THE HONG KONG POLYTECHNIC UNIVERSITY

THE DEPARTMENT OF REHABILITATION SCIENCES

COGNITIVE REHABILITATION PROGRAMME FOR PERSONS WITH TRAUMATIC BRAIN INJURY: DEVELOPMENT AND EVALUATION

Dou Zulin

A thesis submitted to the Department of Rehabilitation Sciences
in Partial Fulfilment of the requirements of
the degree of Doctor of Philosophy

September 2005

DEDICATION

I would like to dedicate this work especially to my wife and daughter, for their undaunted faith in me.

CERTIFICATE OF ORIGINALITY

I 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 acknowledgement has been made in the text.

______________________________ (Signed)

__________Dou Zulin__________(Name of student)

ABSTRACT

*Background***:** Cognitive rehabilitation aims to alleviate or ameliorate cognitive deficits that have resulted from traumatic brain injury (TBI). The present study developed and evaluated a computer-assisted memory rehabilitation programme, based on a postulated EE & EL model (enriched environment and errorless learning), and through the use of comprehensive cognitive training principles for persons with TBI so as to improve their impaired memory functions. The efficacy of this computer-assisted memory rehabilitation protocol was evaluated through formative and summative tests. It was hypothesized that that positive treatment effectiveness would be exhibited in the two memory rehabilitation programme respectively (i.e. computer-assisted or CAMG; and therapist-administered or TAMG) but not in a control group (CG).

Methods: A prospective pretest and posttest quasi-experimental clinical design research was carried out in two phases, i.e. pilot and main study phase. A pilot study was conducted to test out the usability of the training programmes, validity and reliability of measuring instruments and related training procedures. The pilot study involving 15 subjects with TBI gave evidence of the robust content validity and applicability of the two memory training modes. In the main study, 112 subjects were screened by selection criteria from five hospitals and one rehabilitation centre to participate. There were 28 subjects who dropped out of the study due to various reasons. Eighty-four subjects were randomly assigned into the three groups CAMG (n=30), TAMG (n=24) and CG (n=30) and they had completed 1-month, 20-session training and 1-month follow up. It was shown that there were no significant pre-training differences in age, gender, post-injury period, diagnosis, sidedness of brain injury and education level among the three groups. Outcome measures included the Chinese Version of the Neurobehavioral Cognitive Status Examination (NCSE-CV; Chan et al., 1999), the Rivermead Behavioral Memory Test–Chinese Version (RBMT-CV; Neuro-Rehabilitation Working Group, 1998; You, Han & Xu, 2003), The Hong Kong List Learning Test (HKLLT; Chan & Kwok, 1999), The Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski & Schaie, 1990) and a memory self-efficacy questionnaire.

A 20-session computer-assisted memory training package using a human-computer interaction and multimedia presentation was developed for use in CAMG. This software was tailor-made for Chinese subjects with memory disorders. In TAMG training, subjects undertook the same training structure and content as that in CAMG. Instead of delivering through a computer, the training materials were delivered by therapists through a face-to-face mode and training was guided by a colour-print training manual which included all corresponding guidelines for assessment and training instructions of each session.

Statistical procedures such as repeated measures analysis of variance (ANOVA) were used to test and compare overtime trend of CAMG, TAMG and CG. They were used to evaluate the positive effect and possible carryover effects of memory performance in different time spots. Both within-group and between-group comparisons were also made on the outcome measures. A correlation analysis was also conducted to explore correlations between TBI subjects' scores in learning strategies and memory processes.

Results: Subjects in CAMG had shown improvement in sub-test items of NCSE-CV, including orientation, comprehension, repetition, naming, construction, memory, judgment ($P < 0.05$). There were similar changes in TAMG. But there was no statistically significant difference between CAMG and TAMG. Comparing with CG, both CAMG and TAMG demonstrated a significant positive effectiveness in NCSE-CV (memory). In addition, attention was the only sub-score that did not change over time and this finding was consistent across the three groups. Some sub-scores (belonging, story-immediate, story-delay, face and total score) of RBMT-CV in both CAMG and TAMG improved ($P < 0.05$ to $P < 0.01$) but not in CG. There was also no statistical significant difference in the total score of RBMT-CV between CAMG and TAMG.

Significant positive changes of HKLLT sub-score related to memory process were identified in both CAMG and TAMG ($P < 0.05$ to $P < 0.01$). But CAMG demonstrated a more significant positive effectiveness ($P < 0.05$) than TAMG in encoding and storage (in both testing conditions of random and blocked). Concrete concept commonly correlated with the encoding and storing (random condition) in both CAMG and TAMG. Abstract concept correlated with storing and retrieval (random condition); and with encoding (blocked condition) in both CAMG and TAMG. In addition, semantic clustering correlated with storing (random and blocked conditions).

When comparing MFQ over time and across the three groups, it was found that there were significant differences between CAMG and CG as well as between TAMG and CG ($P < 0.05$ to $P < 0.01$). After training, significant differences in memory self-efficacy questionnaire were identified in areas of memory competence, evaluation of programme, and more significantly improvement was found in TAMG than CAMG ($P < 0.0001$).

Conclusion: The present study revealed that errorless learning is likely to be an effective method to improve memory performance and function following traumatic brain injury. This memory training mode may affect the whole memory process including encoding, storage and retrieval, and may produce a better carryover treatment effect up to a month. Significant positive correlation was found between subjects' encoding, storage of memory process and learning strategy factors (semantic clustering, subjective organization ability, concrete and abstract concepts). Self-efficacy enhancement was found better in TAMG than CAMG. This benefit might extend to family and/or care-givers who may experience relief, reduced anxiety, and pride when subjects' improvements in functioning, after training, can be evidenced in the daily activities of the participants.

PUBLICATIONS ARISING FROM THE THESIS

Refereed journal publication:

1. **Dou, Z.L.**, Ou, H.L., Zheng, J.L., Man, D.W.K. and Tam, S.F. (2006). Computerized errorless learning-based memory rehabilitation for Chinese patients with brain injury: a preliminary quasi-experimental clinical design. *Brain Injury*, 20(3), 219-225.
2. **Dou, Z.L.,** Ou, H.L., Man, D. W. K., Tam, S. F., and Hui-Chan, C. W. Y. (2006). The effect of errorless learning on memory process for patients with brain injury: A initial study. *Neurorehabilitation & Neural Repair*, 20(1), 89
3. **Dou, Z.L.**, Ou, H.N., Man, D.W.K. and Zheng, J.L. (2005). The application of errorless learning in memory rehabilitation on memory deficit following brain injury: A preliminary quasi-experimental clinical design study. *Chinese Journal of Clinical Rehabilitation,* 9 (1), 84-87.
4. **Dou, Z.L.**, Man, D. W.K, Tam, S.F and Hui-Chan, C.W.Y. (2005). Computerized memory rehabilitation programmes for persons with traumatic brain injury: New development and evaluation. *Brain Injury*, 19 (Suppl 1), 31.
5. **Dou, Z.L.**, Man, D. W.K., Tam, S.F. and Chan, C.W.Y. (2004). Community-based cognitive rehabilitation service for population with traumatic brain injury in China. *International Journal of Rehabilitation Research*, 27(1), 81-84.
6. **Dou, Z.L.**, Man, D.W.K. and Au, H.N. (2004). Rehabilitation of attention deficits. *Chinese Journal of Rehabilitation Medicine*, 19(4), 307-310.
7. **Dou, Z.L.,** Man, D.W.K., Zhu, H., Tam, S.F., & Hui-Chan C.W.Y. (2003). Feasibility investigation of cognitive rehabilitation service after traumatic brain injury in community. *Chinese Journal of Rehabilitation Medicine*, 18(5), 266-268.
8. **Dou, Z.L.**, Man, D.W.K. and Ou, H.N. (2003). Cognitive rehabilitation and theoretical foundations in persons with brain injury: Part I. *Chinese Journal of Rehabilitation Medicine*, 18(10), 625-626.
9. **Dou, Z.L.**, Man, D.W.K. and Tam, S.F., (2003). The development of tele-cognitive rehabilitation. *Chinese Journal of Physical Medicine and Rehabilitation*, 25(9), 568-571.

10. **Dou, Z.L**., Man, D.W.K., Tam, S.F. and Hui-Chan, C.W.Y. (2003). Cognitive rehabilitation of persons with brain injury: PR China scene. *Brain Injury*, 17 (Suppl 1), 169-170.
11. **Dou, Z.L.** (2003). Tele-rehabilitation and its application in Hong Kong. *Chinese Journal of Physical Medicine and Rehabilitation*, 25 (12), 761-762.
12. Ou, H.N. **Dou, Z.L**. (2005). The application of errorless learning on memory disorders rehabilitation. *Journal of Chinese Rehabilitation Medicine,* 29(4), 312-314.
13. Man, D.W.K., **Dou, Z.L**., Tam, S.F. and Hui-Chan C.W.Y. (2004). Efficacy of computer-assisted memory rehabilitation program for persons with traumatic brain injury: Development and evaluation. *Brain Impairment*, 5 (suppl), 173.

Refereed journal submissions:

1. **Dou, Z.L**., Man, D.W.K., Tam, S.F., Ou, H.N. and Hui-Chan, C.W.Y. (2005). The effectiveness of an errorless learning- (EL) and computer-based training programme in memory rehabilitation for those with traumatic brain injury: An initial study. *Neuropsychological Rehabilitation* (under review). 24 pages.
2. **Dou, Z.L**., Ou, H.N., Man, D.W.K., Zheng J.L., Tam, S.F. and Hui-Chan, C.W.Y. (2005). The effect of errorless learning on memory process for patients with brain injury. Journal of Chinese Physical Medicine and Rehabilitation (under review). 16 pages.

Refereed conference presentations:

1. **Dou, Z.L**., Ou, H.N., Man, D.W.K., Zheng J.L., Tam, S.F. and Hui-Chan, C.W.Y. (2005). The effect of errorless learning on memory process for patients with brain injury. *2005 International Conference on Occupational Therapy,* September 16-21, 2005. Qingdao, China. (Oral presentation, Best paper-Golden reward).
2. **Dou, Z.L**., Ou, H.N., Man, D.W.K., Zheng J.L., Tam, S.F. and Hui-Chan, C.W.Y. (2005). The effect of errorless learning on memory process for patients with brain injury. *7th National Congress on Physical medicine & Rehabilitation*, September 9-12, 2005. Shanghai, China. (Oral presentation, Best paper-Silver reward).

3. **Dou, Z.L.**, Man, D. W.K, Tam, S.F. and Hui-Chan C.W.Y. (2005). Computerized memory rehabilitation programmes for persons with traumatic brain injury: New development and evaluation. 6th World Congress on Brain Injury, May 5-8, 2005. Melbourne, Australia. P. 31 (Oral presentation).
4. **Dou, Z.L.**, Man, D.W.K., Tam, S.F. and Hui-Chan, C.W.Y. (2004). Efficacy of computer-assisted memory rehabilitation programme for Chinese persons with traumatic brain injury: an errorless learning approach. *The 28th International Congress of Psychology ICP 2004*, August 8-13, 2004, Beijing, China. p.390 (Oral presentation).
5. **Dou, Z.L.**, Man, D.W.K., Tam, S.F. and Hui-Chan, C.W.Y. (2004) Cognitive rehabilitation programmes for persons with traumatic brain injury: development and evaluation. *The Fourth Pan-Pacific Conference on Rehabilitation: Art and Science of Enablement*, Hong Kong, 24-26 September 2004, p.76 (Oral presentation).
6. **Dou, Z.L.**, Man, D.W.K., Tam, S.F. and Hui-Chan, C.W.Y. (2002). Health care professionals' perceptions of cognitive rehabilitation needs in People of Republic China for population with traumatic brain injury. *Third Pan-Pacific Conference on Rehabilitation*, Hong Kong, 23rd-25th August 2002, p.62 (Oral presentation).

ACKNOWLEDGEMENT

In developing this thesis, I wish to acknowledge the invaluable supervision of Dr. David Man, my Ph.D. chief supervisor and Prof. Alan Tam, and Prof. Christina Hui-Chan my co-supervisors, who offered me extensive support, provided me with numerous constructive suggestions and criticism, and remained a significant source of encouragement right from the beginning. Secondly, I wish to especially thank the previous Department Head and my co-supervisor, Prof. Christina Hui-Chan, who offered me invaluable resource support to my study. I also would like to express gratitude to the technicians and software programmers who worked at Guangzhou city, China and the Department of Rehabilitation Sciences in facilitating the development of the memory training instrument of this research. I would like to thank my students Dr. Ou Haining, Ot. Zheng Jingli and also my helpers, Li Kuicheng, En Ruixue, Chen Shaozeng, Chen Jingsou and Huang Guiqian; who acted as therapists to train the subjects with brain injuries during the project period. I would like to thank Mr. Peggo Lam, who has acted as a statistical specialist to provide me with many instructional suggestions and advise on statistical procedures, so that I may analyze data accurately. I would also like to thank Third Affiliated Hospital and First Affiliated Hospital, Sun Yat-sen University; The Southern Hospital and Zhoujiang Hospital, Southern Medical University; Guangzhou Industrial Rehabilitation Center for their kind support in subject recruitment. Finally, I would like to thank those subjects who had been involved in the present research, and research students such as Mr. Wallance Soong , Mr. Ben Yip and so on, for their kind support to give it every chance of success, for the same opportunity of seeing their gradual improvement over the period of the training sessions have enriched me in putting up my research preoccupations throughout my Ph.D. study.

TABLE OF CONTENTS

LIST OF TABLES

**Quick note:*

CAMG: Computer Assisted Memory Training Group
TAMG: Therapist Administered Memory Training Group
C G: Control group

LIST OF FIGURES

**Quick note:*

CAMG: Computer Assisted Memory Training Group
TAMG: Therapist Administered Memory Training Group
CG: Control group

LIST OF TABLES

**Quick note:*
CAMG: Computer Assisted Memory Training Group
TAMG: Therapist Administered Memory Training Group
C G: Control group

LIST OF FIGURES

**Quick note:*
CAMG: Computer Assisted Memory Training Group
TAMG: Therapist Administered Memory Training Group
CG: Control group

Chapter One

INTRODUCTION

1.1 Background

Traumatic brain injury (TBI) has been defined as an insult to the brain caused by an external force that may produce diminished or altered states of consciousness, which results in impaired cognitive abilities or physical functioning (National Head Injury Foundation, 1988). Such deficits may either affect a single domain of cognition or may involve multiple areas of functioning, including motor skills, attention/concentration, memory, visual-spatial processing, language, problem solving, reasoning, judgment, and planning. Comparatively, the longer-term problems of traumatic brain injury will tend to be cognitive, intellectual, behavioural and emotional difficulties rather than physical problems. This pattern has been confirmed by a number of studies (Barnes, 1999; Lazaro & Butler, 2000; Marsh & Sleigh, 2002). Thus, cognitive rehabilitation should address all kind of issues such that the person with TBI can compensate for their difficulties and learn more efficiently ways to cope with these problems. Innovative and effective methods should be explored in implementing cognitive rehabilitation for this special population of brain injury survivors.

Similar to other well developed countries in the world, there is a high rate of traumatic brain injury (TBI) in mainland China. The injury is mainly resulted from automobile and industrial accidents (Dou, Man, Tam & Hui-Chan, 2004; Wang & Chang, 2001; Zhu &

Wang, 1994). People with TBI have shown great problems with cognition, emotional functioning and behavioural control. Among the estimated six millions of brain injury survivors in PR China, most of their nature of the injury and severity can alter the lifespan life style of individual forever. Survey results estimated that 43.5% (2.61 millions) of them had cognitive problems, in areas such as attention, memory, problem solving, communication etc. The incidence of reported memory impairment was almost 100% (Kelly, 1999; Wang, et al., 2001; Zhu, et al., 1994). These memory problems obviously affect their interpersonal relationships, and abilities to function at home, school or work (Dikmen, Machamer & Temkin, 1993; Miller, 1992; Ylvisaker, Hartwick & Stevens, 1991). In addition, an onset of a brain injury is a dramatic change to an individual's course of life, profound disruptions to his/her family, huge medical and related expenses over a lifetime, as well as a much reduced quality of life (Bergland & Thomas, 1993; Devany & Devens, 1994). It is crucial that patients with brain injury are provided comprehensive rehabilitation especially in the area of cognitive rehabilitation.

Cognitive rehabilitation (CR) is one of the great challenges to contemporary rehabilitation practice. CR attempts to alleviate or ameliorate cognitive deficits that have resulted from brain injury (Wilson, 1989). Traditionally, CR is a set of therapies used to help improve damaged intellectual, perceptual, psychomotor, and behavioral skills. Actually, it is also a system of interventions designed to increase daily functional ability by improving or augmenting deficits in processing and interpreting information and/or by modifying the environment. A standard definition of CR that serves inter- or trans-disciplinary clinical and research purposes does not exist until now. In other words, currently there is no universal definition of cognitive rehabilitation (Carney et al., 1999; Gontkovsky et al., 2002; Wilson, 1997). Furthermore, the terms such as cognitive retraining, cognitive remediation, and cognitive rehabilitation are often used interchangeably, adding to the ongoing ambiguities about these forms of interventions. Berrol (1990) described cognitive retraining as a systematic effort to improve cognitive deficits that disable information processing; whereas, cognitive rehabilitation is conceptualized as a broader process, in which the overall goal is functional adaptation in daily living. Cicerone and colleagues focused on assessment and understanding of the particular patient's brain-behavioral deficits (Cicerone et al., 2000). Brett and Laatsch (1998) describe cognitive rehabilitation as a systematic effort by specialists to aid individuals with brain damage in developing strategies to compensate for cognitive deficits. McGuire (1990) further notes the importance of basing cognitive rehabilitation on underlying theoretical frameworks in order to develop practical methods of intervention.

Among common cognitive deficits, amnesia or memory disorder is the most common problem among persons with traumatic brain injury. Any strategies that can help the smooth and efficient flowing of memory process and that is believed to be able to enhance memory function. Many approaches have been developed to assist recovery of memory function in recent years. These can be summarized as following: (1) internal encoding and retrieval strategies, e.g. visual imagery (Cherry, Simmons & Camp, 1999; Kosslyn, Beharmann & Jeannerod, 1995), verbal elaboration, PQRST technique, computer-based memory training; (2) strategies of teaching domain specific knowledge including method of vanishing cues (Glisky, Chacter & Tulving, 1986b), errorless learning, spaced retrieval, etc.; (3) reducing demands on memory/enhancing the use of external resource, e.g. environment control, reality orientation training, behavioral modification , external aids and so on (Wilson et al., 1997; Wilson, 2000; 2002 ; Wright & Limond, 2004).

The effectiveness of different procedures of memory rehabilitation has also been reported (Günther et al., 2003; Prevey et al., 1991; Tam & Man, 2004). One of the more successful techniques used in rehabilitating people with memory disorders, which have been adopted in the present study, is errorless learning (EL). Baddeley and Wilson (1994) as well as Wilson et al. (1997) have published this EL approach to teach domain specific knowledge to amnesic patients. Error prevention was found to facilitate learning in amnesic patients, and this errorless procedure is beneficial in terms of enhanced learning and reduced forgetting. Squire and colleagues (1997) compared the effectiveness of errorless and errorful learning on verbal paired associates. They found that under immediate recall conditions, the errorless learning method produced more accurate cued recall than the errorful learning method. Many other investigators (Clare et al., 1999; Evans et al., 2000; Hunkin et al., 1998; Kessels & de Haan, 2003; Kern, et al., 2003, 2005; O'carroll et al., 1999; Tailby & Haslam, 2003) have also confirmed the efficacy of using this learning method on different kinds of memory-impaired patients. Although the vanishing cues method is an effective technique to teach the acquisition of complex knowledge to patients with organic memory disorders and that the knowledge acquired by this means is retained by the patients for a long time (Glisky, 1995), a meta analysis on errorless learning and vanishing cues methods showed that the errorless learning technique is effective in amnesic patients. The effects on the vanishing cues method are only small (Kessels & Haan, 2003).

On the other hand, the application of computer-assisted rehabilitation is getting more and more over the past decade. In the field of computer-assisted cognitive rehabilitation (CACR), computer is playing an increasingly important role (Chen et al., 1997). Numerous computer-based cognitive rehabilitation/retraining programmes have surfaced that purport to provide treatment at a level equivalent to or better than that of more traditional modes of intervention (Bergman, 2002; Gontkovesky et al, 2002). Many clinicians, in fact, have recommended using computers as an efficacious tool in cognitive rehabilitation for more than a decade (Johnson, Thomas & Shein, 1994; Lynch, 2002). Human - computer interaction (HCI) or man –machine interaction (MMI) is now becoming a better realized mode as computer and multimedia techniques are being utilized widely. HCI is concerned with design, evaluation and implementation of interactive computing system for human use and with study of phenomena surrounding them. Thus HCI can be a fit and adaptation process between human activity (such as human memorizing) and computer use. The interactive computing system include two domain components, a) input and devices of computer, dialogue techniques, computer graphics etc; b) feedback that human accept from computer, feedback could be present in form of icon, sound and computer graphics (Barker, 2003; Deb Roy & Alex Pentland, 2002; Wood, 2001).

In the present study, training of memory function was presented as computer software, which could enhance patients' motivation not only through color and symbols on computer screens, but also through adaptive training that had been challenging but not frustrating. Direct feedback of performance gave patients a sense of success. The programme could provide either pure repetitive exercise or support the use of mnemonics strategies (Glisky, 1995). The programme therefore implicitly suggested that practicing either memory tasks or certain strategies would improve general memory performance.

In addition, cognitive rehabilitation can begin in the hospital with the provision of formal inpatient and outpatient rehabilitation services. It can then be extended to a variety of outpatient or daycare (Dittmar, 1997), home or community-based services (Jordan, 2000). The mode of treatment also varies, from basic stimulation, structured programme to home-based ones (Jordan, 2000). Apart from conventional face-to-face therapist-led training (Johnson, et al., 1994; Man, 1997), innovative computer-assisted programmes (Gontkovesky, et al., 2002; Man, Tam, & Hui-Chan,, 2003; Sivak, Hills, & Olson, 1984) and tele-rehabilitation services (Martin, 2000; Tam, Man, Hui-Chan, Lau, Yip, & Cheung, 2003) have been attempted, and have demonstrated initial successful outcomes (Ben-Yishay & Diller, 1993; NIH Consensus Developmental Panel, 1999; Lee, Powell, & Esdaile, 2001). However, development of cognitive rehabilitation is still quite green in most developing countries including the largely populated mainland China (Dou, et al., 2004; Dou, Man, & Tam, 2003; Tam, et al., 2003). It was recently surveyed on the feasibility of launching cognitive rehabilitation services (CRS) in the Guangzhou area of China. It was a preliminary investigation of the level of knowledge and acceptance by health care professionals of using computer-assisted and web-based training methods, as well as conventional face-to-face and community-based strategies (Dou et al., 2004). The four most urgently required CRS areas were identified as: language, memory, orientation and attention rehabilitation. The relative appropriateness of settings for such CRS delivery was ranked, from most to least, as the home, hospital and community, respectively. In prioritizing the modes of CRS, it was suggested that the order of preference would be face-to-face, computer assisted and online/web-based. Home-based intervention was also ranked top among the service treatment settings. All these findings might hint the development of computer-assisted memory rehabilitation for China's increasing need in cognitive rehabilitation and for the persons with brain injury.

