究顧問
李曾慧平博士

研究員
黃啟傑先生

聯絡人
如有任何關於這個研究的問題，閣下可聯絡：
黃啟傑先生　xxxx xxxx
xxxxxxx@netvigator.com

簽署
本人簽署此同意書，表示本人同意參加上述的研究。

參加者簽署　　日期

研究人員已向參加者詳細解釋此同意書的資料，就本人所知，參加者已清楚明白此項研究的性質及所帶來的得益和風險。

研究人員　　日期

Appendix V. Raw material in four training modules

	Alphabet drill	Word drill
1	Q	Aeroplane
2	SPACEBAR	Answer
3	I	Ball
4	ENTER	Banana
5	K	Blue
6	O	Boat
7	E	Bottle
8	L	Brother
9	P	Chicken
10	R	Clock
11	Z	Cupboard
12	A	Doll
13	T	Driver
14	X	Duck
15	S	Elephant
16	Y	Evening
17	C	Face
18	D	Farmer
19	.	Fireman
20	,	Floor
21	F	Flower
22	I	Grass
23	B	Green
24	G	Horse
25	O	Icecream
26	N	Knife
27	H	Lamp
28	P	Light
29	M	Morning
30	J	Mother
31	A	Mouth
32	Q	Nose
33	K	Nurse
34	S	Orange
35	W	Pear
36	L	Pencil
37	D	Plate
38	E	Policeman
39	M	Postman
40	F	Rabbit
41	R	Radio
42	N	River
43	G	Rubber
44	T	Shoe
45	B	Sister
46	H	Sock
47	Y	Teacher
48	C	Umbrella
49	J	Window
50	U	Yellow

Sentence drill

1. Many people believe the color red will bring them lucky
2. I had some good luck the other day
3. Her lifestyle has changed since her success
4. They cannot understand the foreigner speaking English
5. This form lists the entry requirement
6. Many friends come to see her of at the airport
7. Cathy will marry Paul soon
8. I remembered that I had to go out tonight
9. His parents make him study hard
10. The majority of the people support this plan
11. I have to work hard to ease my living
12. Yesterday she had to study for the exam
13. Most of the people I know are very kind
14. Fruit is cheaper from a hawker than in a shop
15. One morning we all went out for breakfast
16. She came in and turned on the television
17. Many people oppose the use of nuclear power
18. They published it in the newspaper
19. Every Sunday I go out with my parents
20. The pavement was too narrow to walk on
21. You should pay more attention to that point
22. I saw a policeman coming towards me
23. The robber pointed his gun at me
24. Every night I must study before I watch television
25. The reason is that she was too busy
26. I was pleased to receive your letter
27. She took out some money from her pursue
28. She got good result in the examination
29. We found a safe place to hide
30. I don’t really care about the working hours

Paragraph drill

(I)

Thank you for your enquiry of 18th August about our plastic tile flooring, We enclose a copy of our brochure showing the designs and range of colours in which the tiles are supplied. Rugby, are a very reliable firm and responsible for all our work in your district. I have asked Mr. Anderson to call on you to inspect your floors; he will then advise you on what preparation is necessary and whether dampness is sufficient to create a problem. Our plastic tile flooring is hard-wearing and if the tiles are laid professionally I am sure the work will give you lasting satisfaction.

(II)

I was very sorry to receive your letter dated 25th June and the medical certificate you enclosed with it. Although you say you hope to be back at work in six weeks time, I feel it would be very unwise for you to attempt to return too soon after what is, after all, a serious illness. I have therefore arranged for you to have two weeks leave of absence on full pay so that you can get away for a holiday and a complete rest after the doctor has pronounced you fit for work. Your colleagues here all join with me in wishing you a speedy and complete recovery.