1.2 Overview of the study

Over the past two centuries, there have been several accounts of the positive effects of environmental stimulation and enrichment on the brain and brain function (Greenwood & Parent, 2002; Renner & Rosenzweig, 1987; Tierney, 2004). Post-injury enriched environmental (EE) has been shown to alter functional and anatomical outcomes in a number of injury paradigms, including traumatic brain injury (Griesbach, et al., 2004; Hamm, et al, 1996; Passineau, Green & Dietrich, 2001). The learning is identified as a critical component of the enriched environment. The mediator of the morphological changes is seen in the cellular mechanisms underlying learning processes in the 'learning and memory' hypothesis (Rosenzweig, 1996), and the learning-and-memory hypothesis is favoured by many investigators (Aggleton & Brown, 1999; Easton et al., 2002; Gaffan, 2001; Packard & Knowlton, 2002; Poldrack & Rodriguez, 2004). Studies showed that memories of familiar environments can survive after brain damage. Thus, an enriched environment has also important effect on memory process.

On the other hand, people with memory deficits need to learn new information, and studies show that it is possible to use well-documented strategies that enhance the learning or recall. Among these learning strategies mentioned above, the errorless learning (EL) technique is one of the effective methods used in training people with memory disorders. In this study, researchers designed, using an open system model, to guide the development of innovative memory retraining. This mode is a combined use of errorless learning and enriched environment, i.e. EL&EE model.

Human memory can be labeled as sensory, short-term (working memory), and long-term memory (episodic versus semantic memory). It can also be a dynamic process comprising of encoding, storage and retrieval of information. Both memory types and processes are inter-dependent on each other. The proposed EL&EE model in the present study hypothesizes that memory strategies may affect directly or indirectly on these memory structures by providing sufficient, relevant, stimulating information to the memory system for best processing.

The study also borrowed the advantages of computer-assisted cognitive rehabilitation (CACR), an instructional technique using computer, which targeted in improved learning among individuals with memory impairment. Recent releases that set a new standard for those producing memory retraining software are the one deal with the ubiquitous problem of recalling names and faces, whereas the other focuses on an equally troublesome memory failure: prospective memory (Lynch, 2002). Both programmes are provided on CDROM, and there is a companion CD entitled “The Nature of Memory,” which can provide patients and families with interesting and useful information regarding how memory works, and the history of memory. But, this kind of memory retraining software which has been based on western language, cultural background, social environment and lifestyle etc. were not used in the present study. Instead, Chinese idioms containing abundant literary quotation have been developed as part of the memory training material. As Chinese receive these idioms story since childhood, and this information can remain in memory for the whole lifetime. It is suggested as very good materials of memory retraining. Thus a set of new software has been developed and it is composed of 20 sessions in total. This software has been tailored made for Chinese clients with memory disorders in the present study. This package possesses four key features: a) it is based upon an EL&EE model; b) it is high relevancy to Chinese cultures, such as the use of poem of Tang dynasty and Chinese ancient idioms; c) participants have opportunity to practice exercises at different and gradable levels of difficulties; d) every session is independent relatively, but they are kept in consistent structure with the rest of the whole content.

In short, the proposed EE&EL model guided the provision of important multiple sensory outputs in an interactive enriched environment provided by a computerized system. A basic assumption is that the human memory information processing framework involves a series of stages that learn between a display and an appropriate response to the information in the display. The rich and colorful user interfaces are developed through an iterative design process consisting of repeated cycles of (re)design, implementation of Chinese cultural-relevant background materials, graphics, video of real work contexts. All these are also based on errorless learning rules It was anticipated that, this model was not only able to generate standard displays of simple visual features (as for testing performance in visual search tasks), but it was also designed to generate multiple point motions using a computer-aided format (called Flash) for tracking multiple points in a dynamic display. Researchers hoped that the project led to good functional outcomes which were related to learning ability, behavioural change, reducing forgetting, problem-solving in real life situation.

The present study thus aimed to develop and evaluate a newly developed computer-assisted memory training programmes for traumatic brain injury (TBI) survivors, which was theory-driven by errorless learning theory, neuroscience theory of "enriched environment", and focused on related memory structures and processes in encoding, storage and retrieval of memory function. A pre-test and post-test control group quasi-experimental clinical design study was adopted. Eighty-four subjects with brain injury with memory disorders were recruited and randomly assigned to two intervention groups (computer-assisted memory retraining groups or CAMG, and face-to-face therapist-administered memory retraining group or TAMG respectively) and a control group (CG). The two different intervention groups (CAMG, n= 30; TAMG, n= 24) received one-month (20-session) training programme which was identical in training content and was errorless-learning based, plus one month follow up. The control group (CG, n=30) did not receive specific training except receiving the cognitive outcome measurements under the same timeframe. It was hypothesized that positive treatment effectiveness would be exhibited in the two memory training modes respectively (i.e. computer-assisted and therapist-administered) but not in the CG. It was hoped that the results of the present study could provide original in-depth practical understanding of the application of EL & EE mode in memory rehabilitation. It was envisaged that the results might be pioneering the evidence-based development of memory rehabilitation in mainland China, integrating the western research findings on cognitive rehabilitation with the contemporary Chinese mode of service delivery system. This new development may be a useful guide to lead the future application of cultural relevant, computer-assisted cognitive rehabilitation services (CRS) in China too.

1.3 Statement of purpose

1.3.1 Aims of research

1. To develop and implement a computer-assisted memory rehabilitation programme (CAMG), based on a postulated EE & EL model (enriched environment and errorless learning) and through the use of comprehensive cognitive skills/training principles, for persons with traumatic brain injury (TBI) so as to improve their impaired memory functions,
2. To evaluate the efficacy of this computer-assisted memory rehabilitation protocol through formative and summative evaluations.
3. To evaluate the effectiveness of this computer-assisted memory protocol through assessing outcomes such as the subjects’ skills in applying the errorless learning principles, their functional independence, and compared to

the outcomes with therapist-administered memory training group (TAMG) and a control group (CG) .

1.3.2 Research questions

1. Did the use of an EE & EL mode implementing on a computer-assisted memory rehabilitation programme help Chinese subjects with TBI achieve better memory skills, functional independence and self-efficacy?
    a. What were the impact of EL & EE model on the memory processes in encoding, storage and retrieval, within a Chinese cultural background?
    b. How would the subjects' self-efficacy evaluation vary in different memory training programmes?
    c. Were there any significant differences in subjects' self-efficacy after training by the computer-assisted memory rehabilitation programme?
2. Were there any significant differences in memory treatment effectiveness among the three delivery groups of CAMG, TAMG and CG?

The treatment effectiveness of the 4-week CAMG, TAMG, and CG were compared in terms of quantitative and qualitative outcome measures and they should be valid and reliable to Chinese subjects. The subjects' basic cognitive state and memory functional status were assessed before and after the retraining. Follow-up assessment was conducted 4 weeks after the last session training.

The outcome measures included subject's memory performance and memory processes (encoding or acquisition, storage or retention and retrieval), functional activities in memory cognitive performance etc. The subject's knowledge and concepts of independent cognitive functions were thus measured by the Chinese version of Neurobehavioral Cognitive Status Examination (NCSE-CV or Cognistat; Chan et al., 2002). The ability to remember a functional activity or to perform a functional skill that required subjects' memory were measured by the Rivermead Behavioral Memory Test – Cantonese version (RBMT-CV; Wilson, Cockburn & Baddeley, 1989; Neuro-Rehabilitation Working Group, 1998), while the subjects' learning strategies and memory processes as well as their correlation were measured by the Hong Kong List Learning Test (HKLLT, Chan & Kwok, 1999). The subjective evaluation in applying the learned memory strategies in community or home were measured by the Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski & Schaie, 1990) among the CAMR, TAMR, and CG groups. Information on subjective evaluation of perceived usefulness of the memory training based on EE & EL model in both CAMG and TAMG were also assessed by a specific designed self-efficacy questionnaire in the present study.

1.3.3 Study significance and value

Traumatic brain injury (TBI) is frequently a lifetime disability with varying rehabilitation needs over that lifetime. Cognitive rehabilitation is considered as the extension of basic physical training. Its development would complement the reality of functional improvement cater to their real needs at different stages of recovery and adjustment in their social environment. The development of cognitive rehabilitation programme would have a strong impact in PR China where the largest disabled population is found and the need of CRS is pressing. CRS development is also going along the Chinese policy of promoting quality rehabilitation programmes for best integration of rehabilitation services within the same region.

Another important value is the consideration of cost-effectiveness. The cost of computer-assisted rehabilitation in the long run can be less than that of therapist led face-to-face hospitals or rehabilitation settings, though it is understood that their crucial role during initial acute phase centres cannot be undermined. In PR China, most of the patients with TBI will stay at hospital only temporarily after their accidents. They have to return home due to lack of financial support. Therefore the development of a feasible, computer-assisted rehabilitation model may be especially suitable for Chinese situation in the viewpoint of the cost-effectiveness.

1.4 Outline of subsequent chapters

There are altogether six chapters in this research project. After this introductory chapter, chapter two will give a general review of the literatures on cognitive rehabilitation in persons with traumatic brain injury, with a focus on memory dysfunction. Chapter three presents a conceptual framework of “enriched environment and errorless learning” (EE & EL) in postulating the development of a computer-assisted memory training programme (both the structure and process). Chapter four describes the methodology which outlines the detailed aims and objectives of developing a relevant training programme for Chinese persons with a traumatic brain injury and having residual memory problems. Data analysis, the procedures of conducting pilot and the main study will also be covered.

Chapter five presents the data analysis results and hypotheses testing. Chapter six presents the discussions of the results of the present study, including a comparison the present results with the existing theoretical understandings, possible explanation of the effectiveness of the memory retraining in the three respective delivery modes, summarizing the effect of subjects' pre-training characteristics on training outcomes, etc. Limitations and implications of the present study are also discussed.

Chapter Two

LITERATURE REVIEW

This chapter covers three main parts, namely the literatures related to:

1. Traumatic brain injury (TBI), associated memory problems and an outline of memory rehabilitation strategies;
2. Related cognitive rehabilitation theories, in particularly the therapeutic effects of enriched environment on memory function and for persons with brain injury; and
3. Specific memory rehabilitation strategy using an eclectic, errorless-learning based and computer-assisted programme.

The literature review also serves the purpose to develop a rationale for a conceptual framework (to be elaborated in more details in chapter 3) which guides the development of a theory-driven computer-assisted memory training programme in the present study. This newly developed memory training programme was envisaged to provide effective training of patients who had survived a brain injury and had associated memory deficits.

2.1 Review of cognitive rehabilitation following brain injury

2.1.1 Basic concept of cognition, cognitive deficits and cognitive rehabilitation

Cognition is commonly defined as the “the process of knowing” (Prigatano, 1986). It is involved in perceiving, discrimination, memory, attention, learning, understanding, reasoning and judging etc. The cognitive deficit is a impairment to one or more of the cognitive processes, resulting in lose of efficiency or reduction of function (Wilson, 1989). Cognitive rehabilitation refers to the therapeutic process of increasing or improving an individual's capacity to process and use incoming information so as to allow increased functioning in everyday life (Sohlberg & Mateer, 1989). Pragmatically, cognitive rehabilitation can be any programme of guided therapy to learn (or relearn) ways to concentrate, remember, and solve problems after an illness or brain. It involves recovery of brain impairment through restoration of skills and compensation of lost skills by various kinds of strategies or aids. Therapy can be provided at the individual's home, school, or work site.

2.1.2 Cognitive deficits in traumatic brain injury (TBI)

Traumatic brain injury (TBI) often results in multiple physical and neuropsychological deficits including reduction in intellectual capacity, disorders of language and perception, impaired attention, and personality changes. Changes in memory, attention, and concentration are often a result of cognitive impairment (Cope, 1995). Changes in cognitive dysfunction may range from mild to severe (Carney, Chesnut & Maynard, 1999). Difficulty in planning and initiating activities, carrying out tasks of daily living, and work are also reported (Wilson, 2002). Major cognitive deficits of TBI have been outlined as below (Bennett, Dittmar & Ho, 1997):

1. decreased speed and efficiency of information processing e.g. thinking, overall slowness of mind (a problem in keeping with and entering into conversations);
2. disrupted attention and concentration;
3. problems with learning and memory;

4. perceptual disturbances, loss of senses of self;
5. disorders of communication;
6. difficulties with executive functions difficulty in implementing plans and follow through, ability to make decisions); and
7. decrease general intelligence.

However, a particularly salient and enduring problem is memory impairment among patients with moderate to severe TBI (Levin, High, & Eisenberg, 1988; Wilson, 1992). The memory impairments can hinder the ability to recall previously learned information or experiences, to remember recent events, or to acquire new information and skills. Long after most physical disabilities have reached stabilization or recovery (Brown, Darling, & Hardman, 1997; Paul, Joseph, & Todd, 2002), lingering memory problems prevent many survivors of brain injury from returning to active employment, independent living, or full social lives (Hutchinson, 1997).

2.1.3 Cognitive rehabilitation strategies

Therapeutic strategies of cognitive rehabilitation have been classified as either restorative or compensatory (Neistadt, 1990). Restorative cognitive rehabilitation (RCR) training is based on the theory that repetitive exercise can restore lost function. Restorative training focuses on improving a specific cognitive function. Compensatory cognitive rehabilitation (CCR) strives to develop internal substitutes and/or external prosthetic assistances for specific cognitive function, its training focuses on adapting to the presence of a cognitive deficit (N.I.H. Consensus Developmental Panel, 1999). In actual clinical practice, the two strategies do not exist independent of each other in management of patients' cognitive problems but rather complimenting to each other (See in Figure 2.1)

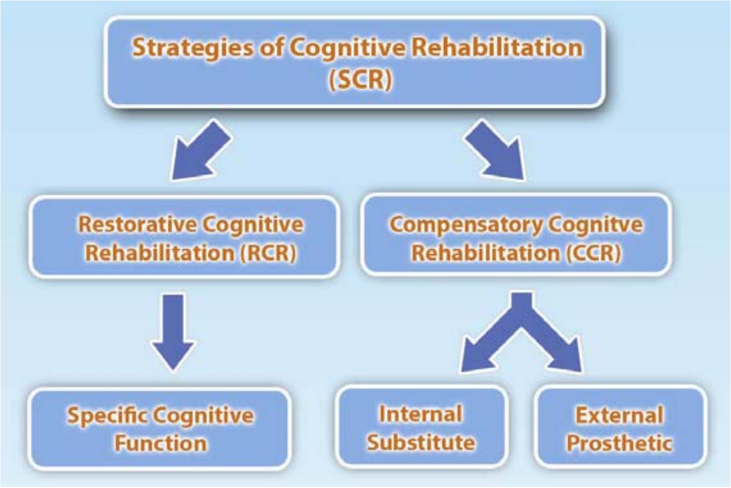


Figure 2.1 Simple classification of cognitive rehabilitation (by Neistadt, 1990)

2.2 Cognitive rehabilitation theories

More elaborative theories have been explored such that cognitive rehabilitation in the present study can be based on scientific theories of brain functioning, cognitive neuropsychology, speech therapy techniques, and neuropsychological assessment findings (Perna, Bekanich & Williams, 2000). The subsequent paragraphs outline the theoretical foundations for cognitive rehabilitation and the major theories to be described include:

1. Neuroplasticity and enriched environment;
2. Information processing theory;
3. Context-focused theory; and
4. Theory on spontaneous recovery.

These theories are based a great deal on literature review, and serve as the relevant guidelines in the development of treatment principles and memory training programmes adopted in the present study.

2.2.1. Neuroplasticity and enriched environment (EE)

Neuroplasticity refers to the ability of neurons to changes their function, chemical profile (amount and types of neurotransmitters produced), or structure (Woolf, Clifford & Salter, 2000). Thus, upon brain lesion, the neuro-tissues are postulated to be capable of performing anatomical reorganization so as to regain lost functions. Neuroplasticity is related to different factors such as age, type of lesion, severity, intensity and duration of rehabilitation and so on. One of the important attributes to good recovery relates to environmental factors closely. For example, the proposed application of an enriched environment (EE) in the present study, and it is “the combination of complex inanimate and social stimulation” (Rosenzweig, Bennett & Hebert, 1978). This definition implies that the relevance of single contributing factors cannot be easily isolated. There are good reasons to assume that it is the interaction of factors which is an essential element of an enriched environment, not any single element that is hidden in the complexity. Controls for the importance of single variables on the effects of enriched environment have been tested, particularly for the effects of socialization and general activity (Bernstein, 1973). For example, in a recent study, mice were assigned to living condition of different groups: group with a learning task, wheel running (containing a running wheel for physical exercise), enrichment (consisted of social interaction, stimulation of exploratory behavior with objects such as toys and a set of tunnels, and a running wheel for exercise) or standard housing respectively (van-Praag, Kempermann & Gage, 2000). Both enrichment and voluntary exercise were found to enhance the survival of newborn neurons. Learning group did not affect cell survival, and this result was similar to control (standard housing). The results have revealed that no single variable can account for the consequences of enrichment.

The relationship between "enriched environment" and brain plasticity has, in fact, been researched widely and deeply. There are countless dramatic evidences that environment influence brain development and recovery after traumatic brain injury (Sargeant, Webster & Salzman, 2000; Wagner, Kline & Sokoloski, 2002), as well as the improvement in memory and learning. It is known to enhance cognitive recovery and is felt to correlate with some physiological aspects of clinical rehabilitation process, increases neuron size and density (Kolb, Forgie & Gibb, 1998; van-Praag, Kempermann & Gage, 2000). Alterations in synapses, (including recovery of synaptic effectiveness, denervation hypersensitivity, synaptic hypersensitiveness and unmasking of silent synapses, the synthesis of new proteins and growth of new synaptic connections), activity-related changes in neurotransmitter release, functional reorganization of the cerebral cortex, provide powerful morphological evidence for cognitive rehabilitation following brain injury. Investigators also found that training or differential, enriched experience led to significant changes in brain neurochemistry or biochemistry, anatomy, electrophysiology. The following sub-sections present further reviews of experimental research progress and important findings in the field of neuroplasticity, before the next review on information processing theory.

2.2.1.1. The effect of enriched environment on intact brain

Improved learning and memory. The enriched environment has been shown to enhance memory function in various learning tasks (Renner & Rosenzweig, 1987). Mice in enriched environment also did better on the watermaze task (a test of spatial memory) than controls in standard housing did (Kempermann, Kuhn, & Gage, 1997). Similarly, voluntary wheel running and treadmill training had been shown to enhance spatial learning (Van Praag, Kempermann, & Gage, 1999). In the exercise studies, differences between sedentary and active animals were best observed when tasks were made more challenging. In addition, when tested on a different spatial memory task (a T-maze), enriched rats did better than isolated rats with a running wheel. So, the degree of learning improvement might be greater following enrichment that includes exercise than exercise alone. However, direct comparisons on several memory tasks between running and enriched groups were needed to draw definite conclusions.

Anatomical changes. Both enrichment in environmental stimuli and exercise can enhance the number of new neurons in the dentate gyrus. The brain can literally grow new connections with environmental stimulation. However, the mechanisms by which new cells are generated might differ between the two conditions. Enriched living only affects cell survival and does not affect cell proliferation. By contrast, running increased cell division and net neuronal survival in C57BL/6 mice, cell proliferation and survival might therefore be regulated differently by different behavioural or environmental manipulations within a constant genetic background (Kempermann, et al. 1997). Apart from their effects on the production of new neurons in the dentate gyrus of the hippocampus, both enrichment and exercise result in further morphological changes. Brain cortex become thicker, more dendritic branching, more growth spines and larger cell bodies are reported (Diamond, Linder, Johnson, Bennett & Rosenzweig, 1975).

Effects of growth factors. During development, growth factors provide important extracellular signals regulating proliferation and differentiation of stem and progenitor cells in the central nervous system (Calof, 1995). Several of these factors have also been suggested to function in learning and synaptic plasticity, in particular NGF and BDNF (Kang & Schuman, 1995; Figurov, Pozzo-Miller & Olafsson, 1996). So, there seems to be some overlaps in the expression of these factors in enrichment, running, learning and neurogenesis. The mechanism of action and the cause and effect relationship between these factors remain to be determined.

2.2.1.2. Effect of enriched environment on damaged brain

The functional and anatomical changes. Postinjury enriched environment (EE) has been shown to alter functional and anatomical outcomes in a number of injury paradigms, including traumatic brain injury (TBI). Passineau et al. (2001) examined the effect of EE on behavior and on the histological integrity of brain tissue selectively vulnerable to brain trauma created by the fluid percussion injury (FPI) model. This severe FPI model includes posttraumatic ischemia within the thalamus, hippocampus, and medial and parietal cortices. In addition, contusions are seen within the lateral parietal cortex, fimbria of the hippocampus, and subcortical white matter, as well as neuronal necrosis in the subculum and CA3 regions of the hippocampus. Using the severe, parasagittal fluid percussion injury (FPI) model, the experimental results showed that injured rats recovering in the enriched environment showed significantly ($P < 0.05$) shorter latencies to find the platform in a Morris Water Maze task versus injured/standard animals on day 12 post-TBI. There were no differences between the sham/enriched and sham/standard groups. No significant group differences in swim speed were observed. At 14 days post-TBI, enriched rats had approximately twofold smaller lesion areas in regions of the cerebral cortex posterior to the injury epicenter compared to injured/standard rats. In addition, overall lesion volume for the entire injured cortical hemisphere was significantly smaller in rats recovering in the enriched environment. This study illustrated that environmental factors and activity could influence the functional outcome, tissue integrity, and possibly the recovery of brain-injured rats. In short, this animal study illustrates that environmental factors and activity can influence the functional outcome, tissue integrity, and possibly the recovery of brain-injured rats. Passineau et al (2001) suggest that while the primary injury mechanisms have produced an adequate amount of tissue perturbation in both groups to cause widespread reactive astrocytosis, EE is acting to attenuate delayed tissue destruction and preserve the integrity of the neuropil. Another possible interpretation of this data is that the tissue destruction is equivalent in both groups, but that exposure to the EE causes a plasticity response in the rats which causes sprouting of new axonal–dendritic connections within the lesion cavity. It is intriguing to think that these new neuronal cell processes and the new synapses they form might also be functional, contributing to the improved performance of the EE/TBI animals versus the standard/TBI group.

The biochemical changes in molecular level. Enriched environment have also been shown to alter a number of brain parameters, in addition to cell proliferation (Kempermann, et al. 1997; Young, Lawlor & Leone, 1999). For instance, growth factor expression (Falkenberg, Mohammed & Henriksson, 1992; Torasdotter, Metsis & Henriksson, 1998), protein kinase C activation (Paylor, Morrison & Rudy, 1992) and metabolism (Gonzalez-Lima, Ferchmin & Eterovic, 1994) were reported. EE paradigms differ from one laboratory to the next, but voluntary exercise, social interaction, and visual novelty are common themes. Studies of experience dependent behavioral plasticity have demonstrated that enriched environment induces changes in neurotrophin expression (Ickes et al., 2000). Environmentally induced changes in protein levels of nerve growth factor (NGF) have been documented and they have also found that there is an increased expression of hippocampal mRNAs for NGF, brain-derived neurotrophic factor (BDNF), and neurotrophin-3 (NT-3) following enriched environment. These environmentally induced changes in brain neurotrophin levels were associated with improved spatial learning and increased exploratory behavior.

To summarize, environmental conditions play a powerful role in the basic activity level of the brain and that long-term alterations in the level of external stimuli lead to profound alterations in the production of neurotrophic factors throughout the brain. These neurotrophins can then ultimately affect the physiological, morphological, and behavioral efficiency of the brain. Increasing the basal activity level of the brain by external stimulation can therefore be seen as a viable therapeutic approach, since the environmental stimuli appear to alter the basic levels of neurotrophic factors and this enhancement can in turn affect recovery of damaged neurons.

2.2.1.3. Clinical significance of EE

Environment stimulation has been rightfully compared to a brain “nutrient”. The outside world is the growing brain’s real food. It also feeds the brain. In other words, as we vary the type of “training” environment, the brain varies the way it develops. Literatures, especially animal studies, have shown significant relationship between “enriched environment” and the improvement of cognitive ability. There are, though limited studies, that are related to human subjects, too. For example, studies from fMRI examinations and clinical observation. The cognitive stimuli in the EE are particularly interesting for the problem of human head injury. Many patients who suffer from severe, long-lasting memory and cognitive deficits are non-ambulatory. However, there is some evidence that the recovery of memory function can be enhanced by certain forms of mental activity (Carney, Chesnut & Maynard, 1999; Goldstein & Levin, 1995). In hospitals, a controlled study found that patients with “a view room” recovered faster than those who stared at a brick wall. The stimulation apparently affects more than well-being. We also found that when clients receive cognitive training in environment that are familiar to them e.g. their own living environment or work place, their cognitive ability will improve much better. EE may therefore serve as a metaphor for what may be achievable in human traumatic brain injury (TBI). But it is difficult to measure and quantify. It is clearly that further investigation on human subjects would help future conceptualization of the research problem.

Many cognitive theories have proposed on how enriched environment affects the brain. One of them is the ‘learning and memory’ hypothesis (Rosenzweig, et al., 1996). The mediator of the morphological changes has been seen in the cellular mechanisms underlying learning processes. The emphasis of this hypothesis is on teaching/learning strategies in a variety of different environment, including culture, social, and physical environments. Different environments elicit different information-processing demands. It would result in the reorganization of the multiple levels of brain integration. The computer-assisted cognitive rehabilitation, for instance, is based on this view and was adopted as a training modality in the present study. Thus persons with brain injury, when being trained with familiar material (basic and functional memory task), can improve ability to function through relearning/adaptation and under an enriched surrounding that can be created by the computer programming.

2.2.2. Information processing theory

One of the soundest information processing theoretical principles is Luria’s functional classification and blocks of the brain. His theory, in fact, formed the theoretical foundation for cognitive rehabilitation. Luria (1980) suggested that central nervous system (CNS) processes information in three stages. Firstly, the nervous system registers the stimulus event. Secondly, at the analysis level, the system interprets and organizes the raw sensory information. Finally, at the hypothesis formation level, the system compares the stimulus with experiences in long-term memory and relates the stimulus to the overall purpose and goal. Failure in processing can occur at any point of these three stages of information processing. This information processing is compatible with Luria’s concept of brain blocks. The brain is divided into three blocks: The first block includes the brain stem and the old cortex. It regulates wakefulness and the response to stimuli. The second block, including the temporal, parietal, and occipital lobes plays a key role in the analysis, coding, and storage of information. The third block or frontal lobe is involved in the formation of intentions and programs. All three blocks work together in any given task. Luria theorized that recovery of function can occur through new connections established.

Information processing theory can be a type of model of cognitive rehabilitation in the use of teaching/learning tools (Cope, 1995). This is because the persons with brain injury have less available processing capacity than the normal persons. The amount of information that can be assimilated at any one time is significantly reduced. Persons with brain injury have also difficulties structuring and organizing information. Strategies to efficiently process information are not employed automatically. Clinically, the patients may not automatically attend to the relevant features of the task, to group similar items together, to formulate a plan, or to break the task down into steps. Therefore, it is through cognitive retraining specifically targeted at the sources of problems can facilitate the rate of recovery. The emphasis is on broadening person’s ability to handle increasing amounts of information by incorporating efficient mental strategies and developing an efficient behavioral repertoire.

2.2.3. Context-focused theory

It is defined as a context-sensitive framework which is different from traditional approach (Ylvisaker, Hartwick & Stevens, 2002). Contextualized approach focuses on impairment, disability (functional activity), and/or handicap (participation). Primary goal is to help individuals achieve their real world objectives and participate in their chosen real-world activities blocked by cognitive impairment. This flexible approach might include any combination of the following interventions: (1) Impairment-oriented interventions designed to improve real-world functioning by restoring cognitive functions with de-contextualized retraining exercise (if there is good reason to believe that retraining exercise odd restorative potential). (2) Activity (disability)-oriented interventions designed to improve real-world functioning by helping the individual to compensate for chronic cognitive impairment (if there is good reason to believe that strategic compensation is possible, and to improve performance of specific, functional tasks, thereby reducing disability without necessarily reducing the underlying impairment). (3) Participation (handicap)-oriented interventions designed to lessen the impact of cognitive disability on real-world status and functioning by engineering the individual's environment to reduce the impact of cognitive disability and by modifying the expectation and supportive behavior of everyday people in the individual's life (i.e., providing education, training, problem solving, and other forms of support). In recent years, this approach has evolved as a consequence of research and clinical experience with individuals with TBI, findings and theoretical developments in cognitive science, and reflection on related intervention research and trends in fields with a longer history of service and outcome research.

Context-focused theory have been supported by many studies which tend to conclude that special expertise lies primarily in domain-specific knowledge, domain-specific strategies, and domain-specific motivation to be strategies, and domain-specific motivation to be strategic, rather than superior cognitive processing abilities in the abstract. One explanation for the relative domain specificity of cognitive skill is the frequent finding the efficiency and effectiveness of information processing is in large part contingent on domain-specific declarative and procedural knowledge and its organization.

At a high level of generality (e.g., scripts, plan, general schemas), knowledge structures (e.g., managerial knowledge units) are generally associated with frontal lobe function. Damage to these knowledge structures slows down information processing; and social behavior; interferes with directed and sustained attention; and causes ineffective encoding, storage, and retrieval of information. Based on this context-focused theory and principles, the present study's conceptualization or programme development addressed on how to promote transfer of training, and facilitated task completion through everyday life activities in different functional levels.

2.2.4. Theories on spontaneous recovery

Spontaneous recovery, particularly following traumatic brain injury, is a commonly observed phenomenon. Spontaneous recovery may occur because the patient's environment continues to stimulate them in more or less than the same manner (Corrigan & Yudofsky, 1996), thereby including an automatic compensation, substitution, regeneration or reorganization within the central nervous system. This re-growth can result in some return to function. Some neuronal tracts that lose stimulation from neighboring damaged areas become hypersensitive to the action potential of the remaining axons. The hypersensitivity may diminish loss of function related to the damaged area. The individual differences are most relevant to spontaneous recovery. They include cerebral dominance, location of lesion, extent or magnitude of neurological damage, time post-onset, age at injury, rate of improvement immediately following injury, and premorbid level of functioning, demographic variable, as well as "milieu" (geographical and social situation). An essential component of cognitive rehabilitation and in devising an eclectic strategy should include a theory about recovery. The more clearly a deficit can be articulated, the more effectively it can be treated. It is clear that for cognitive rehabilitation to be successful, the clinician must have knowledge of the impaired cognitive system, how it should function, and where in the information processing process it is disrupted. Once clarified, it has usually been up to the therapist's ingenuity to devise a treatment that will improve the impaired ability.

To sum up, there are still considerable controversies surrounding what is the best method to ensure maximum learning of real-life skills, how to implement it, and how to measure its components in cognitive rehabilitation studies following TBI (Bajo & Fleminger, 2002; Carney, et al., 1999). According to the above-mentioned theories, there have been streams of theoretical development that have shaped and promoted the modern rehabilitation progression.

2.3 Memory problems in TBI

The following section outlines basic memory literatures so that the memory deficits and its management can be discussed further. Assessment and intervention of memory deficits in persons with TBI will follow, and ultimately errorless learning and computer-assisted approaches will be described and suggested as an eclectic approach in the present study.

2.3.1 Types of memory

There are different types of memory. In general, it is labeled sensory, short term (working memory), and long-term memory (declarative and non-declarative memory) (See Figure 2.2).

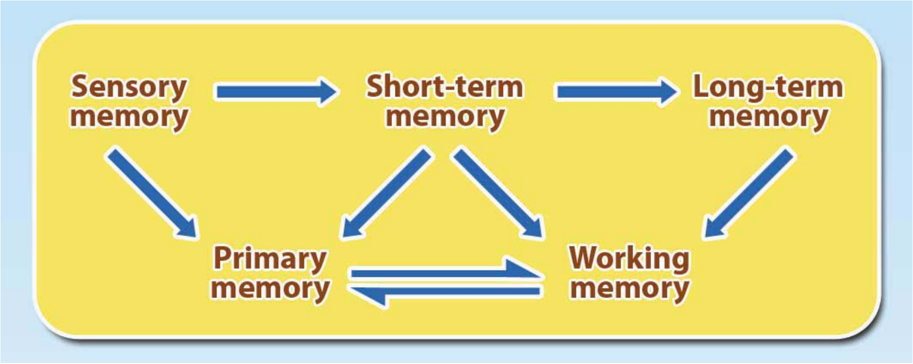


Figure 2.2 Types of memory

Sensory memory is a large capacity, short term store of information specific to a sensory modality (visual or iconic memory and auditory or echoic memory). The more commonly described memory structure is working memory (WM) which commonly refers to the cognitive process that enables individuals to maintain and manipulate a limited amount of information over a brief period of time (Baddeley, 1986 & 1992). The term working memory replaces (or updates) the term short-term memory (STM) in that WM represents an active form of information processing; whereas short-term memory represented more of a passive store. When WM is being used to solve a problem or perform a task (Cowan, 1996), it differs from STM in its emphasis on functional operations and inclusion of multiple subsystems. As such, WM is a critical component for a variety of cognitive skills, such as problem solving, planning, and active listening (Jonides, 1995). In addition, WM also plays a key role in many everyday activities that there are essential for occupational functioning (e.g., engaging in a telephone conversation while taking notes) and scholastic activities (e.g., mental arithmetic). Individuals with significant WM deficits have great difficulty recording features from a changing environment and keeping them in mind to guide behavior (Smith, Jonides & Koeppe, 1996). In addition, everyday activities, such as writing and reading comprehension, may be affected by impairment in WM (Engle, 1996). According to Baddeley (1986), WM has two types of components: storage (phonological loop and visuo-spatial sketch pad) and central executive functions (see Figure 2.3).

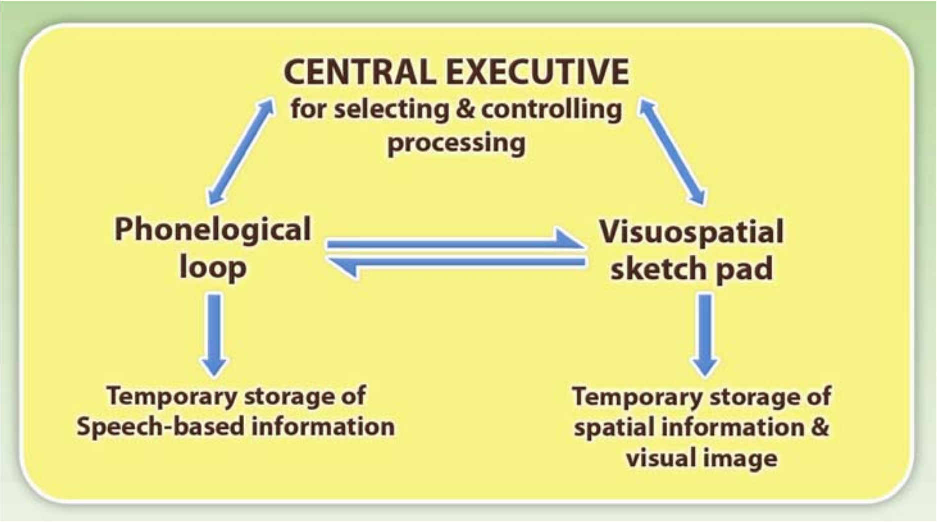


Figure 2.3 Baddeley & Hitch's model of working memory

Impairment in WM or STM presents a "bottleneck" which prevents the addition of new information to long term storage. WM is therefore thought of as a key step in the encoding of information and the transfer of this information into episodic memory (Jonson, 1992). It is fairly well established that structures in the prefrontal cortex and the parietal lobes are critical in storage and manipulation within WM (Fletcher & Henson, 2001). Importantly, the cognitive functions occurring at this early stage in information processing directly impact later memory processing (DeLuca et al., 2000). As such, the clinical assessment of WM and how it relates the acquisition of information is a crucial part of the overall e valuation of memory.

Another way of classifying memory is the use of explicit memory which is often equated with declarative or conscious memory, and is the conscious recollection information. Implicit memory, on the other hand, is also termed nondeclarative or unconscious memory. It refers to information that can be demonstrated to be stored and accessed but without conscious knowledge of the memory process. The latter includes procedural (skill based, stimulus-response learning, particularly of motor skills), priming and classical conditioning. This is operationally defined regarding change in performance such as savings or priming.

Declarative memory includes semantic memory, or context-free, reflecting general knowledge of symbols, concepts and rules for manipulating them. In contrast to episodic memory, semantic memories rarely concern specific information about situations in which they were learned (see figure 2.4). Semantic memory may be differentially impaired in brain injury. Episodic memory, or context-dependent memory for specific events, includes autobiographical information, preserving the temporal and spatial features of past events that there are not necessarily of particular significance. It is the primary area of clinical investigation in patients with memory complains. Episodic memory deals with conscious retrieval of information that is encoded in a particular place at a particular time (Tulving, 2000). This form of memory is typically assessed by having subjects recall or recognize information acquired in the laboratory (e.g., a list of words or a series of faces).

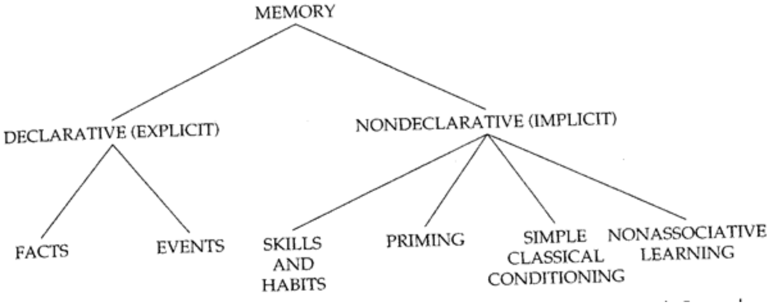


Figure 2.4 The structure of memory (Squire, Knowlton & Musen, 1993)

A crucial finding is that amnesia does not include all aspects of human memory. An important dissociation in this respect can be made between explicit and implicit memory. There is abundant evidence that implicit and explicit memory involve different neural process while patients suffering from amnesia typically display impairments on tasks of measuring explicit memory, implicit learning remains relatively intact, even in patients with severe deficits. Therefore, rehabilitation methods that have recently been developed predominantly aim to promote the use of strategies based on implicit learning.

2.3.2 Memory process

Memory is also a dynamic process. It equals to retaining and retrieving information about past experience. In general, memory processes includes encoding, storage and retrieval. The recall tasks that people is most familiar with is actually manifestation of memory, such as free recall, cued-recall, serial recall. In addition to this, memory also include recognition, relearning and implicit memory tasks etc. The traditional three store model of memory consists of:

1. Sensory registers, the brain hold sensory stimuli for brief period of time in a raw, unanalyzed form;
2. Short-term memory (STM). The brain holds acoustically-coded information for somewhat longer period, although it is still retention of information over brief periods (e.g. seconds or minutes) to longer intervals (e.g., hours). It possesses limited capacity system, and the capacity will be increased with chunking. It also controls processes and flow of information among different memory systems.
3. Long-term memory (LTM). Retention of large amounts of information material lasts over long interval. It includes items encoded in terms of meaning. The term is used to contrast with short-term memory. There is no specific time interval to characterize at what point short-term memory stops and long-term memory starts. It has gained common acceptance and meaning is inferred from its usage context.

2.3.3 Memory storage areas in the cortex

Memories are stored by brain networks: an individuals experience is encoded by brain networks involving multiple cerebral structures (Fuster, 1997). There is no single anatomical structure that alone deals with memory functions. Associated brain areas include somatosensory areas, limbic system, basal ganglia, temporal lobe and frontal lobe. The medial temporal, diencephalic, and frontal areas are involved in normal declarative memory processes (Zola-Morgan & Squire, 1993). The hippocampus, amygdala, and adjacent related medial temporal areas are involved in STM operations. In particular, the hippocampus is strongly implicated in transferal of potentially transient STM information into a more permanent from in the neocortex (Bliss & Collingridge, 1993; Zasler, 1991). Within this frontal-temporal memory retrieval system, there may be distinct functions associated with the frontal and temporal areas. With right hemisphere specialization for episodic memory function and left hemisphere for semantic memory. The medial temporal and diencephalic systems are involved in memory acquisition and consolidation, while a frontal-temporal system are involved in retrieval from LTM. Sensory memories have also different association areas in the cortex. For example, visual memory is related to inferior temporal lobe; auditory- superior temporal gyrus, (R): non-verbal (L): verbal; tactile to parietal lobe; kinesthetic - parietal lobe, motor cortex; olfactory - through CN1 to hippocampus; gustatory - through CN 7,9,10 to orbitofrontal cortex. LTM is a function of the hippocampus and other cortical areas that researchers are only beginning to understand. For example, storage of the names of tools is a function of the medial temporal lobe and the left premotor area. The storage for the names of animals is primarily a function of the medial occipital lobe. As mentioned above, both the amygdala and hippocampus play an important role in encoding memories that have emotional significance.

2.3.4 Theories of memory

Early theories of memory were based on a computer model. Memories were compared to computer files that could be placed in storage and pulled up into consciousness when needed. According to modern theories about memory, it is not a factual-based record of reality. Our memories are not passive or literal recordings of reality. For example, specific events are remembered differently by various members of one family. Some members have forgotten the memory while others inflexibly recall their occurrence. People rarely recall all of the details in an event accurately. Individuals often recall occurrences that made general sense or fit their expectations of what should have happened, but were not actually part of the original event (Gutman, 2001).

Once an experience has been repeatedly retrieved, it becomes consolidated and no longer depends upon the integrity of the medial temporal lobe structures to act as an index. Sleep also plays a role in the consolidation process. As more time elapses and the memory become blurry, the range of cues that elicits a specific remembered event progressively narrows. Adults typically face declining memory function as they grow older, and especially as they move into very late life. However, the magnitude of age-related memory deficits varies across different forms of memory. Specifically, whereas performance in tasks assessing semantic memory, primary memory, procedural memory, and various forms of priming tends to be relatively little affected by the normal aging process, age related impairments are legion in tasks assessing episodic memory (Craik & Jennings, 1992).

2.3.5 Hypotheses of memory deficits following traumatic brain injury (TBI)

While most would agree that memory problems are significant in TBI patients, findings concerning the specific nature of the memory problems remain unclear. Some researchers hypothesized that it reflect an encoding problem (DeLuca et al., 2000; Levin, High & Eisenberg, 1988), others supported a storage or consolidation deficit (Vanderploeg, Crowell & Curtiss, 2001), and still others proposed a deficit in retrieval (Baum, Vanderploeg & Curtiss, 1996). Different hypotheses are thus outlined as below.

Impaired acquisition/encoding process. A recent study of age-, gender- and education-matched moderate to severe TBI group and health control in verbal list task concluded that memory impairment after TBI was caused primarily by deficiencies in initial acquisition of verbal information rather than retrieval (DeLuca, et al. 2000). This encoding deficit hypothesis suggested that TBI-related memory problems represented an impaired ability to attend to and register new information. Relative to healthy controls, TBI patients demonstrated impaired semantic organization strategies (Crosson et al., 1988; Levin & Goldstein, 1986), and/or slower rates of learning (Blachstein, Vakil, & Hoofien, 1993; Crosson et al., 1988; DeLuca et al., 2000; Levin et al., 1988).