(III)

On 7th April we have to send to the station 160 bags of cement, weighing a total of about eight tons and should be glad if you would place a covered wagon of the necessary size at our disposal in time for loading at eight o’clock on the morning of that day. Kindly confirm by return that a suitable wagon will be provided at our works for the day and time stated. You already have received formal acknowledgment of your order of 12th July, but as this is your first order with us, I feel I must write to tell you how pleased we were to receive it and to thank you for the opportunity you have given us to supply the goods you need.

(IV)

I feel I have the necessary qualifications and experience needed for the position of private secretary to your managing director, advertised in the South China Morning Post. When I left High School at eighteen it was intended that I should go to University College, London, to study modern languages, but owing to emigration to Hong Kong I was unable to accept the place offered, I then decided to train for secretarial work and, as you will see from the resume enclosed, successfully completed a two-year course at the Hang Seng Secretarial College.

(V)

We should be glad if you would consider some revision in our present rate of commission. The request may strike you as unusual since the increase in sales last year resulted in a corresponding increase on our total commission. Marketing your goods has proved to be more difficult than could have been expected when we undertook to represent you. Since then, German and American competitors have entered the market and firmly established themselves. Consequently, we have been able to hold our own only by putting pressure on our salesmen and increasing our expenditure on advertising.

(I)

We noticed that one of the outer edges of the wrapping had been worn through, presumably as a result of friction in transit, and when we took off the wrapping were not surprised to find that the carpet itself was soiled and slightly frayed at the edge. This is the second time in three weeks we have had cause to write to you about the same matter and we find it hard to understand why precautions could not be taken to prevent a repetition of the earlier damage. Although other carpets have been delivered in good condition, this second experience within such a short time suggests the need for special precautions against friction when carpets are sent by rail and we hope that in handling our future orders you will bear this in mind.

(II)

On 2nd March last I ordered one hundred tennis rackets, to be delivered at the end of this month, persistent bad weather has seriously affected sales and I now find that my present stock will probably be ample for the current season, I am therefore writing to ask you to cancel part of my order and to deliver only fifty of these rackets instead of the one hundred ordered. I am sorry to make this request so late, but hope that, because of our long-standing business connection, you will see your way to agree. Should sales improve I would get in touch with you again and take a further delivery.

(III)

We thank you for your order of 19th May and as it is your first with us would like to say how pleased we were to receive it. When opening new accounts it is our practice to ask customers for trade references, Will you therefore please send us the names and addresses of two other suppliers with whom you have dealings. We shall be glad to receive this information by return and meanwhile have put your order in hand for dispatch immediately we hear further from you.

(IV)

You already have received formal acknowledgment of your order of 12th July, but as this is your first order with us, I feel I must write to tell you how pleased we were to receive it and to thank you for the opportunity you have given us to supply the goods you need. I hope our handling of this order will lead to further business between us and to a happy and lasting association. We shall certainly do our best to make it so.

(V)

Michael derives satisfaction from helping our customers and field engineers troubleshoot equipment problems. Many of those who've received help from Michael specifically ask for him when they again contact tech support, and for good reason. He is professional, courteous and quick to help. His technical skills are sharp and without prompting, he keeps them honed to a razor edge. I often see Michael in our lab before or after work hours, replicating equipment problems. Additionally, Michael doesn't abandon his customers when the whistle blows.

Appendix VI. A block of random sequences of allocation generated by dice rolling

Dice Result	**2**	**4**	**3**	**6**	**4**	**1**
	2	**5**	**3**	**5**	**6**	**2**
	4	**3**				

(I) Result of rolling a die

Dice	**1**	**2**	**3**	**4**	**5**	**6**
Block	AB	BA	BA	AB	AB	BA

(II) Corresponding dice number to block sequence

1	B	**11**	A	**21**	B
2	A	**12**	B	**22**	A
3	A	**13**	B	**23**	B
4	B	**14**	A	**24**	A
5	B	**15**	A	**25**	A
6	A	**16**	B	**26**	B
7	B	**17**	B	**27**	B
8	A	**18**	A	**28**	A
9	A	**19**	A	**29**	--
10	B	**20**	B	**30**	--

(III) Random sequences of allocation