Impaired consolidation process. There are also controversial studies which proposed consolidation, rather than encoding or retrieval deficit in memory problem among persons with TBI (Vanderploeg et al., 2001). However, concluding that TBI patients having encoding deficits based on impaired learning strategies has methodological shortcomings. For example, the learning strategy scores on the California Verbal

Learning Test (CVLT; Delis et al., 1987) were used to assess on free recall of the words. That is, these strategies are observed and measured on recall, not encoding of incoming information. Therefore, these scores may either reflect encoding strategy, a recall strategy, or some combination of the two. Another methodological shortcoming in previous research regarding encoding problems in TBI was confusion between the terms encoding and acquisition. These concepts were viewed as non-equivalent. Encoding, like consolidation and retrieval, was believed to be a neuroanatomic-cognitive process while acquisition is a functional behavior that could be observed and measured (Erickson & Scott, 1977), and included encoding and consolidation (Deluca & Chiaravalloti, 2004). So, while impaired rate of learning in persons with TBI certainly reflects an acquisition problem, the underlying deficit may be in encoding, consolidation, or some combination of these. For instance, if information is not being consolidated and stored in long-term memory (LTM), then there would be little improvement from trial to trial. However, if rate of learning (or learning slope) does not differ between TBI and control subjects in light of demonstrable consolidation and/or retrieval difficulties, then an underlying deficit in encoding would be unlikely (Chan, Kwok, Chiu, Lam, Pang, & Chow, 2000).

On the other hand, evaluation of consolidation and retrieval is less methodologically problematic. Consolidation is a post-encoding process that involves maintenance, elaboration, and storage of new information in LTM (Squire, Cohen & Nadel, 1983). The maintenance and elaboration of information in LTM begins immediately, but extends across days and weeks, and involves hippocampal structures (Zola-Morgan & Squire, 1990). Support for consolidation deficits in TBI reported that, relative to healthy controls, TBI patients demonstrated more rapid rates of forgetting (Carlesimo et al., 1997; Levin et al., 1988) and poorer performance on recognition tasks (Crosson et al., 1988; 1989). If information is not being effectively consolidated, then it will rapidly decay from LTM (rapid forgetting) and be poorly recognized on delayed recognition testing.

A recent study designed by Veanderploeg et al (2001) obtained the following findings: a. rate of learning was comparable across groups, consistent with no encoding differences; b. TBI patients had a significantly more rapid rate of forgetting of new information than either acquisition-matched or demographic-matched controls, consistent with consolidation problems in TBI, c. TBI patients had less proactive interference than demographic-matched control participants, consistent with a consolidation problem in the TBI group, d. TBI patients and acquisition-matched controls had comparably low rates of proactive interference, consistent with impaired acquisition in both of these groups, and e. TBI patients and controls did not differ in the benefit experienced from semantic or recognition retrieval cues, consistent with no differences in retrieval processes. These results supported an impaired consolidation hypothesis, rather than encoding or retrieval deficits, as the primary deficit underlying memory impairment in TBI.

Impaired retrieval process. It was reported of relatively preserved learning abilities and retention of new information in TBI patients, but difficulty in retrieving that information from LTM. Some researchers had reported that at least some TBI patients scored significantly worse on delayed free recall tasks, while having relatively better performance on cued and/or recognition tasks (Baum et al., 1996; Crosson et al., 1988;

Duchnick, Vanderploeg & Curtiss, 2002). Others, however, had used this same methodology but reported negative findings (DeLuca et al., 2000).

2.3.6. **Clinical manifestation**

Although problems with memory may be seen early after traumatic brain injury, their devastating impact is often realized only several months or years later. Amnesia may be regarded as one of the most common complaints. Baddeley (1982, citation by Wilson & Moffat, 1992) suggested that the human amnesic syndrome was characterized by: (1) difficulty in learning and remembering new information of nearly all kinds; (2) normal short term memory when this is measured by the regency effect in free recall and digit span tasks; (3) inability to recall information prior to the onset of amnesia, that is, there is almost always a period of retrograde amnesia, which may range from minutes to years; (4) normal or nearly normal functioning of other cognitive abilities.

2.3.7. Assessment of memory functions

2.3.7.1 An overview

The systematic development of psychological tests to assess human cognition only began in the early 20th century. Despite its short history, the assessment of cognitive processes is an integral component of psychologists' training and is considered an important service that they can offer to the clinic and community (Anastasi, 1988). There are many neuropsychological assessments available to investigate learning and memory skills in patients with TBI. In general, these evaluations may include objective, standardized or non-standardized and subjective measures. Former evaluation is generally quantitative measures, latter is most qualitative ones and can be in the form of questionnaires. Both forms of memory evaluations would be adopted in the present study.

Subjective measures are problems reported by clients or others (e.g., family members) or derived from clinical observation. Clients' self-reports concerning memory deficits after TBI are usually quite consistent. A number of questionnaires for measuring functional memory belong to this type. The focus of these instruments is to identify frequency of forgetting, changes in memory over time, the seriousness of memory complaints, and the spontaneous use of strategies. Other types of questionnaires assess the client's overall judgment of memory, knowledge of memory, the demands on memory in day life, memory for past events, cognitive effort when something is forgotten, and the relationship between personality and memory.

Most memory questionnaires do not address issues of rehabilitation; rather, they are simply a series of questions related to the client's everyday memory functioning. Few of them are standardized or normative in nature. The major purpose of memory questionnaires is to serve as a structured interviewing instrument and to provide further diagnostic information. Some commonly used questionnaires are listed as fellows:

- The Everyday Memory Questionnaire (Sunderland, Harris & Baddeley, 1983);
- The Memory Functioning Questionnaire (Gilewski, Zelinski & Schaie, 1990);
- The Cognitive Failures Questionnaire(Broadbent et al., 1982);
- The Present Functioning Questionnaire (Tuokko & Crockett, 1991);
- The Prospective Memory Process Training Memory Questionnaire (Mateer et

al., 1987).

Besides these questionnaires, the quantitative testing of learning and memory usually consist of employing a test instrument that has been standardized in terms of administration, and evaluated in terms of psychometric properties, such as reliability and validity. Memory testing can involve administering a test that is specialized for a specific function (e.g., verbal memory) or administering a larger battery of memory tests that are designed to be more inclusive (e.g., verbal and visual memory, immediate and delayed recall). It should be recognized that virtually all tests of “memory” that have been developed and are popularly used are in fact tests of episodic memory. The typical neuropsychological or educational evaluation of memory is often limited to episodic memory assessment. This is perhaps due to the fact that episodic memory is the system most vulnerable to brain damage or dysfunction. Some of the more commonly used instruments are listed below (the detailed descriptions of selected instruments for the present study can be referred to chapter 4 - research methodology):

- The Rivermead Behavioral Memory Test (Wilson, Cockbun & Baddeley, 1985);
- Wechsler Memory Scale –Revised (Wechsler, 1987);
- The California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1987);
- Rey Auditory-Verbal Learning Test (Lezak, 1983);
- Instrumental Activities of Daily Living Scale (Lawton & Brody, 1969).

2.3.7.2 Memory assessments used in Hong Kong/Chinese mainland

There is a growing trend of research in neuropsychological assessments which include memory functions, and more studies take place in Hong Kong and Chinese mainland. During the early stage of the development of neuropsychological assessment, tests were mainly translated and adapted from western ones. As tests are translated or adapted for use in populations of other cultures, the issue of cross-cultural validity arises. Some tests of cognitive processes were developed and used in Hong Kong and Chinese mainland. Local norms have been collected for these tests, and the cross-cultural validity of these tests has also been established. Some examples are:

- The Chinese Version of the Neurobehavioral Cognitive Status Examination (NCSE-CV; Chan et al., 2002)
- The Rivermead Behavioral Memory Test –Cantonese Version of RBMT (RBMT-CV; Neuro-Rehabilitation Working Group, 1998)
- Chinese Mini-Mental State Examination (CMMSE; Chiu, Lee & Chung, 1994).
- The Clinical Memory Test (Xu & Wu, 1986).
- The Hong Kong List Learning Test (HKLLT; Chan & Kwok, 1999).

According to Chan's et al's (2003) opinion, evaluations satisfying criteria for test use in local cultures should be:

1. Proper procedure had been reported for test development.
2. Tests on validity had been conducted (e.g., convergent or discriminant validity).
3. Normative data were available with a sample size greater than 50.
4. Translation and cross-checking of translation (e.g., back translation) had been carried out (for verbal tests).

5. Cross-cultural comparison (by empirical studies or by comparing local findings with western findings) had been conducted to demonstrate the applicability of the test in the local population.

Thus these criteria were adopted when selecting outcome measures in the present study, such as the use of Neurobehavioral Cognitive Status Examination - Chinese Version, and the Rivermead Behavioural Memory Test - Chinese version. Details can be referred again to Chapter 4 (Methodology).

2.4 Rehabilitation of memory deficits

2.4.1 Rehabilitation management principles

Memory cannot be directly rehabilitated if it is the result of injury to the diencephalic-hippocampal system critical for consolidation of declarative memory (Bennett et al., 1997). Memory can, however, be indirectly remediated by improving an individual’s pacing, fatigue management, organizational skills, speed and efficiency of information processing, cognitive processing capacity, and attention abilities. There are three basic principles required for successful rehabilitation:

1. The natural rehabilitation principle - refers to the fact that the rehabilitation of the amnesic processes must start from those process that are least deteriorated.
2. The specificity principle - the memory deficits that they present can be of two types–specific and nonspecific. The specific type alternations are those that take place as a result of focal lesions or lesions localized in the brain and which, consequently, may be limited to only of left temporal lesions.

3. The central regulation principle - refers to the executive mode, to the consequences of lesions caused in the prefrontal lobe, which lead actually not to a memory problem but instead to a problem of disorganization of the entire mnemonic process.

There are many designs and models that can be useful in providing treatment. Harrell et al. (1992), for instance, developed a clinical eight-step model that has been effective with their clients. It is applicable in all rehabilitation settings and with clients at various levels of recovery. It can also be used with various approaches to treatment, including focus on the direct retraining of memory using pen-and-paper tasks, computerized tasks, and use of compensatory strategies and aids. The Eight - Step Model is listed as the following:.

1. Select a task or strategy
2. Obtain a baseline measure
3. Set goals with the client
4. Choose and teach strategies
5. Practice strategies
6. Obtain a post-practice measure
7. Develop transfer and generalization of strategies for real-life situations
8. Practice transfer and generalization

This model is implemented after assessments have been made. The client has been determined to be ready for treatment, and a treatment plan has been devised. Raymond (1996) also recommended six phases in developing and implementing rehabilitation programme on memory training:

Phase1. Gather and review all pertinent medical records regarding the patient's complaints of memory problems.

Phase2. Complete a detailed interview with the patient to determine what, when, how and why the specific memory problems occur.

Phase3. Complete a formal neuropsychological evaluation to determine the specific strengths and weaknesses related to memory skills.

Phase4. Select the most applicable memory strategies and the most applicable remediation exercises for the patient. These should include metacognitive components (e.g., self-monitoring and self-evaluation)

Phase5. Demonstrate the use of the strategies to the patient.

Phase6. Encourage the patient to use the strategies in real life situations.

It is very obvious that this model emphasize on the use of all strategies which alleviate memory disorders, and develop transfer and generalization of strategies for real-life situations. The above-mentioned principles and models would be used to guide structuring the memory training programme in the present study.

2.4.2 Memory rehabilitation approaches

Many approaches have been developed to assist recovery of memory function in recent years (see Figure 2.5). These approaches can be summarized as:

1. Use of internal encoding and retrieval strategies, e.g. visual imagery (Cherry, Simmons & Camp, 1999; Kosslyn, Beharmann & Jeannerod, 1995), verbal elaboration, PQRST technique, computer-based memory training.

2. Strategies of teaching domain specific knowledge or skill including method of vanishing cues (Glisky, 1995), errorless learning, spaced retrieval, etc.
3. Reducing demands on memory /enhancing use of external resource, e.g. environment control, reality orientation training, behavioral modification, external aids, etc (Wilson, Evans, Emslie & Malinek, 1997; Wright & Limond, 2004).

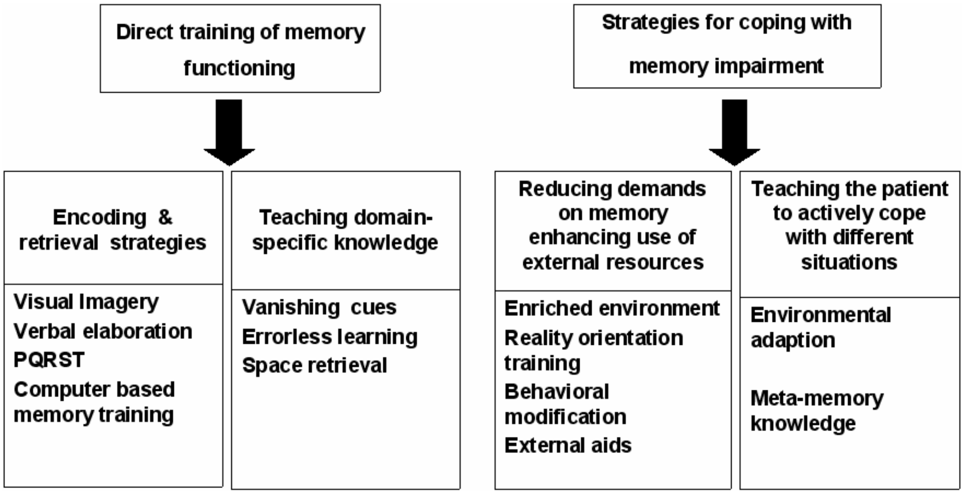


Figure 2.5 Memory rehabilitation approaches (Thone, 1996)

Wilson et al (2000, 2002) also summarized three major approaches to memory rehabilitation: a) environmental adaptations, b) new learning, and c) training use of functional adaptations or compensatory memory aids (Wilson, 1989, 1992, 1999, 2000, 2002) and others. Some of these approaches were selected for its relevancy to the present study and separately elaborated in the subsequent paragraphs.

2.4.2.1 Errorless learning approach

The origin and development. Errorless learning originated in behavioural psychology research in the 1960s (Terrace, 1963 & 1966). Sidman and Stoddard (1967) used a similar technique to teach visual discrimination to pigeons and to children with intellectual disabilities. Although new learning was poor in both groups, it was found that training under errorless conditions facilitated learning in these populations. However, the general technique was not applied to the treatment of memory disorders until the 1990s. In rehabilitating individuals who demonstrated severe memory impairment, the errorless learning (EL) technique (a learning technique developed by Baddeley and Wilson in 1994), was reported to act as another approach to teach “domain specific knowledge to amnesic patients”, and it had proven to be particularly effective. Prevention of errors during acquisition of information was found to lead to better memory than does learning under errorful conditions.

EL has been reported as one of the more successful techniques used in rehabilitating people with memory disorders, especially those with more severe forms of impairment. In the errorless learning programmes, subjects are instructed to say that they do not know an answer instead of giving a wrong answer; they are encouraged not to guess. It appears to be superior to trial-and-error learning, where individuals are encouraged to guess and thus are more likely to produce errors during learning (Baddeley & Wilson, 1994; Wilson et al., 1994). This is thought to be due to the fact that, in the traditional trial-and-error approach, errors are remembered implicitly and interfere with retrieval of target items (O’carroll et al., 1999). The EL learning technique involves learning or encoding new information without error. To achieve this, individuals are given the correct information during each learning episode. In a typical experiment, this involves the examiner providing the same new information to the patient over multiple learning trials, with the patient repeating or writing down the information. And it should be combined with expanding rehearsal to enhance its effectiveness. EL management strategies can be outlined as the following:

1. Try to pair new learning with old, familiar concepts that the patient is able to recall.
2. Be sure to write down as many things as feasible that the patient has to remember from day to day and place them on wall charts or notebooks that the patient can carry around.
3. It is important to remember that old, over-learned tasks will be the most preserved in memory.
4. Frequent cuing and rehearsal of new information are musts.
5. It is important to not only tell the patient but to demonstrate, if possible, what is to be remembered. Use as many sensory modalities as possible.
6. Keep memory training consistent.

These guiding principles were, in fact, used to design the training materials, methods of instruction and ways to deliver feedback to the participants in the present study.

EL mechanism. To date, the actual mechanism of errorless learning improving memory function remains unclear. It has been suggested that the beneficial effects of errorless learning operate through implicit memory, whereas others implicate that it is explicit memory that is responsible for the enhanced memory performance after errorless learning. Two theories have been proposed, and both focus on the distinction between implicit and explicit memory. The first theory proposes that the benefits seen under EL conditions are supported by implicit memory. This memory theory was first proposed by Baddeley and Wilson (1994) to account for the facilitation in memory performance observed in amnesic patients who were subjected to the EL learning technique. The second theory proposed that these benefits are supported by alternative residual explicit memory, which was first suggested by Hunkin et al (1998). Based on their experimental findings, Hunkin and colleagues argued that the benefits associated with EL learning must therefore reflect the operation of residual explicit memory. Evidence supporting this second theory was also open to qualification. Tailby et al. (2003) considered that the benefits seen under errorless learning reflect the operation of residual explicit memory process, however, a concurrent role for implicit memory processes was not ruled out. There are two possible explanations for their research finding. First, it is possible that EL learning may be supported by a combination of implicit and explicit memory processes. A second and related possibility is that EL learning may be supported by different processes in different individuals. For instance, it is possible that EL learning relies primarily on implicit processes in very severely impaired patients who lack explicit memory abilities, but relies more on explicit processes in those demonstrating only a mild impairment.

The implicit memory (prior learning, procedural memory and classical conditioning) theory was first proposed by Baddeley and Wilson (1994) to account for the facilitation in memory performance observed in amnesic patients who were subjected to the EL learning technique. Baddeley and Wilson's study (1994) found that once errors were produced or elicited, amnesic subjects had a great difficulty eliminating them, they thought the errors that occur during trial-and-error or errorful learning were consolidated through implicit memory processes. In subjects with normal memory functions, these errors were corrected by explicit memory, resulting in an accurate memory trace. In patients with amnesia or older people with memory problems, however, explicit memory was impaired while implicit memory is still intact. Thus, errors made during learning are not corrected in these subjects, resulting in the consolidation of an incorrect memory trace. Preventing the occurrence of errors during learning might therefore be effective in the enhancement of the memory performance in that only the accurate responses is implicitly consolidated. In other words, an important component of memory therapy should be to avoid the occurrence of error during the learning process. Errorless learning minimizes the demands on explicit memory, which is impaired in schizophrenics and some amnesics, and instead relies more on important implicit memory. This technique is used under the assumption that new learning is stronger and more durable if mistakes are eliminated during training. Therefore, performance becomes automated through imitative learning and repetitive practice of perfect task execution. By reducing the task to its basic components, which should have a high likelihood for success; errorless learning minimizes failure during the acquisition of new skills and reduces the need for self-correction.

In contrast, others (Hunkin et al., 1998) have suggested that it is not implicit memory that is responsible for the beneficial effects of EL, but that these effects are the result of what they call residual explicit memory function. They studied patients with severe memory problems, focusing on priming effects of word stems that were learned either in an EL or an EF condition. If the beneficial effect of EL has its origin in implicit memory, a positive correlation should be found between recall and priming of the EL words. Furthermore, priming effects (prior exposure to a stimulus exerts an effect on a subsequent stimulus detection or identification) should be higher for correctly remembered words than for words that were not remembered. However, Hunkin et al. (1998) did not find this relation between priming as an index of implicit memory and EL recall. Based on these researches, Hunkin and colleagues argued that the benefits associated with EL learning must therefore reflect the operation of residual explicit memory. This conclusion was strengthened by their findings of EL learning advantages in free recall—a task that is arguably explicit.

The evidence of efficacy. There have been numerous studies showing that amnesic subjects can learn some things normally or nearly normally, even though they may have no conscious recollection of learning anything at all. EL is a promising technique in cognitive rehabilitation, both in research and in clinical practice (Kessels & De Haan, 2003b; Grandmaison & Simard, 2003), the benefits of EL learning have been shown in a number of learning tasks using a variety of materials and information. There is evidence that the prevention of errors during learning might be helpful in improving an impaired memory performance, both in amnesia as well as in normal age-related memory decline. Kessels et al (2005) examined the contribution of implicit and explicit memory function to the memory performance after errorless and errorful learning using the process-dissociation procedure. A group of young adults (N = 40) was compared to a matched group of older individuals (N = 40) on a spatial memory task (i.e., learning the locations of everyday objects in a room). The results clearly showed an age-related decline in explicit spatial memory, while implicit spatial memory was unaffected. Furthermore, the young group benefited from errorless learning compared to errorful learning, while the older group did not show a difference between the two learning conditions. Also, it was found that the effects of errorful learning were related to explicit memory function, and not implicit processing.

The errorless learning training programme was found often to be conducted in conjunction with the spaced retrieval technique or the vanishing cues technique. Some studies in Alzheimer's using errorless learning and spaced retrieval techniques together were reported in the literature (Arkin, 2000; Clare et al., 1999; Clare, Wilson & Carter, 2000; Kixmiller, 2002). The information to be learned consisted of autobiographical information (Clare, et al, 1999; Arkin, 2000); various information such as names of people (Clare, et al, 2000); how to use a calendar and future appointments (Kixmiller, 2002). The total of 17 subjects trained with the errorless learning approach combined with the spaced retrieval technique all showed significant improvement in the percentage of information recalled after the training sessions. Of these subjects, 29% reportedly maintained their learning over a 7-week period, 17.6% over a 6-month period, and 0.06% over a 2-year period.

2.4.2.2 Computer-assisted cognitive rehabilitation

Historical review. In the field of cognitive rehabilitation, computer usage has been playing an increasingly important role (Chen et al., 1997; Johnson, Thomas & Shein, 1994). In the past decade, the development of computer-assisted cognitive rehabilitation (CACR) had experienced three stages: video games, educational software, and specially written CACR software (Lynch, 2002). The initial application of video games as therapeutic recreation in the late 1970s was soon followed in the early1980s by the use of the first personal computers and available educational software. By the mid-1980s, both the IBM PC and Macintosh platforms were established, along with simplified programming languages that allowed individuals without extensive technical expertise to develop their own software. Several rehabilitation clinicians began to produce and market specially written cognitive retraining software for one or the other platform. Actually, the early history of computer-assisted cognitive retraining (CACR) paralleled that of the development and proliferation of video games and personal computers (Lynch, 2002). Subsequent to the development of telerehabilitation, online or e-rehabilitation, virtual reality, expert system etc, application of CACR software have obtained extensions in temporal and spatial field (Man, Tam & Hui-Chan, 2003; Tam & Man, 2004).

Applications of CACR. Technological developments over the past decade had also led to corresponding advances in the field of cognitive rehabilitation (Gontkovsky et al., 2002). Numerous computer-based cognitive rehabilitation or retraining programs have surfaced that purport to provide treatment at a level equivalent to or better than that of more traditional modes of intervention. Many clinicians have recommended using computers as an efficacious tool in cognitive rehabilitation for more than one decade, due to its flexibility and cost-effectiveness (Johnson, Thomas & Shein, 1994; Hall & Cope, 1995). In spite of the methodological difficulties encountered when trying to compare directly investigations examining the efficacy of computerized cognitive rehabilitation (Chen et al., 1997), many findings demonstrated an overall positive trend for such interventions and in the treatment of persons with brain injury (Lynch, 2002; Man, Tam & Hui-Chan, 2003; McGuire, 1990; Tam & Man, 2004).

Computer-assisted retraining has been used to improve specific neuropsychological processes, predominantly attention, memory, and executive skills. The emphasis is on the transfer of new information into long-term storage, as well as on short-term, temporary retention. Indeed, Glisky and Schacter (1987 & 1988) demonstrated that both amnesic individuals and brain injured patients with severe memory impairments could learn vocabulary of computer-based terminology and a series of basic computer operations. Glisky (1995) argued that individuals with memory impairment would be able to use preserved implicit memory to acquire new declarative knowledge as well as new skills.

In addition, there have been two recent releases that set a new standard for those producing memory retraining software: one deals with the ubiquitous problem of recalling names and faces, whereas the other focuses on an equally troublesome memory failure: prospective memory (Lynch, 2002). These retraining softwares have some innovative designs and attractive human-computer interaction (HCI) application. Issues of transfer and generalization of this computer-assisted training procedure have recently been reported, such as the investigation of the effectiveness of a computer-assisted programme for rehabilitation in re-training memory skills, effective transfer of memory training outcomes to actual daily applications was found for brain-injured patients through theory-driven software integrating memory re-training strategies (Tam & Man, 2004).

Advantages of CACR. As summarized by Armstrong (1989) and McGuire et al. (1987), the advantages of utilizing computers as tools in cognitive rehabilitation were mentioned and further outlined in several studies (Bracy, et al., 1999; Watakins, 1999; Burda, Starkey, & Dominguez, 1994; Chen et. al, 1997; Green, Green & Harrison, 1994; Johnson & Gravie, 1995; Smart, 1998; Tam & Man, 2004). These advantages are namely that: a) computers are capable of highly controlled presentation of stimuli in a standardized format and can record data more accurately, consistently and objectively than can a therapist or observer; b) the stimuli presented by computers can be attractive, bright and colourful, helping to engage and focus the client's attention; c) the computer is infinitely patient and very flexible. Computer is able to present a variety of tasks according to the client's needs and abilities, at a level that will challenge but not frustrate the client. It allows the client to work at his or her own pace in a non-threatening environment; d. the computer can provide feedback immediately in a clear, consistent and non-judgmental fashion and, finally, some clients may find working with a computer a novel, enjoyable, challenging experience that improves their motivation and, therefore, the training outcomes.

The development of a computer-assisted memory training programme in the present study also adopted the behavioral approach to memory rehabilitation that was suggested by Wilson (1992). She recommended that the approach has the following advantages: a) it can be adapted to a variety of patients, problems, and settings; b) the goals are small and specific; c) assessment and treatment are tied together; d) treatment can be assessed easily and continuously. There is evidence that this approach can be effective. Wilson (1992) further suggested that behavioural principles such as shaping, chaining, prompting and modeling etc. could be valuable for memory rehabilitation. The effectiveness of applying such behavioural principles in memory rehabilitation has been demonstrated in many studies (Bellus, Kost & Vergo, 1998; Giles & Shore, 1989; Gliksy & Schacter, 1987).

2.4.3 Human-computer interaction (HCI) theory and its application to cognitive rehabilitation

Human-computer interaction (HCI) is the study of how people design, implement and use of interactive computer systems and how computers affect individuals, organizational and society. Users expect highly effective and easy to learn interface and developers realize the crucial role the interface play. This kind of human - computer interaction (HCI) or man –machine interaction (MMI) may be a better, realized mode along with application of computer and multimedia techniques widely.

HCI is concerned with design, evaluation and implementation of interactive computing system for human use and with study of phenomena surrounding them (Pew, 2003). Actually, HCI is a fit and adaptation process between human activity and computer use.

Computer-mediated cognition and behavior, computer-mediated learning, knowledge representation and so on have been studying and implanting for a wide range (Barker, 2003; Roy & Pentland, 2002; Wood, 2001). Traditional errorless learning strategies may be carried out on computer software by HCI. The memory process will be initiated under errorless or minimizing error learning, such as through powerful, accurate and robust stimulation combined with some learning strategies including vanishing cue, repetition and rehearsal mnemonics, spatial retrieval etc (Bergman, 2002; Gontkovesky, McDonald, Clark & Ruwe, 2002,). These stimulations provided by a computer was postulated to help patients to establish an enriched environment (EE) which were suggested to be part of a new eclectic mode by using most recently developed HCI in the present study.

2.4.4 Clinical practice of combination of enriched environment and errorless learning

A basic assumption in present study was that the human memory information processing framework involved a series of stages. The present study provided important multiple sensory inputs and delivered in an interactive enriched environment through a computer. The rich and colorful user interfaces were developed through an interactive design process consisting of repeated cycles of (re)design, implementation of Chinese cultural relevant materials, graphics, videos of real life contexts (for example, activities of daily life). Accurate test and feedback based on errorless learning rules were adopted. This model (combination of enriched environment and errorless learning) did not only generate standard displays of simple visual features, but it was also designed to generate multiple point motions using a Flash computer format for tracking multiple points in a dynamic display. It was anticipated that the study could lead to a satisfactory functional outcome related to increasing learning ability, behavioural change, reducing forgetting, and problem-solving improvement in real life situation.

To conclude, the memory problems associated with brain injury have been discussed in terms of the neuronatomical and modern memory theories. The process of amnesia in persons with brain injury has been postulated and different assessment methodologies, intervention approaches have been outlined. The use of errorless-based learning approach, enrichment in environment, and computer-assisted technology has been elaborated for the design of efficacious and effective treatment programmes in the present study. The importance of functional and daily life application is noted and the implication of applying western findings to Chinese culture is also highlighted. The current development of cognitive rehabilitation in PR China is reported and the impact of innovative computer-assisted memory programme is well supported by a recent survey in China. This confirms the need to develop theory-driven cognitive assessments and interventions in persons with brain injury.

Chapter Three

CONCEPTUAL FRAMEWORK

This chapter describes an innovative, memory intervention model, the enriched environment and errorless learning (EE&EL) model, which has been used in guiding the development of computer-assisted memory strategies for patients with traumatic brain injury (TBI). The following illustration further describes background of this proposed model, its theoretical rationale, anticipated target goals and therapeutic effect on patients with TBI.

3.1The establishment of EE & EL model

3.1.1 Background of proposed EE & EL model

As mentioned in the previous chapter, amnesia is among the most frequently reported and one of the most debilitating residual impairments following traumatic brain injury (TBI). Many researches reported that the most exciting recent work in new learning has been in the area of errorless learning (EL), demonstrating that amnesic patients learn better if they are prevented from making mistakes during the learning process (Wilson et al., 1994; Hunkin et al., 1998). The benefits of EL have been shown in a number of learning tasks using a variety of materials and information (Clare et al., 2000; Ducharme, 2003; Fillingham, Hodgson, Sage & Ralph, 2003; Kessels, Boekhorst & Postma, 2005; Tailby, & Haslam, 2003). In addition, the important effect of an enriched environment on intact and damaged brain has been supported by countless dramatic evidences. An enriched environment (EE) can elicit molecular, neuro-biochemical, morphological and electrophysiology changes in brain cells in animal experimental studies (Hicks et al., 2002; Kang & Schuman, 1995; Figurov, Pozzo-Miller & Olafsson, 1996; Ickes et al., 2000; Passineau, Green & Dietrich, 2001; van Praag, Kempermann, & Gage, 2000; Taub et al., 2002). This environmental effect influences brain development and recovery after the onset traumatic brain injury (Sargeant, Webster & Salzman, 2000; Wagner, Kline & Sokoloski, 2002). Furthermore, there is increasing evidences that intervention through re-training (such as in the form of computer-aided drills) can result in improved cognitive function, including memory and learning (Renner & Rosenzweig, 1987; Van Praag, Kempermann & Gage, 1999).

3.1.2 The conceptual framework of EE& EL model

In present study, an open system model has been proposed to describe the core elements of memory training per se, and through the use of an enriched environment (stimulating, real life situation or context), errorless learning (active and self-generated) strategies, and implemented by means of computer-assisted methods in enhancing the memory functions. The eclectic use of a computer-aided, enriched environment with an errorless-learning-based learning thus structures this new intervention mode, i.e. so-called EE& EL model in the present study (see figure 3.1).

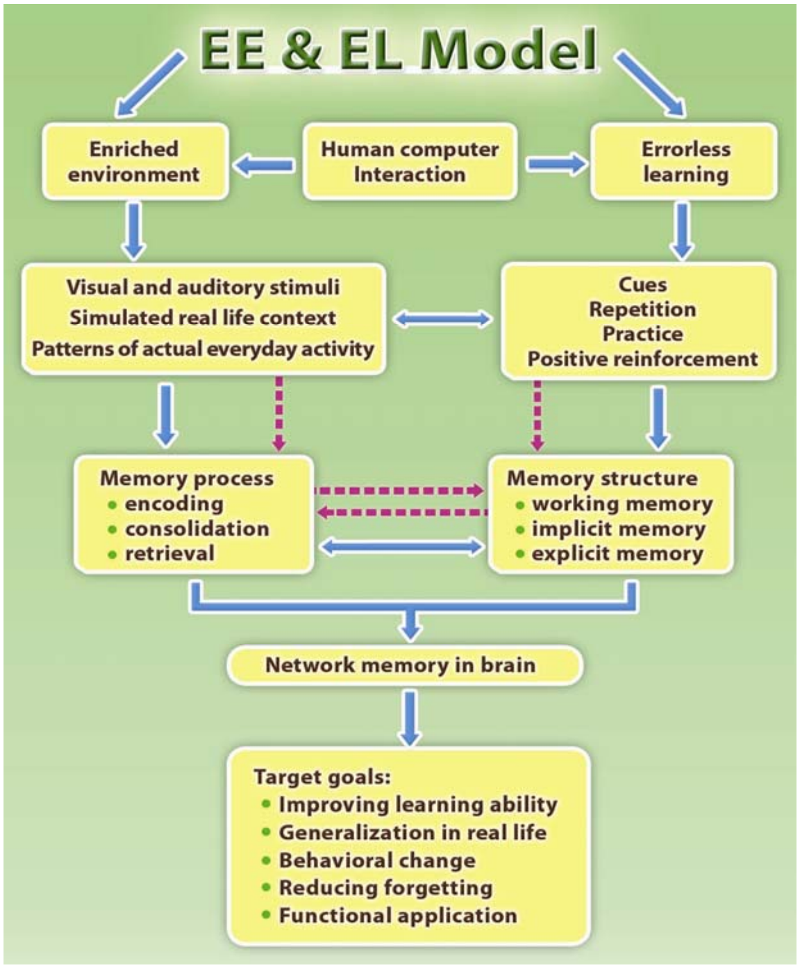


Figure 3.1 EE & EL model in computer-assisted memory rehabilitation (proposed by Man & Dou, 2003)

EE & EL model is conceptualized as an open system encompassing input (stimuli such as auditory and visual signals from the external environment), throughput (the memory structures and the information processing) and output (learning and memory functions for daily activities). As mentioned earlier in literature review, memory structure can be classified as sensory, short-term (working memory) and long-term memory (episodic versus semantic memory). And memory is also a dynamic process. It includes encoding, storage and retrieval. Both the types and processes of memory are inter-dependent on each other. They have been used to explain how the EE & EL model actually works.

According to this postulated EE & EL model, the objective of memory training is proposed to minimize potential for error, reduce memory burden, maximize ease of memory storage and retrieval, promote transfer of training and generalization in everyday activities, and facilitate task completion through guided sequences. In doing so, computer presents stimuli that are attractive, bright and colorful, helping subjects to engage and focus in attentive tasks (Tam & Man, 2004). These stimuli are anticipated to create a simulated enriched environment (EE) which formulates part of a new intervention mode in the present study. We believe that EE & EL model may affect directly or indirectly on memory processes and structures by providing sufficient, relevant, stimulating information to the memory system through systematic human-computer interaction (HCI).

3.2 The theoretical rationale of EE & EL model

3.2.1 The effect of EE & EL model on memory processes in persons with TBI

It is clear that the encoding, storing/consolidation and retrieval of information have set the scene of viewing the problems in terms of memory processes as mentioned earlier. Vanderploeg et al. (2001) reported of results supporting an impaired consolidation hypothesis, rather than encoding or retrieval deficits, as the primary deficit underlying memory impairment in TBI. But Deluca et al. (2000) postulated that memory impairment after TBI was caused primarily by deficiencies in initial acquisition of verbal information rather than in compromised retrieval. The clinical significance of these findings should thus be geared toward incorporating the scientific principles of cognitive neuroscience into the clinical rehabilitation of persons with traumatic brain injury, such as in the present study. In other words, there is a need for incorporating theoretical and empirical findings into the identification and development of effective rehabilitative interventions. For instance, what would be the benefits of providing additional learning opportunities in improving consolidation and how it interacted with task difficulty? In addition, would such additional learning opportunities only improve relatively easily-acquired information or would this training be generalized to more complex learning circumstances? Can increased independence be achieved with the application of special strategies that maximize learning?

Application of EE & EL intervention model may answer part of these questions mentioned above. First, the new memory rehabilitation model might promote powerful, accurate, robust early learning by explicitly providing design features (such as visual and acoustic stimuli) that would allow a computer to respond only to correct actions but not to most users' errors. The design was hypothesized to be effective in promoting errorless learning. Second, subjects would learn entirely through "active, self-generated" use of the computer-aided system, rather than through the conventional methods of directed instruction and considerable repetition. In brief, the design and methodology might engage subjects' active attention and possibly their procedural learning. Third, rapid generalization might occur across functionalities where the content would change and become more complicated, but the design organization and procedure would remain consistent. Furthermore, the learning generalization demonstrated on the practiced task should be relevant to the overall recovery, and relevant to the performance of useful daily activities in real-life situation. Finally, this rapid transfer of training occurred not only across the various strategies, but could also across a series of highly heterogeneous subjects as well as different places. In another words, this EE & EL model might support amnesic people in their daily lives, at home, at work, in school, and in the community. Thus, it can be seen that the model should influence the impaired consolidation process of memory. In addition, encoding is an active process, and requires selective attention to the materials to be encoded. Memory retrieval is not a random process, cues can help with retrieval. This methodological requirement has also been provided in this intervention model. So, the positive effect of EE & EL model on memory processes may be obtained in clinical practice of memory training.

Theoretically, Murre (1997) postulated hypothesis associated with consolidation mechanism and this also explained the effect of EE & EL model on memory process. Murre (1997) thought that when a memory was retrieved, related memories became temporarily activated. Although they stayed below the threshold of consciousness, this activation might lead to a strengthening of the cortical base of these related memories through processes that might also underlie semantic priming (i.e., the facilitation of one word through previous presentation of an associate, e.g., faster recognition of the word dog if the word cat has been presented previously). In this way, memories that are not rehearsed might be consolidated through rehearsal of associated memories. Actually, mechanism by which consolidation might operate is subconscious activation of memories (Metter & Murre, 2004). This theory happened to have the same view with implicit memory theory on which errorless learning relied.

Many researches revealed that implicit memory (skill memory) may remain relatively intact after suffering from brain injury, even in patients with severe deficits (Wilson et al., 1994). There may be residual explicit memory (knowledge memory) under mild-moderate brain injury (Hunkin, et al, 1998; Kessels, et al, 2005). The abundant evidence showed that implicit and explicit memory involved different memory process and could be responsible for knowledge or skill learning respectively (see Figure 3.1). The implicit memory process or a combination of implicit and explicit memory processes would be initiated under errorless or minimizing error learning. Error prevention in the errorless learning condition may ensure that only correct responses are strengthened or reinforced. Thus, error prevention would lead to better performance on subsequent cued recall.

It is assumed that any strategies that can help the smooth and efficient flowing of the process will enhance memory function. The adoption of a computer-assisted approach thus may serve the purpose of provision of high level of stimuli, active involvement and interaction with computer. Through the possible programming, suitable gradation, repetition can be built in the training regime to reinforce the impaired encoding and consolidation process of memory in persons with traumatic brain injury. Moreover, through the errorless learning approach (error prevention), it is proposed that learning can still take place due to the presence of both the implicit and residual explicit memory.

3.2.2 The effect of EE & EL model on memory structure

As mentioned earlier, working memory (WM) plays important role for simultaneous involvement in storage and processing information. It involves a variety of cognitive skills and everyday activities. Impairment in WM presents a “bottleneck” which prevents the addition of new information to long term storage. WM is therefore thought of as a key step in the encoding of information and the transfer of this information into long term memory (Jonson, 1992). It is a connecting link between the preceding and the following in memory structures (sensory memory and long term memory). Importantly, the cognitive functions occurring at this early stage in information processing directly impact later memory processing (DeLuca, et al., 2000).

According to Baddeley (1999), WM has two types of components: storage (phonological loop and visuo-spatial sketch pad) and central executive functions. It is proposed that EE & EL model relates to the working memory model. Computer presents stimuli not only that are attractive, bright and colorful, but also that create different sound cues with application of multimedia techniques widely. The visual and auditory stimuli provided by this human - computer interaction (HCI) excite directly structures in the prefrontal cortex and the parietal lobes (see description below). Research had revealed that these regions of brain cortex are critical in storage and manipulation within WM (Fletcher & Henson, 2001). Thus, the simulated enriched environment has better impact on storage (phonological loop and visuo-spatial sketch pad) and central executive functions. In errorless learning condition, it also addresses the appropriate use of active participation via the use of elaboration and self-generation methods, interesting, meaningful activities, instead of passive learning/just having learning activities alone. This will emerge better effect on working memory. The clinical practice also supports that the active learning is superior to passive reception (Tailby & Haslam, 2003). The characteristics of working memory may explain this phenomenon. WM is not passive temporary storage of information like computer, it need reasoning, comprehending and learning in information process for the performance of such cognitive tasks and then processing information is transferred into long-term memory for retention. Thus, participants are encouraged to generate their own answers without error (i.e. “self-generated”) in response to semantically rich descriptions (cueing) of the target words in EL, the encoding information without error in a meaningful and active manner would thus strengthen the memory representation. Thus, the effectiveness of the modified EL is different from the standard EL (i.e. examiner-generated) condition.

According to Fuster’s view (Fuster, 1997), memory is stored in overlapping and widely distributed networks of interconnected cortical neurons. The different types of memory, for examples, implicit or explicit, are probably interlinked in mixed networks that span different levels of perceptual and motor hierarchies. All aspects of memory retrieval, including recall and recognition, can be viewed as the activation of network memory, that is, the increased firing of the cortical neurons making up a memory network. According to this hypothesis, EE & EL model may activate extensive cortical regions. These regions include areas identified as the substrate for the long-term storage of what the working-memory test requires the subject to retain. Thus it appears that both kinds of memory share the same substrate. The evidence that have obtained of functional interactions, in working memory, between neurons in separate cortical areas further argues for a common and widely distributed substrate. Indeed, whatever its cortical distribution, the same network probably serves to store a long-term memory, and to retain actively that memory for the short term. It means that anticipated target may be reached so long as EE & EL model activate network memory.

3.3 The target goals of innovative EE & EL model

The enriched environment (EE) and errorless learning (EL) are likely to be combined to form a new model (see Figure 3.1) by using recently developed human-computer interface (HCI) techniques. EE & EL model will influence effectively different memory phases and processes. The model may provide important multiple sensory inputs and delivered in an interactive enriched environment. The rich and colorful user interfaces would be developed through an interactive design process consisting of repeated cycles of visual-figural tasks etc. redesign, implementation of Chinese cultural relevant semantic materials, and graphics with meaningful and cultural-relevant stimuli, videos of real life contexts (for example, activities of daily life). All arrangements promote transfer of training and facilitate task completion through guided sequences.

Chapter Four

RESEARCH METHODOLOGY

This chapter firstly describes the aims, research questions and hypotheses of the study. The subsequent parts give an account of the research design, sampling methods, procedures of the 2-phases study (pilot and main study), instrumentation, and data analysis for specified hypothesis testing.

4.1 Aims of research

1. To develop and implement a computer-assisted memory rehabilitation programme, based on a postulated EE & EL model (enriched environment and errorless learning) and through the use of comprehensive cognitive skills/training principles, so as to improve the impaired memory functions of patients with TBI;

2. To evaluate the efficacy of this computer-assisted memory rehabilitation protocol through formative and summative evaluations;

3. To evaluate the effectiveness of this computer-assisted memory protocol through assessing outcomes such as the subjects' skills in applying the errorless learning principles, their functional independence, and comparing to the outcomes with therapist-administered memory training group (TAMG) and a control group (CG).

4.2 Research questions

1. Did EE & EL model-guided, computer-assisted memory rehabilitation programme help Chinese persons with TBI achieve better memory skills, functional independence and self-efficacy?
    a. What would be the impact of EL & EE model on the memory processes in terms of encoding, storage and retrieval of information?
    b. What would be subjects' evaluation of the two types of memory training programmes (that is, CAMG and TAMG)?
    c. Were there any significant differences in memory self-efficacy after training by the computer-assisted memory rehabilitation programme?

2. Were there any significant differences in memory treatment effectiveness and self efficacy among the CAMG, TAMG and CG?

4.3 Hypotheses of the study

It was hypothesized that positive treatment effects would be exhibited in subjects through the two memory rehabilitation programmes respectively (i.e. computer-assisted or CAMG; and therapist-administered or TAMG) but not in a control group (CG). The sub-hypotheses were:

1. After completion of the 20-session memory training programmes, subjects who were either in CAMG or TAMG would achieve statistically significantly higher memory performance and skills.
2. After completion of the 20-session memory training programmes, the scores reflecting memory processes (including encoding, storage and retrieval of

information), in either CAMG or TAMG, would reach statistically significantly improvement as indicated in outcome measures. It was anticipated that CAMG training would have a better treatment effect than TAMG and there would not be any treatment effect in CG.

3. After termination of treatment and during 1-month follow up, the effectiveness of both CAMG and TAMG would be maintained (that is, there would be no significant differences).
4. After training, subjects' memory self-efficacy evaluation would be improved in TAMG and CAMG, but not in CG.

4.4 Research design

A prospective pretest and posttest quasi-experimental clinical design was adopted in this study. Such study design was especially useful in determining whether the new computer-assisted memory training programme offered any advantages over conventional methods (in this case, therapist-administered treatment). Changes in memory-related outcome measures would be detected before and after intervention, and during one month follow up. 90 subjects were planned to be recruited and divided equally into three independent groups. Statistical analysis was performed to ensure that there was no significant difference in group membership, in terms of the groups' demographics, pre-training memory skill levels and self-efficacy etc. A total of 30 subjects were expected in each of the two intervention groups and they attended treatment sessions adopting one of the two memory training strategies (CAMG or TAMG). Another 30 subjects would also be recruited. They were also persons with TBI, but they were either not engaged in any specific memory training programme or put on waiting list for cognitive rehabilitation. These patients acted as the control group for comparison. The respective training characteristics of the three groups is outlined in Table 4.1.

A pilot study was conducted, before the main study, to a small number of 15 patients (5 patients in CAMG, TAMG and CG respectively) who were different subjects from the groups in the main study. This pilot study aimed to test out the usability of the training programmes, validity and reliability of measuring instruments and related training procedures. Revision of the programme structure, method of instructions and usage of measurement instrument had been achieved before launching the main study.

Groups	Computer-assisted memory training Group (**CAMG**)	Therapist-administered memory training Group (**TAMG**)	Control Group **(CG)**
Settings	Hospital- or home-based	Hospital-based	Hospital- or Home-based
Programme Modes	• Cognitive challenging • Individualizedmemory – specific computer-assisted instructional package • Self-pacing, with feedback At home, with family support	• Cognitive challenging • Individualizedmemory – specific pencil-and–paper training, and by face- to-face contactSupportive exercise from therapist and with feedback.	• No-specific training

Table 4.1 Programme characteristics of CAMG, TAMG and CG

4.4.1 Sampling size estimation

The sample size estimation (using ANOVA as an example) was initially carried out by the Power Analysis and Sample Size programme (PASS 2004). Using a sample size of 60, an alpha of 0.05, the number of level (k) of 3, and an expected effect size of 0.5 (pure estimation only) for the interventions, the power was estimated to be 0.93. In order to minimize the likelihood of a type II error due to this small sample size, efforts were made to increase the effect size of the independent variable, decrease sources of extraneous variation, and conduct qualitative formative evaluations to improve the sensitivity of the study. Thus, theoretically, a total of 180 patients should be recruited. However, it would not feasible to treat that number of patients over the specific period of study. The number was thus modified to be a total of 90 as suggested number for recruitment (30 for each group). Further justifications would be as follow:

1. Using more stringent selecting criteria (only people with moderate to severe TBI were selected), and subjects were anticipated to produce greater change in outcome, which would help improving the effect size (thus reducing the sample size).
2. Comparing to similar TBI studies on cognitive rehabilitation and using similar selection criteria and outcome measures, a group size of 30 seemed to be able to reflect significant, positive change after intervention, if any (for examples, Cockburn et al., 2003; Evans et al., 2000; McMillan et al., 2002).
3. Through analyzing the results of the pilot study, the treatment effectiveness might hint the need of using a larger or smaller sample size.

Thus, an estimate of 90 Chinese adults (ultimately 84 subjects were recruited after some drop outs – see chapter 5 for details), aged from 18 to 55, three months post-TBI, and who were reported to have post brain injury memory impairment, would be identified through a two-stage random sampling. In the first stage, clusters of hospitals serving these subjects were identified. For example, subjects were identified from several hospitals in Guangzhou city, PR China. These hospitals include the Third Affiliated Hospital and First Affiliated Hospital, Sun Yat-sen University; Southern Hospital and

Zhujiang Hospital, Southern Medical University; Guangzhou Industrial Rehabilitation Center, etc. Subjects were then selected randomly (drawn by lot) from these clusters and they would then invited to join this study.

4.4.2 Detailed inclusion criteria of subjects

Inclusion criteria of subject were namely those who:

1. had suffered from a traumatic brain injury (including closed, open and penetrating head injury and might require neurosurgery), and were at least 3 months post-operation;
2. were Chinese, of age ranging from 18 to 55;
3. demonstrated evidence of cognitive problem(s), especially memory disorder through cognitive assessments, during post brain injury period of 3-6 months;
4. demonstrated attention span for at least 5 minutes and were medically stable;
5. had fair verbal comprehension and expression power, and were able to attend to and follow task instruction.

All subjects were also screened by the following cognitive assessments and according to operationally defined cut off points adopted in the present study:

1. The Everyday Memory Questionnaire for Brain Damage Patients (Abbreviated version or EMQ-A, Sunderland, Harris & Baddeley, 1983; cut off point ≥6 out of 13 questions; see appendix A1a, b).

The Everyday Memory Questionnaire for Brain Damage Patients (EMQ; Sunderland, Harris, & Baddeley, 1983) addresses the various everyday memory problems, and it consists of 28 items, tapping prospective memory, episodic memory, memory of faces, of places, and of routes, procedural memory, failure to follow a story read or in TV, etc. The abbreviated version test, however, was used in this study as screening assessment as it is shorter (only 13 questions) and easier to fill out. The scale was simplified in comparison to the 7-point one used by Sunderland et al. (1983) and the scores ranged from: 0 = never to 1 = possible. For example: a. forgetting where you have put something; losing things around the house. b. failing to recognize places that you are told you have been before. c. not remembering a change in your daily routine, such as a change in the place where something is kept, or a change in the time something happens. The results of EMQ could thus identified persons with memory problems and they might be benefited from the training programmes in the present study. In addition, EMQ is presumably close to the Rivermead Behavioural Memory Test (RBMT, Wison, Cockburn, Baddeley, 1985), which was also used as a standardized, memory outcome measure in the present study. However, the difference between the two is that the RBMT is an objective measure of memory performance, whereas the EMQ consists of subjective, meta-memory reports that do not necessarily reflect the objective level of performance. But the questionnaire was well validated and found to be reliable. Research showed that the reliability indices such as re Cronbach's alpha (0.889), test-retest (Pearson's γ=0.852) and split-half reliability (Spearman-Brown =0.892) (Efklides et al., 2002).

2. The Rancho Los Amigos Level of Cognitive Functioning Scale (RLAS; Hagen, Malkmus & Durham 1982) (Cut off point ≥VII level of the VIII levels; see appendix A2a, b).

The Rancho Los Amigos Level of Cognitive Functioning Scale (RLAS; Hagen, Malkmus & Durham 1972, revised 1974) describes ten stages of cognitive functioning through which patients with brain injury typically progress. The pattern of recovery has been further described according to various cognitive manifestations. As patients progress through these stages, the principal defining cognitive limitations evolve from deficits in arousal and consciousness, to basic attention and anterograde amnesia, to higher level attention, memory, executive functioning, processing speed, insight, and social awareness. It deserves emphasis again that not all patients will progress through all of these stages of recovery, in large part related to severity of diffuse injury, secondary complication, or, possibly, the residual effects of focal damage. So a cut off point ≥VII level of RLAS VIII levels would be adopted as a screening criterion in this study. As it was clinically relevant that only when patients were attentive and conscious enough, they were more ready for training and treatment effectiveness was more promising.

4.4.3 Exclusion criteria

Those who were:

1. having previous psychiatric history;
2. having epilepsy or other neurological disorders
3. computer-phobic;
4. having received similar computer-assisted cognitive training before.

Thus, more than 90 subjects (a total of 112 subjects) were successfully recruited according to the inclusion and exclusion criteria, in order to consider possible attrition during training period. They were respectively allocated to the two intervention groups (CAMG and TAMG), as well as a CG. The general information of subjects recruited can be further referred to appendix A3a, b.

4.4.4 Ethical considerations and measures

The following ethical guidelines were implemented according to the Cooperative Multicenter Traumatic Brain Injury Clinical Trials Network (2002), National Institute of Child Health and Human Development. Ethical approval of the present study was obtained from the Human Subjects Ethics Sub-Committee, The Hong Kong Polytechnic University (see appendix A4). Ethical considerations of the present study were:

1. The researchers of the present study possess the knowledge necessary to contribute meaningfully to final study design, including understanding of the scientific, ethical and practical issues underlying the research.
2. The researchers possess the knowledge of the potential problems associated with the conduct of the research and identify solutions or alternatives.
3. Team members responsible for data quality and management activities possess the required experience and qualifications.
4. The study has developed cooperative relationship with the clinical settings and exercising appropriate leadership in matters of study design, data acquisition, data management, data quality and data analysis.

5. The researchers adopted procedures to ensure the safety and confidentiality of all records.
6. The study recruited subjects as appropriate for both rehabilitation goals of the subjects and the scientific goals of the research. Plans for the recruitment and retention of subjects were also evaluated.
7. The study did not include any procedures or measures that may adversely affect the subjects' health and quality of life.
8. The study provided subject with adequate information of the research procedures and subjects' consents were obtained. (see appendix 5a,b)

4.5. Instrumentation

Instrumentation adopted in the present study can be categorized as:

1. two training programmes (for CAMG and TAMG respectively) had been designed and developed for treating memory disorders in persons with TBI;
2. cognitive screening assessments;
3. memory-related outcome measures.

Five hospitals participated in this multi-centre study. Each hospital had set up an OT training room, and each of them was equipped with a desktop computer. The recommended specification is showed as follow: Pentium 4 3.0 GHz CPU, 512 MB ram, 40GB Hard disk, CD-Rom drive, 17" monitor and speakers. For software, we need MS windows XP professional, Macromedia Flash player, and also Apple quick-time player.

This computer is operated by occupational therapists who had at least 2-year of relevant experience in TBI and cognitive rehabilitation, had received a one-day workshop on using the treatment software, patient handling technique and they are also provided with a user manual to ensure all procedures were standardized.

Assessment and training procedures are further elaborated in following description.

4.5.1 Training programmes /software

A major goal of a training programme/software used in the present study should be highly simplified and structured, based on theory and principles from neuropsychology and cognitive psychology. Thus design objective of both CAMG and TAMG programmes would be "to minimize potential for error, reduce memory burden, maximize ease of memory storage and retrieval, promote transfer of training, and facilitate task completion through guided sequences". According to this consideration, the current training packages were tailor-made for Chinese TBI subjects with memory disorders. Three guiding principles were followed in developing the programme structure: a) the application of the errorless learning method; b) the designing of an enriched training environment; and c) the provision of opportunities for participants to practice exercises at different and gradable levels of difficulty.

The CAMG package, consisting of 20-sesssion package, was developed using a human-computer interaction and multimedia presentation. The training package was divided into four training parts. Part 1 was training on basic memory tasks related to sensory memory (visual-figural, visual-verbal, auditory-verbal, etc.). Part 2 was training on basic memory tasks related to working and semantic memory (immediate recall of digits, immediate recall of related words, etc.). Part 3 contained mnemonic memory strategies (association, categorization, story, mental imaging, habituation, etc.). Part 4 was the application of memory strategies learned into daily life situations. In the last part on performing simulated independent daily living functions in the community, the participants were asked to verbally answer functional problems as displayed by the computer screen. The content of the tasks was also presented in a hierarchy through controlling. a. the amount of the stimulation; b. the power of the stimulation; c. the complexity of the stimulation, and d. the level of execution. Specifically, the tenth and twentieth sessions were reviews

Sessions	**Training content**
Session 1-4	*Sensory memory training including :* • visual-figural/verbal, words and sentences, auditory-verbal, dialogue, short article • their immediate and delay recall in sequence, recognition • 3 levels in each category, 6- 8 items in each level
Session 5-7	*Working memory training including* • information storage temporary and storage-based reasoning , immediate recall of digits • counting and its application in functional activities • 3 levels in each category, 6- 8 items in each level
Session 8-9	*Semantic memory training including* • immediate recall of related words • Chinese ancient idioms, sentences, paragraph-length material, short articles, face-name recognition, birthday etc. • 3 levels in each category, 6- 8 items in each level
Session 10	*Review activities in first stage of memory training including*: • visual-figural, visual and auditory-verbal or nonverbal tasks • recall of digits, counting etc. • 3 levels in each category, 6-8 items in each level
Session 11-15	*Mnemonics application in memory strategies*, including • association, categorization , story-telling, mental imagery etc. • reading of Tang poem, free memory recall etc.3 levels in each category, 6-8 items in each level.
Session 16-17	*Memory application in ADL*, including • commodity and its usage, naming furniture, • how to cook, use of environmental adaptation etc. • 3 levels in each category, 6-8 items in each level
Session 18-19	*Memory application in community*, including: • consulting a doctor in hospitals and shopping in a supermarket • answering problems related to activities
Session 20	*Review activities in second stage of memory training* • assessment activities on applying memory strategies to solve typical daily living problems.

Table 4.2 Brief outline of a 20-session memory training programme for CAMG & TAMG

of memory strategies learnt during previous sessions. Assessments in applying memory strategies to solve typical daily living problems were also administered (see table 4.2).

In brief, this computer-assisted memory rehabilitation package possesses the following features:

1. Theoretically, CAMG was based upon an EE&EL model;
2. Participants took an active part in learning;
3. Training content integrated with real life situation;
4. Step-by-step training, learning information quantitative was controlled, every session was relatively independent with others, but is kept in consistence with the whole content;
5. High relevancy to Chinese cultural, such as the use of poems of the Tang dynasty and Chinese ancient idioms (environmental enrichment);
6. Built-in generalization probes across sessions and after training period.

The TAMG programme adopted the same training structure content as the CAMG, but the training mode was different. The detailed structure and content of the CAMG and TAMG are outlined in appendix A6.

In CAMG, patients were firstly required to identify or define the information to learn with help, and then the computer provided the necessary information for the patients to generate correct solution through an errorless approach. The patients were not encouraged in guessing work so as to avoid mistakes, and they should consider about alternatives and the consequences of an intended action.

But in TAMG, training was delivered by therapists, and similar content was converted into a paper format and in the form of a training manual. It contained all corresponding guidelines for assessment and training instructions of each session (presented colored pictures and indicators of answers to raised memory questions). Therapists also gave guidance through a face-to-face mode. Moreover, the use of training manual also ensured that the consistency in implementation of the training programme and thus good inter-trainer reliability can be achieved (see a separate operational manual of memory training for patients with TBI, Chinese version 2.0). One kind of the training materials, for example, was using familiar Chinese idioms and poems (applicable to either CAMR or TAMR training modes) and adopting errorless learning strategies. This could be demonstrated by using a well-known Chinese story, in which a famous Chinese idiom was embedded (see appendix A6). As Chinese idioms contain abundant literary quotation and Chinese learned this kind of idiom-related stories since childhood, they will be stored in semantic memory. The training session would be to associate the memorizing of a Chinese idiom with the pictures. This kind of training material comprised of 20 Chinese 4-worded to 7-worded idioms. Word lengths were varied so as to allow for a sufficient number for memory training purpose. For each of the Chinese idiom, a semantically-rich description was firstly created for subjects' use in the self-generated EL condition. Pilot testing of the semantic descriptions was conducted on five individuals during pilot study so as to ensure that the semantic information was sufficient and clear enough to identification. Further illustrative examples of training are:

Figure 4.1 showed the picture of a Chinese idiom, “Hua She Tian Zu, means “drawing a snake and adding a new pair of feet”. More than just memorizing it, subjects chose one of three suffix–words to complete a full idiom.

Figure 4.1 First picture of “Hua She Tian Zu”


春秋时期，楚国有个人祭祀祖先，拿出一壶酒招待帮忙办事的人。但人多酒少，于是有人提议比赛画蛇，谁先画完就喝那壶酒。


于是他们就在地上画起蛇来。有一个人画得最快，看到其他人没画好，心里很得意，骄傲地说：“我还能画上四只脚呢！”于是给画好的蛇添上四只脚……


这个人画完后想喝酒，但是另一个画好的人一把抢走酒壶并嘲笑道：“蛇本来没有脚，你为什么要加上四只脚呢？这已经不是蛇了。”这个人只好认输，只怪自己画蛇添足。

Figure 4.2 **Figure 4.3** **Figure 4.4**

Second to fourth pictures of “Hua She Tian Zu

The figure 4.2 - 4.4 showed the content of Hua She Tian Zu, with pictures. Subjects needed to arrange them into a right order on the screen (CAMG) or on a piece of paper (TAMG) according to the story content which it was heard or read.


请选择“画蛇添足”这个成语的配图。


画龙点睛

有一次，南北朝时的画家张僧繇在寺庙的墙壁上画了四条没有眼睛的龙。人们问他：“这是为什么？”他说：“画上眼睛，龙就飞走了。”大家说他吹牛，要他画上试试。他就给两条龙画了眼睛。这时，雷电交加，墙壁破裂，有眼睛的龙腾云飞上了天，没有眼睛的龙仍在墙上。


请选择我们之前要你记住的成语是：

○画蛇添足 ○画虎类犬 ○画龙点睛

Figure 4.5 Figure 4.6 Figure 4.7

From “Hua She Tian Zu” to “Hua Long Dian Jing”

Figure 4.5 showed immediate recall of memory with distraction. Participants were asked to match one out of four pictures with presented idiom, Hua She Tian Zu.

Figure 4.6 showed another story without pictures (Hua Long Dian Jing, means “bring the painted dragon to life by putting in the pupils of its eyes”) to substitute the last Chinese idiom presented (Hua She Tian Zu).

Figure 4.7 showed examples that participants were asked to select or answer one correct target Chinese idiom remembered previously from three idioms by delayed recall with reference (Hua She Tian Zu).

1. The word-stem completion exercise - participants were asked to pick out the correct suffix word which was chosen from a series of options (select 1 out of 3 to complete the idiom) which hinted them by observing the meaningful pictures (see Figure 4.1).
2. Figures' sequence - subjects were told a story corresponding to the target Chinese idiom (e.g. Hua She Tian Zu, meaning "drawing a snake and adding a new pair of feet"), then the three pictures were shown before subjects were asked to arrange them on the screen in a correct sequence according to the story content which was heard or read (self-generated mode). Participants were given 30-60 seconds to finish. A failure to respond was not accepted and participants were strongly encouraged to provide a response repetitively (see Figures 4.2; 4.3; 4.4).
3. Immediate and delayed interference recall - After participants finished a story by giving correct sequence, they were asked to remember the idiom immediately by recalling of memory with distracters, such as by asking them to match 1 out of 4 pictures together with presented idiom (see Figure 4.5). Then subjects were provided with another story corresponding to the Chinese idiom without pictures (e.g. Hua Long Dian Jing, means "bringing the painted dragon to life by inking the pupils of its eyes" (see Figure 4.6). The training cycle then repeated.
4. After taking a break of five minutes, participants were then asked to recall Chinese idioms they had remembered previously. If they failed to give correct response, a cue would be given (see Figure 4.7).

4.5.2 Outcome measures

The outcome measures were on subjects' knowledge, skills, behaviours, functional activities in memory respectively. Several specific outcome measures for assessing subjects' pre- and post-training, and during follow up had been selected:

1. The Neurobehavioral Cognitive Status Examination–Chinese version (NCSE-CV or Cognistat; Chan et al., 1999);
2. Rivermead Behavioral Memory Test - Cantonese version (RBMT-CV, Neuro-Rehabilitation Working Group, 1998);
3. The Hong Kong List Learning Test (HKLLT, Chan & Kwok, 1999);
4. The Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski & Schaie, 1990);
5. Questionnaire developed to record subjects' demographics;
6. Questionnaire on subjects' memory self-efficacy and subjective evaluation of training programmes;
7. Open ended questions would also be recorded for qualitative analysis during and after training to tap subjects' responses to treatment effectiveness and programme content.

The content, together with their respective validity and reliability of the above-listed assessments can be referred to the following details:

4.5.2.1 The Neurobehavioral Cognitive Status Examination – Chinese Version (NCSE-CV or Cognistat) (appendix A7a, b)

The Neurobehavioral Cognitive Status Examination (NCSE), now known as Cognistat, was designed by Northern California Neurobehavioural Group as a bedside screening tool for detecting and characterizing cognitive dysfunction (Northern California Neurobehavioral Group, Inc. 1988). The NCSE consists of subtests measuring arousal, orientation, attention, comprehension, repetition, naming, visual constructive skills, memory, calculation, abstract reasoning, and judgment. The instrument uses a screening-metric format, whereby successful passing of the screening question assumes passing of other (usually less demanding) questions in the section. A score of 78 is achieved by passing all screening questions. Four additional points can be earned if the examinee fails the screening questions on the Construction, Similarities, and Judgment subtests and proceeds to correctly answer the remaining questions in the subscale (for a maximum score of 82).

Adequate reliability and validity of the NCSE has been established (Kiernanet al., 1987). Early studies revealed the instrument's utility with psychiatric patients (Lamarre & Patten, 1994). In addition, the NCSE has been demonstrated to be sensitive to cognitive dysfunction in older medical inpatients (Fulop et al., 1992) and as an adjunct measure of response consistency in rehabilitation patients who have had a stroke (Toedter et al., 1995). The NCSE can be used with all adult age groups, although the manual urges caution in scale interpretation when assessing older individuals and lowers the cutoff for impairment on the Construction, Memory, and Similarities subtests. There are several reports in the literature on the utility of the NCSE in assessment of cognitive dysfunction with different populations. The test authors (Kiernan et al., 1987) provided standardization data for 119 healthy adults between the ages of 20 and 92, and for 30 neurosurgical patients. In another study, it was reported of higher accuracy of the NCSE in comparison to other brief screening tests in detection of cognitive dysfunction in 30 neurosurgical patients (Schwamm et al., 1987). A prior study of the NCSE and neurosurgical patients with documented brain lesions suggested that the instrument performed better in detecting cognitive dysfunction than the MMSE or the Cognitive Capacity Screening Examination. The authors believed the reason for the superior performance of the NCSE was that the instrument examined more neurobehavioral domains and did not use a composite score to describe cognitive functioning. The utility of examining individual subtests, however, was again questioned by a recent study that found the NCSE to measure a solitary cognitive factor (Englehart et al., 1999). Thus, it has been proposed that combining all subtests to form a single NCSE Composite score may show the greatest utility in cognitive assessment (Drane et al., 1998). All but the memory section are given in the screen and metric paradigm.

Though NCSE is a global cognitive test and is not memory-specific in nature, the Hong Kong Chinese version of NCSE is available to use (Chan et al., 1999). The content, substantive and discriminative validity of the NCSE for assessing cognitive function of Chinese stroke patients was evaluated. The equivalence of this NCSE version was substantiated by an expert panel review. Relevance and representativeness of the test content were also evaluated. Culturally irrelevant test items were identified under the attention, language, memory, and reasoning sub-tests. Item analysis using item difficulty, discriminative, and internal consistency indices (Alpha = 0.37 to 0.82) indicated that most of the original and revised sub-tests behaved as expected. Similarly, validity and reliability of this Hong Kong Chinese version NCSE had been studied among 788 Chinese patients (Xu et al., 2002). Results revealed that the test - retest reliability was high in most items ($\gamma > 0.7$, $P < 0.01$). Patients with cognitive disorders had lower score in NCSE as compared with normal subjects ($P < 0.01$). A positive correlation also existed between scores of sub-items memory of NCSE and the scores assessed by Rivermead Behavioural Memory Test ($\gamma = 0.72$, $P < 0.01$). By using the cut -points of the original test, the sensitivity and specificity of NCSE were 93.5% and 65% respectively. In present study, The Hong Kong Chinese version of NCSE was used to measure participants' knowledge and concepts of independent cognitive functions as a global cognitive assessment.

4.5.2.2 Rivermead Behavioral Memory Test –Chinese Version (RBMT-CV) (appendix A8a, b)

Wilson et al (1985) developed the Rivermead Behavioural Memory Test (RBMT) to assess changes in everyday memory which comprises 12 subcomponents, testing such features as the capacity to memorize and recall a new name, recognition of previously presented unfamiliar faces and of pictures of objects, recalling a brief prose passage immediately and after a delay, and the immediate and delayed recall of a simple route. The test also involves measures of orientation in time and place, and some simple tests of prospective memory. The subtests designed are unlike most others because they do not measure memory for unfamiliar materials, nor do they measure memory in a quasi-laboratory fashion. The items assess the client's ability to remember a functional memory activity or to perform a functional skill that requires memory. For example, the examiner hides an object such as a comb or pencil at various locations in the room, and the client must recall the object and its placement after a delay. The client must recall the purpose of an alarm (a single for an appointment) when the alarm goes off. Conventional memory tests for paired associations are used to supplement the battery. It is ecologically valid, using tasks similar to activities of everyday life; it tests both short-term and long-term memory for verbal and spatial information as well as prospective memory. That is, remembering to do something in the future (Efklides et al., 2002). Therefore, it is a very useful tool for memory testing, particularly for neuropsychological assessment and remediation of memory problems (Baddeley et al., 1996; Cockburn et al., 1990).

Items on the RBMT have been shown to discriminate successfully a memory impaired from a non-memory impaired sample. It was proved to be sensitive to memory deficits and, in contrast to more conventional methods, correlated well with frequency of memory hours (Wilson et al., 1989). In a study following up a group of amnesic patients several years later, Wilson (1991) found that level of performance on the test accurately predicted capacity to cope independently, in contrast to more conventional measures, such as the Wechsler Memory Scale-Revised. It was also demonstrated that the test could discriminate two groups of clients who were previously identified by occupational therapists as having everyday memory problems. The test correlates moderately with a variety of standardized memory tests but does not correlate strongly with tests of intelligence. Different administrators provide reliable and comparable scores. RBMT offers four alternative versions in order to avoid operational memory, the alternative forms also correlate strongly.

The RBMT has been translated and standardized in a number of different languages. The validity of a Chinese version RBMT had been tested in Hong Kong (Neuro-Rehabilitation Working Group, 1998) and in mainland China (You, Han & Xu, 2003). In addition to language changes, photographs of memory recognition were also substituted by Chinese faces. The Story subtest was replaced by a local news report, which contained the same number of ideas as the original RBMT subtest. This can increase the validity and reliability of the test in a Chinese culture. The Rivermead Behavioural Memory Test - Chinese version (RBMT-CV) has also demonstrated a very high inter-rater reliability (100% agreement between the raters for two scoring systems) and good alternate form reliability (correlation between performance on parallel forms ranging from 0.67-0.84), as well as good psychometric properties of the Chinese version (Man & Li, 2001). You et al (2003) reported that the test-retest reliability for 27 patients was high in most items ($r >$ 0.7, $P <$ 0. 01). The split half reliability of the two tests was 0.856 and 0.896 respectively. Patients with memory impairment had lower scores in RBMT than those without memory impairment ($P < 0.05$). By using the cut-points of the original test, the sensitivity and specificity of RBMT were 87.5 % and 76.5 %, respectively. There was no statistically significant difference between the results of the Chinese version of RBMT and the original version. Thus the RBMT-CV is of satisfactory reliability and validity, and it can also serve as a good instrument in measuring and evaluating memory impairment for Chinese patients. In addition, it allows for repeated assessments to monitor stability, improvement or deterioration over time.

In addition, the RBMT was particularly suitable for use in this multi-centre study (Evens, et al. 2000). The validated Chinese version had been used for testing patients' memory functions over several time periods as the RBMT-CV also offered four alternative versions and would thus be used in three different period of measurement. The preliminary score of all items was transformed into a standard score, the functional memory level would thus be divided into normal, fair, moderate and severity category according to identified memory impaired situation. The scoring of all items followed the prescriptions of the original RBMT too.

4.5.2.3 The Hong Kong List Learning Test (HKLLT) (appendix A9a, b)

The Hong Kong List Learning Test (HKLLT; Chan & Kwok, 1999), a newly developed neuropsychological assessment in Hong Kong, is based upon the model of the California Verbal Learning Test (CVLT; Delis et al., 1987). The HKLLT emphasizes the evaluation of organization strategies in learning and memory. The HKLLT consists of a randomly presented word-list (list A) like the one in the CVLT, and also another word-list (list B) that is presented in block, with the words that are semantically related presented together. The words in the list A come from four categories and are organized randomly (random condition). The list for the random presentation condition consisted of 16 two-character Chinese words, with four items from each of four categories: *furniture*, *vegetable* (both are concrete objects); *relative* and *country* (relatively abstract nouns). The words were arranged randomly with the condition that no two items from the same category were presented consecutively. The list B consists of words from another four categories that are semantically clustered (blocked condition). For the blocked condition, there were another 16 two character. Chinese words from four categories: *clothing*, *flower* (concrete objects); *music* (e.g., folk songs and opera) and *occupation* (relatively abstract nouns). These items were organized into clusters based upon the categories. It should be noted that the words of the lists were not randomized between the two conditions, that is, list A was always used in the random condition and list B was always used in the blocked condition. The level of typicality, frequency, and difficulty of words in the two lists was matched.

The test consists of three immediate recall trials, two delayed recall trials (10 and 30 minutes), and one recognition task. The HKLLT has been designed to examine the following variables which were considered to be relevant to the present study:

1. Rate of learning (acquisition);
2. Rate of forgetting (retention);
3. Encoding versus retrieval deficit;
4. Learning strategies:
    a. Semantic clustering
    b. Subjective organization ability
    c. Primacy versus recency effect
    d. Concrete versus abstract concepts
5. Memory intervention:
    a. Rrepetitive practices
    b. External organization cues
6. Intrusion errors;
7. Preservation errors;

8. Vulnerability to interference.

Normative data have been obtained from 338 native Chinese speakers (age range = 7-95). This test was also found to differentiate between normal adults and those with Alzheimer Disease (AD), and between adults with mild and moderate AD (Au, Chan, & Chiu, 2003). The best predictor of normal versus impaired group membership was the rate of forgetting in the first 10 minutes for the random condition, and the total retention for the blocked condition. Regarding the differentiation between adults with mild and moderate AD, semantic clustering was identified as the best predictor. There was one study that investigated the effect of ruptured aneurysm of the anterior communicating artery (ACoA) on cognitive functions (Chan, Ho & Poon, 2002). The study found that HKLLT was able to detect memory deficits of ACoA aneurysm patients, who demonstrated significantly worse total learning and higher rate of forgetting than normal controls.

Two major characteristics of the HKLLT are identified: a. it is a Chinese verbal learning test that contains Chinese characters rather than English words; b. it was designed with a purpose to evaluate the effectiveness of two memory interventions, namely, repetitive practices and external organization cues. In the present study, this validated Chinese assessment form was thus used for testing memory process and learning strategies. The scores on HKLLT were computed as scoring guide and recorded on a scoring form, but the measure of the overall recognition performances were replaced by the discrimination score since it considered both correct hits and false alarm errors.

4.5.2.4 The Memory Functioning Questionnaire (MFQ) (See appendix A10a, b)

The Memory Functioning Questionnaire (MFQ; Gilewski, Zelinski & Schaie, 1990), a subjective measure of memory function, is a reliable instrument for assessment of self-perceptions of memory abilities. It consists of 64 items requiring seven-point Likert scale judgments on various aspects of everyday remembering and forgetting. The higher values indicate fewer problems. It is composed of four parts:

1. General frequency of forgetting, including ratings of the frequency of forgetting (in general and specific situations).
2. Seriousness of forgetting measured the perceived seriousness of forgetting in 18 specific situations;
3. Retrospective functioning rated changes in memory ability in comparison with five time-points earlier in life;
4. Mnemonics usage rated the frequency with which eight specific mnemonics were used.

Many researchers have presented evidence that the MFQ is a reliable instrument (Hertzog, Hultsch & Dixon, 1989; Hertzog & Rogers, 1989; Ponds & Jolles, 1996; Revell et al., 2001). Studies evaluating the concurrent validity of the MFQ with respect to memory performance and depression have been completed. The MFQ also has moderate concurrent validity with memory measures and is preferable to responses to a single question about memory self-perception in assessing memory complaints in normal adults. In the present study, MFQ would assess self-efficacy in applying the learned memory strategies in participants' community or activities of daily life.

4.5.2.5 Questionnaire on subjects' demographic characteristics (appendix A3a, b)

A recording form was developed for the present study to record the demographic information of the subjects. The information were subjects' age, gender, their level of education, time of post-brain injury, computerized tomography (CT) or magnetic resonance imaging (MRI) evidence, diagnosis, sidedness of brain lesion, present existing functional disorders, severity of amnesia and level of cognitive functions for screening purposes, such as previously mentioned Everyday Memory Questionnaire (EMQ) and Rancho Los Amigos Level of Cognitive Functioning Scale.

4.5.2.6 Questionnaire on memory self-efficacy and subjective evaluation of training programme (see appendix A11)

Information on subjective self-perception of usefulness of the 20-session memory training, based on EE & EL model in either CAMG or TAMG were collected. The information can be further categorized in five areas, namely:

1. Self-confidence (4 items)
2. Self-efficacy in memory skills (evaluation of own competence) (13 items in functional application)
3. Subjective evaluation of training programmes (5 items, covering personal satisfaction, programme effectiveness, and usability)
4. Comments on content and structure of the programmes (3 items, including graphical and textural quality).
5. Suggestions for improvement (7 items, including training methods and duration etc.)

Participants were also asked open-ended questions periodically so as to tap further their viewpoints on the usefulness, efficacy, satisfaction and functionality of sessions they had gone through. Their responses were then used for content analysis by the end of training programme. For instance, the first reflective checking was held after the fifth session. Subjects should have completed basic memory skill trainings and they were asked to comment on questions related to the usability and the like on a rating scale from 0 to 7, and to share their opinions about content design and improvement of training method. The tenth and twentieth session reviewed memory strategies and assessment to be made on applying these strategies to solve typical daily living problems. After they had completed the final sessions, a questionnaire on evaluating the quality of the overall programme was also administered (see appendix A11)

4.6 Implementation

4.6.1 Assessment procedures

All assessments were completed in a pencil-and-paper format, by means of face-to-face mode. They were carried out by several independent raters who were either therapists or medical professionals working in hospitals participating in the present study. They were not involved in the training programme. Moreover, they were blind to the study, and thus were not aware of the research objectives so as to avoid bias in reaching desirable outcome. All of them had professional background in rehabilitation medicine, occupational therapy or speech therapy. They were given briefing, de-briefing and training sessions before actual evaluation on subjects, so as to standardize the procedures, maintain consistency across raters. Global cognitive, memory and functional assessment would be administered before, after the intervention period, and during 1-month follow-up. A pilot study of using five patients in each group was attempted so that evaluation procedures could be revised before implementation of the main study.

4.6.2 Training procedures

In the present study, CAMG using the EE & EL model focused mainly on direct retraining of memory. Intervention settings would be within inpatient or outpatient service of the rehabilitation department in several comprehensive hospitals in Guangzhou, PR China. Subjects in each of the two training groups (CAMG and TAMG) would receive a total of 20 training sessions, 5-day training weekly, and each session would last for about 45 minutes. They would be trained by a separate group designated therapists (usually the case therapists, but were not the same independent raters carrying out the assessment) in administering the respective CAMG or TAMG programmes. They followed a one- month training protocol which had been designed with detailed implementation procedures. Each session consisted of basic component memory skill training, typical daily task management utilizing/integrating the component memory skills, customized programmes and skill consolidation as well as generalization in practice. These innovative systems composed of an assortment of applications supporting an array of tasks and functions from simple to complex. As indicated in previous session 4.5.1, the training protocol adapted the same training structure and contents across CAMG and TAMG (see Table 4.2)**.**

4.6.3 Instructional strategies adopted in memory skill training programme

As mentioned before, objectives of the instructional strategies were to assist subjects to structure, manage, or interact appropriately in their environment through therapeutic management. In the context of the present memory training, the underlying cognitive mechanisms of daily memory were designed with unique, area-specific strategies. The contents of the tasks were presented in a hierarchy through controlling a) the amount of the stimulation; b) the power of the stimulation; c) the complexity of the stimulation; and d) level of abstraction respectively. To ensure the same amount and type of materials would be delivered in TAMG (comparable to CAMG), a training manual was fabricated to ensure the consistency of the programme implementation and thus to achieve good inter-trainer reliability. Written instructions detailing the experimental procedures and materials used were also provided in this manual, such as all the corresponding guidelines for assessment and training instructions of each session. Although trainers of the therapist-administered training programme were qualified therapists who possessed abundant experiences in clinical practice, they were strictly instructed to follow the standard training processes specified in the manual. Trainers had been paired together to practice their assessment and training skills during pilot study. Case presentations and follow-up discussion were used to illustrate assessment techniques and correct feedback to trainees’ responses.

4.6.4 Programme modes of CAMG, TAMG and CG

4.6.4.1 The computer-assisted memory training group (CAMG)

A computer-assisted memory skill training package had been developed in the present study. The programme was equipped with interactive multimedia presentations on the knowledge and skill required for persons with TBI to function independently in daily life. Subjects went through this self-paced, computer-assisted training strategy with real-time computer feedback. But the training might be complemented with face-to-face support from a therapist, only if it was really needed.

4.6.4.2 The therapist administered memory training group (TAMG)

As mentioned in 4.5.1 and 4.6.3, subjects of the TAMG participated in a conventional, face-to-face, therapist-instructed memory training programme. The content of training was identical to that of the CAMG. In TAMG, the training package would be delivered by therapists who gave instructions through a face-to-face mode. The training material had been converted into a color-printed manual.

4.6.4.3 Control group (CG)

Subjects with TBI who were wait-listing for cognitive training formed the control group. Their demographic characteristics were listed in appendix A3a and b. Demographical characteristics of the control group were age-, gender- and diagnosis-matched with the subjects who participated in two training groups. Their results from the outcome measures, which were similarly applied to CAMG and TAMG, were assessed three times in a 2-month interval (pre-, post-training period and 1-month follow up). Monitoring by regular phone contact was performed to ensure that they did not receive any training that might affect their memory skills and self-efficacy.

4.7 Pilot Study

As mentioned earlier, a smaller-scaled pilot study was implemented with the intension to develop memory training strategies that would be used in the experimental group of the main study. The pilot stage incorporated pre- and post-test quasi-experimental study with five subjects from each group and tried to test the feasibility of the computer-assisted rehabilitation set-up and the instruments to be utilized. Feedback from the subjects and collaborating hospital colleagues were used to further perfect and finalize the design. Before the pilot study, the subjects' knowledge and self-rated on how to manage memory problems in daily life were assessed. The subjects' basic cognitive state (as measured by NCSE, HKLLT and RBMT) and functional status (FMQ) were assessed before and after the study.

4.8 Main study

The main study again adopted a pre- and post-test quasi-experimental clinical design. The recruited subjects were randomly assigned to one of three experimental groups. Statistical analyses were performed to ensure that there was no significant pre-test group difference in potential confounding variables such as the age, pre-training memory skill level.

4.9 Data processing and analysis

The independent variable of the present study was taken as the three different memory training programmes (though CG received no active treatment) for persons with traumatic brain injury.

The dependent variables were respectively subjects':

1. knowledge and concepts of independent cognitive functions (as measured by NCSE-CV);

2. ability to remember a functional memory activity or to perform a functional skill that required memory (as measured by RBMT-CV);
3. organization strategies in learning and memory process (as measured by HKLLT);
4. Self-efficacy in applying the learned cognitive strategies in their everyday activities (as indicated mainly by FMQ).

Statistical procedures such as the among groups repeated measures analysis of variance (ANOVA) were used to test and compare the effectiveness of the two intervention groups and a control group. They were also used to evaluate the main effect and possible interaction effect(s) among independent variables and variables like the subjects' cognitive/memory skill levels in pre- and post-training, and during follow up. Moreover, subjects would be stratified according to education, gender, sites and duration of injury, by means of analysis of covariance, so as to control confounding variables and/or study the possible interaction effects of those factors, such as the well documentation of left lesion side in affecting patients’ spatial memory abilities. A comparison within the same group and between different groups (e.g. CAMG and TAMG) was made based on common themes, for example, the three memory processes.

Chapter Five

DATA ANALYSIS AND RESULTS

Both descriptive and inferential data were analyzed in the present study. The scores of formative and summative memory-related assessments were measured in pre-, post-test and during follow up period. As mentioned earlier, the independent variable of the present study was the different memory training programmes for persons with traumatic brain injury. The dependent variables were firstly, subjects' knowledge and concepts of independent cognitive functions (as measured by NCSE-CV); secondly, subjects' ability to remember a functional memory activity or to perform a functional skill that requires memory (as measured by RBMT-CV); thirdly, organization strategies in learning and memory process and their correlation (as measured by HKLLT); fourthly, subjects' self-efficacy in applying the learned cognitive strategies in their everyday activities (by using FMQ). Fifthly, subjects' self-reported efficacy, as measured by self-designed questionnaire of memory training including self-confidence, self evaluation of own competence, evaluation of programme, suggestions for improvement, comments on content and design etc.

Statistical procedures were conducted for both within-group and across-group analyses. For across-group analysis, tests such as repeated measures analysis of variance (ANOVA) were used to test and compare trends of the two intervention groups and a control group over an extended time period (1-month training and 1 month follow up). The tests were also used to evaluate if the positive treatment effect was established and if there was possible carryover effect of memory performances. When there was a significant main effect of condition, contrast comparisons were made between each of the nine pairs of conditions (that is, 3 groups times 3 time slots, i.e. pre-test, post-test and follow-up) using a Bonferroni corrected alpha, with significance level set at 0.05/9, so as to reduce the likelihood of a type I error (the probability of which was increased by multiple comparisons). A comparison within the same group was also made using a post hoc Bonferroni adjustment, based on the outcome measures: scores of NCSE-CV, RBMT-CV, MFQ and HKLLT (the mean scores of three groups' outcome measures can be referred to appendix A12-17), but the comparison within group don't need be described in result in order to avoid miscellaneous and prolixity. Open-ended questions that come from questionnaire of self-reported efficacy were also used to triangulate with the quantitative data to answer specific research questions, if appropriate. Moreover, subjects were stratified according to education, gender, sidedness and duration of brain injury, by means of Chi Square Test or one way analysis of variance (ANOVA), so as to control confounding variables and/or study the possible interaction effects of these factors. It was anticipated that subjects' learning strategies might be related to the memory process. A correlation analysis was thus conducted looking at correlations between learning strategies scores and memory process scores (both scores were measured by the HKLLT).

5.1 Demographic characteristics of subjects

From March 2004 to May 2005, a total of 112 subjects with TBI were enrolled (see figure 5.1) from five different hospitals and one rehabilitation center in Guangzhou city, PR

China, to participate in the main study. They were randomly assigned into the three groups: CAMG (n=39), TAMG (n=36) and CG (n=37).

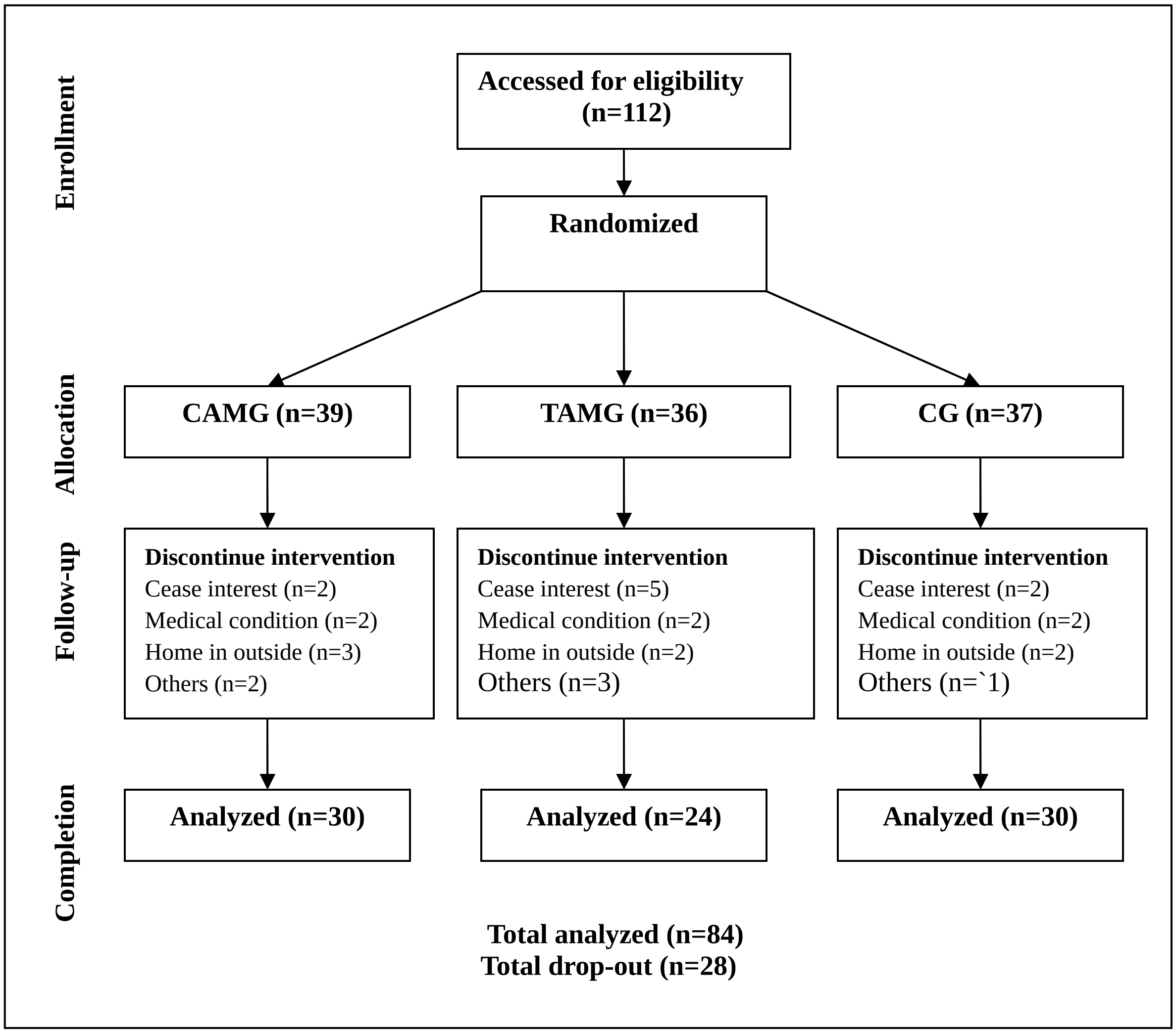


Figure 5.1 Flow chart of phases of randomized trial

Ultimately, there were 28 subjects who dropped out from the study due to different reasons such as ceasing interest (n=6), deteriorated medical condition (n=7), no further follow up when subjects left Guangzhou area (n=9) and other unknown reasons (n=6) (see Table 5.1).

Reasons of dropped out	**CAMG**	**TAMG**	**CG**
Ceasing interest	2	2	2
Deteriorated medical condition	3	2	2
Left Guangzhou area	2	5	2
Others	2	3	1
Total	9	12	7

Table 5.1 28 subjects who dropped out of the study because of different reasons

Note: CAMG: computer assisted cognitive rehabilitation;
TAMG: Therapist administered cognitive rehabilitation;
CG: control group.

The results of eighty-four subjects who were able to complete all the sessions and the final follow up were analyzed. 30 patients in CAMG group, 24 patients in TAMG group and 30 patients in CG group respectively. There were no details, from clinical notes that they were either open or closed head injury. We also do not have information on length of stay in ICU. From patients' medical records, MRI or CT scan, it was found that most of the subjects suffered from focal brain injury rather than diffuse brain injury. All of them had received brain operation. As all of the participants in this study had the post-injury period longer than 3 months (Most of the subjects had received their treatment between 3 to 6 months), and fulfil the inclusion criteria, the level of their initial injury severity. Thus we assumed that a similar degree of lesion and relevant impairment to cognitive function might occur. and that their brain lesion and post-injury status would be comparable. The completers' overall mean age was 39.74 years (SD = 11.42). The mean age in each group were 37.83 (SD=10.58), 43.62 (SD=11.93), 38.53 (SD=11.42) respectively. The mean post-injury period (chronicity) of the subjects was 174.98 days (SD=176.51), their distributions (SD) in CAMG, TAMG and CG were 206.30(239.79), 145.13(97.46), and 167.53(149.40) respectively. The mean count of the gender, sidedness of brain injury and educational levels were found to be quite balanced. There were no statistically significant differences on gender, brain injury sites and educational level among three groups, as indicated by Chi Square Test or ANOVA test results (see Table 5.2).

	CAMG		**TAMG**		**CG**			
	(n=30)		**(n=24)**		**(n=30)**		**χ^2 value**	**P-value**
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**		
Age	37.83	10.58	43.62	11.93	38.53	11.42	2.024	0.142
Chronicity(day)	206.30	239.79	145.13	97.46	167.53	149.40	0.839	0.436
Gender								
Male	22	73.3%	17	70.8%	22	73.3%	0.053	0.974
Female	8	26.7%	7	29.2%	8	26.7%		
Side of Brain Lesion								
Left side	7	23.3%	5	20.8%	12	40.0%	3.563	0.468
Right side	17	56.7%	12	50.0%	12	40.0%		
Both side	6	20.0%	7	29.2%	6	20.0%		
Level of education								
Primary	5	16.7%	3	12.5%	9	30.0%	3.787	0.436
Secondary	16	53.3%	15	62.5%	12	40.0%		
Tertiary	9	30.0%	6	25.0%	9	30.0%		

Table 5.2 Demographic characteristic of subjects following TBI

5.2 Across-groups comparison in the pre-training baseline

One way analysis of variance (ANOVA) was used to analyze the pre-training baseline differences of four outcome measures (including basic cognitive function as measured by NCSE-CV; everyday memory performance as measured by RBMT-CV; memory process

	CAMG **(n=30)** **Mean±SD**	**TAMG** **(n=24)** **Mean± SD**	**CG** **(n=30)** **Mean± SD**	**F-value**	**P-value**
NCSE-CV					
orientation	9.57±2.59	8.58±2.54	9.60±2.79	1.223	0.300
attention	7.63±1.07	7.63±1.14	7.87±0.51	0.627	0.537
comprehension	5.43±0.97	5.42±1.02	5.33±1.32	0.067	0.935
repetition	10.67±2.06	10.42±2.78	10.67±2.51	0.090	0.914
naming	7.30±1.34	7.54±0.98	7.60±1.22	0.515	0.599
construction	2.50±2.26	1.83±1.81	2.43±1.96	0.841	0.435
memory	6.40±2.92	4.29±3.54	5.87±2.78	3.327	0.041
calculation	3.27±1.31	2.92±1.28	3.30±1.34	0.672	0.514
similarities	5.00±1.95	4.63±1.86	4.47±1.91	0.613	0.544
judgment	4.73±0.87	4.58±1.18	4.50±1.28	0.334	0.717
RBMT-CV					
belonging	1.13±0.86	0.62±0.77	0.70±0.84	3.126	0.041
Total score	10.27±6.25	7.50±4.01	9.53±5.36	1.852	0.163
HKLLT					
Random encoding	5.17±1.95	4.59±1.81	4.69±1.87	0.744	0.478
Random storage	3.87±3.16	2.48±2.08	2.68±2.43	2.294	0.107
Random retrieval	0.58±0.25	0.49±0.22	0.52±0.25	1.093	0.340
Blocked encoding	5.01±2.80	4.56±1.96	4.06±1.62	1.410	0.250
Blocked storage	4.38±3.79	3.50±3.49	2.72±2.32	1.978	0.145
Blocked retrieval	0.54±0.27	0.44±0.23	0.46±0.29	1.146	0.323
MFQ					
Frequency of forgetting	98.63±34.86	72.83±23.53	72.83±23.53	4.082	0.020
Seriousness of forgetting	67.20±21.11	57.92±22.22	57.92±22.22	1.540	0.221
Retrospective functioning	15.97±5.71	13.67±7.31	13.67±7.31	0.812	0.448
Mnemonics usages	45.63±12.96	54.83±3.63	54.83±3.63	6.580	0.002

Table 5.3 The baseline comparison of outcome measures between the experimental group and control group

and learning strategies as measured by HKLLT; functional everyday memory activity as measured by FMQ) among the CAMG, TAMG and CG. (see Table 5.2). No significant differences across the three groups were found, except a few sub-test scores e.g. Memory subscore of NCSE-CV ($F_{(2,81)} = 3.327$, $P = 0.041$), Belonging sub-score of RMBT-CV ($F_{(2,81)}=3.126$, $P=0.049$), General frequency of forgetting sub-score of FMQ ($F_{(2,81)}=4.082$, $P = 0.02$), and Mnemonics usage sub-score of FMQ ($F_{(2,81)}=6.58$, $P = 0.002$).

By means of post hoc test of Turkey HSD, it was found that there was statistically significant difference between CAMG and TAMG in three subscores, namely the NCSE-Memory ($P = 0.037$); FMQ- General frequency of forgetting and mnemonics usage ($P = 0.022$ & 0.002 respectively). So as to manage these three different sub-test baselines for subsequent analysis, NCSE-memory, FMQ-general frequency of forgetting, FMQ-mnemonics usage would be taken as covariates in multivariate analysis later

5.3 Comparing knowledge and concepts of independent cognitive functions as measured by NCSE-CV in CAMG, TAMG, and CG

5.3.1. Within-group comparison of NCSE scores

Within-group comparison of over-time trend was analyzed by a 3 (Groups) × 3 (assessment times) repeated-measures ANOVA. Table 5.4 shows the three mean differences (T1, T2 and T3) in each of the ten subscores of NCSE over time and in each of the three different groups. The positive values of T1 (defined as the mean difference between post- and pre-training values) and T2 (defined as the mean difference between the follow-up and pre-training values) would thus indicate post-training main effect while

T3 (defined as the mean difference between follow up and post-training values) indicated carryover effect during follow up respectively.

To be more specific, it was obvious that there were significant improvement in ‘Orientation’, ‘Repetition’ and ‘Memory’ subscores for both CAMG and TAMG. ‘Similarities’ was found to be significantly improving only during T2 measurement in CAMG, while ‘Construction’ improved similarly during T2 in TAMG. Both findings seem to suggest that there would be a gradual improvement during training period but became more significant during follow up.

For CAMG alone, it was obvious that subjects improved in ‘Comprehension’ and ‘Naming’ as a result of training and the training effect was maintained during follow-up. For TAMG alone, ‘Calculation’ was found to have improved significantly during training period and the carryover effect was identified. There were no significant changes in nearly all subscores in CG, except in ‘Orientation’ and ‘Comprehension (as reflected by T2 values only) indicating possible natural recovery in these areas.

In addition, ‘Attention’ was found to be the only NCSE-CV subscore that did not change over time and this finding was consistent across the three groups. In order words, all subjects demonstrated appropriate level of attention for the memory training and it may be a result of setting stringent subject selection criteria.

5.3.2 Across- group comparison of NCSE-CV scores

When comparing the three groups using repeated measure analysis of variance (ANOVA),

Sub-test items	CAMG			TAMG			CG		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
orientation	0.967**	1.133**	0.167	1.667**	1.958**	0.292	0.700	0.967*	0.267
attention	0.167	0.333	0.167	0.292	0.208	-0.083	0.133	0.133	0.000
comprehension	0.367*	0.467**	0.100	0.000	0.167	0.167	0.300	0.400*	0.100
repetition	0.600*	0.733*	0.133	0.833**	0.792*	-0.042	0.167	0.433	0.267
naming	0.500**	0.533**	0.033	0.208	0.333	0.125	0.100	0.200	0.100
construction	0.567	0.400	-0.167	0.542	0.667**	0,125	0.200	0.333	0.133
memory	2.167**	1.933**	-0.233	2.750**	2.458**	-0.292	0.800	0.667	-0.133
calculation	0.267	0.400*	0.133	0.458*	0.542**	0.083	0.033	0.100	0.067
similarities	0.467	0.633*	0.167	0.333	0.542	0.208	0.267	0.467	0.200
judgment	0.267	0.333	0.067	0.458*	0.458	0.000	0.200	0.367	0.167

Note: T1: *mean difference between post-pre training;*

T2: *mean difference between follow up-pre training;*

***T3*:** *mean difference between follow up-post training*

** P< 0.05; ** P < 0.01*

Table 5. 4 Within-subjects pairwise comparison of NCSE-CV scores mean difference between post- pre training and follow up among CAMG, TAMG and CG

it was found that only main effect of Memory subscore demonstrated significant difference ($F_{(2, 81)}$ = 3.814，*P* = 0.005). Using Post-hoc Boferroni test to compare TAMG, CAMG, and CG, it was found that TAMG>CG and CAMG>CG (*P* < 0.01)，but there was no significant difference between TAMG and CAMG (see appendix A18).

Thus, except for NCSC-memory, other main effect of NCSE subscores had no significant change over time and across the three training groups (see figure 5.2). In other words, the training programmes (CAMG and TAMG) were effective to improve memory performance, as reflected by NCSE-CV.

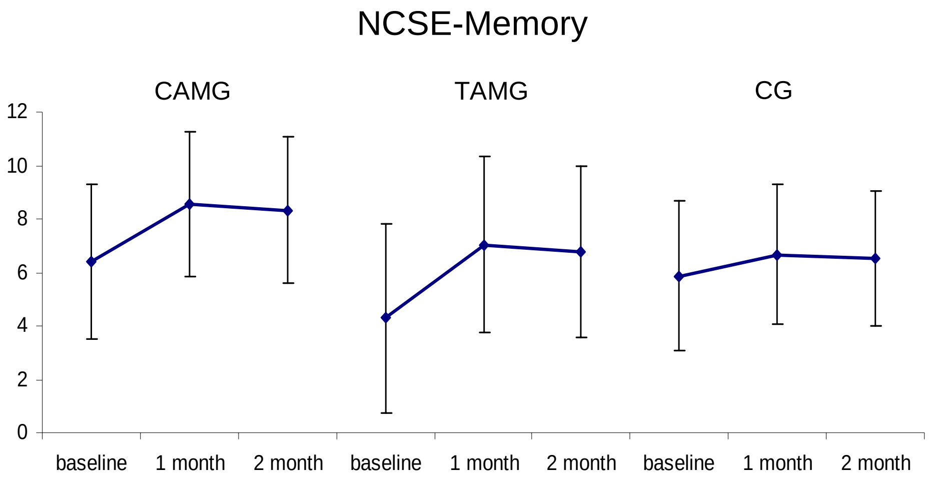


Figure 5.2 NCSE –memory subscore over-time trend during pre-training, post-training and follow up among CAMG, TAMG and CG

5.4 Comparing the ability to remember a functional memory activity or to perform a functional skill that requires memory as measured by RBMT-CV in groups in CAMG, TAMG, and CG

5.4.1 Within-groups comparison of RBMT - CV

Table 5.5 shows the mean differences in RBMT - CV over time (T1, T2 and T3) and within each group. It was found that there were significantly improvements in T1 and T2 in ‘Story (immediate)’ and ‘Message’ in both CAMG and TAMG (P <0.05 to P <0.01), but there was no similar improvement in CG. In CAMG, it was also evident that there was improvement during training (T1 and T2) in ‘Face’, ‘Orientation’ and the total score of RMBT-CV (P < 0.05 to P < 0.01), while selective improvements were observed in ‘Picture’ and ‘Route (delay)’ for TAMG. Main effect of mean differences between follow up and post-training (T3) in CAMG, TAMG and CG were computed. It was found that there were no significant changes in all RBMT-CV subscores except the ‘Belonging’ subscore in CAMG only. Thus the effect of training in most areas seems to be maintained over time during follow up (see table 5.5).

5.4.2 Across-group of RBMT- CV

It was found that ‘Belonging’ ($F_{(2,80)}$ = 2.463, P=0.047), ‘story-immediate ($F_{(2,80)}$) = 2.681, P=0.034)’, ‘Story-delay’ $F_{(2,80)}$ =4.314，P=0.002), ‘Face’ ($F_{(2,80)}$=3.452，P=0.01) and the total score ($F_{(2,80)}$ =9.476，P=0.001) demonstrated statistically significant differences (see appendix A19). Further post-hoc Boferroni test showed that TAMG > CG and CAMG > CG (P<0.01)，but there was no significant difference between TAMG and CAMG (see figure 5.3).

	CAMG			TAMG			CG		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Name	0.333	0.267	-0.067	0.208	0.167	-0.042	-0.133	-0.200	-0.067
Belonging	0.167	-0.133	-0.300*	0.250	0.417*	0.167	0.133	0.067	-0.067
Appointment	0.367*	0.300	-0.067	0.125	0.250	0.125	-0.100	-0.100	0.000
Picture	0.367*	0.267	-0.100	0.500**	0.417*	-0.083	0.167	0.133	-0.033
Story(immediate)	0.700**	0.667**	-0.033	0.625**	0.542**	-0.083	0.167	0.300	0.133
Story(delay)	0.567**	0.467**	-0.100	0.250	0.250	0.000	-0.033	-0.100	-0.067
Face	0.667**	0.633**	-0.033	0.333	0.333	0.000	0.067	-0.333	-0.100
Route(immediate)	0.267	0.367*	0.100	0.208	0.208	0.000	0.167	0.200	0.033
Route(delay)	0.333	0.467*	0.133	0.417*	0.375	-0.042	0.033	0.100	0.067
Message	0.500*	0.600**	0.100	0.792**	0.667**	-0.125	0.067	0.133	0.067
Orientation	0.233*	0.333**	0.100	0.083	0.083	0.000	0.100	0.000	-0.100
Date	0.333*	0.033	-0.300	0.042	0.292	0.250	0.133	0.133	0.000
Total	4.833**	7.333**	2.500	3.833**	3.958	0.125	0.667	0.567	-0.100

Note: T1: *mean difference between post- and pre- training;* ***T2:*** *mean difference between follow up and pre- training;*

***T3*：** *mean difference between follow up and post-training.*

** P< 0.05; ** P < 0.01*

Table 5.5 Within-subjects pairwise comparison of RBMT - CV scores mean difference between post- pre training and follow up among CAMG, TAMG and CG.

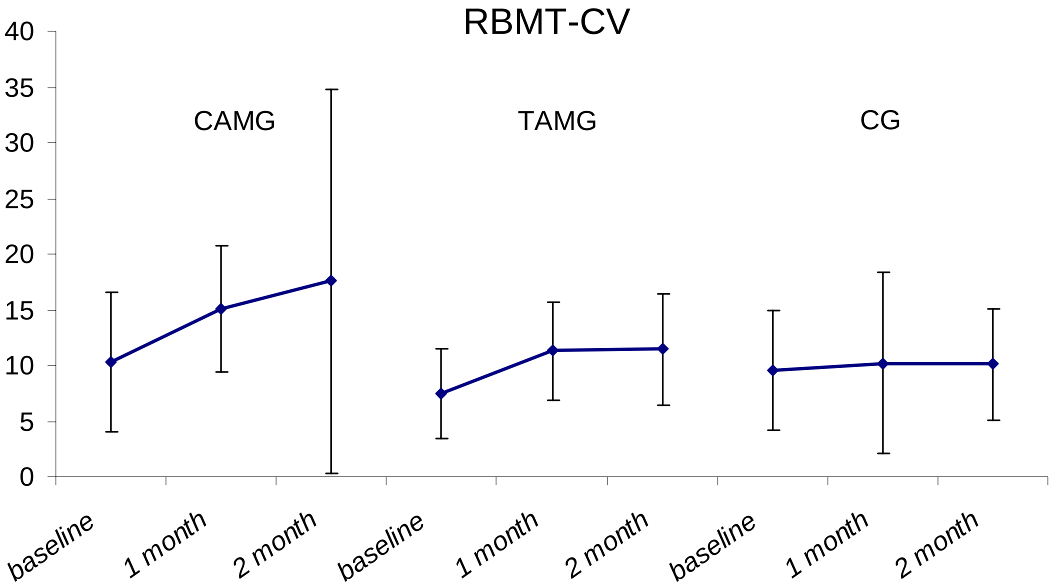


Figure 5.3 Overtime trend of RBMT- CV total score during pre-training, post-training and follow up among CAMG, TAMG and CG.

Note: Actually, there are related figures for subtests in each dependent variable which is statistically significant. To avoid printing too many figures, only the figure indicating significant meaning is shown. The same situation is used in following HKLLT, MFQ dependent variables.

5.5 Comparing memory process as measured by HKLLT in groups with CAMG, TAMG, and CG

5.5.1 Within-group comparison of HKLLT -memory process scores

The over-time trend of mean differences of memory processes score (encoding, storage

	CAMG			TAMG			CG		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Random encoding	1.422**	2.456**	1.033**	0.806**	1.681**	0.875**	0.189	1.011**	0.822**
Random storage	2.767**	2.717**	-0.050	1.583**	1.312**	-0.271	0.117	-0.067	-0.183
Random retrieval	0.203**	0.180**	-0.023	0.236**	0.223**	-0.013	0.060	0.079*	0.019
Blocked encoding	2.611**	2.244**	-0.367	1.500**	1.319**	-0.181	0.356	0.567	0.211
Blocked storage	3.233**	2.333**	-0.900**	1.333**	1.000*	-0.333	0.050	-0.067	-0.017
Blocked retrieval	0.267**	0.240**	-0.027	0.296**	0.298**	0.002	0.104*	0.128**	0.024

Note: T1: *mean difference between post- and pre- training;* ***T2:*** *mean difference between follow up and pre- training;*

T3**:** *mean difference between follow up and post-training.*

** P< 0.05; ** P < 0.01*

Table 5.6 Within-subjects pairwise comparison of memory process scores mean difference in HKLLT -random condition between post- pre training and follow up among CAMG , TAMG and CG

and retrieval) in HKLLT (both random and blocked conditions) was reflected in Table 5.6. Table 5.6.shows similar improvements in the three memory processes of both conditions (random and blocked) during training and follow up when analyzing CAMG and TAMG. However, similar changes in CG over time (T1 and T2) were found in 'blocked retrieval' only. The carryover effect (T3) was only identified in 'random encoding' ($P < 0.01$) and was consistent across the three groups. In addition, it was shown that there was a decline in 'block storage' when computing the mean difference between follow up and post-training (T3) in CAMG, indicating the training effect could be maintained over time.

5.5.2 Across-group comparison of HKLLT-memory process scores

When comparing the three groups using repeated measure ANOVA, it was found that all six memory scores demonstrated significant improvement, namely 'Random Encoding' ($F_{(2,80)} = 8.193$，$P = 0.000$), 'Random Storage' ($F_{(2,80)} = 8.285$，$P = 0.000$), 'Random Retrieval' ($F_{(2,80)} = 3.752$，$P = 0.006$), 'Block Encoding'($F_{(2,80)} = 7.386$，$P = 000$), 'Block Storage' ($F_{(2,80)} = 7.816$，$P=0.000$), 'Block Retrieval'（$F_{(2,80)} = 4.472$，$P = 0.002$）. Boferroni test revealed that CAMG > CG in all memory processes except in 'block encoding' ($P = 0.076$) and TAMG > CG in all memory processes ($P<0.05$ to $P <0.01$) too (see appendix A20). When comparing CAMG and TAMG and their changes in mean difference between pre- and post-training (T1), CAMG > TAMG in all conditions (Random/Blocked Encoding and Random/Block Storage; $P \leq 0.01$or $P < 0.05$ respectively), except for 'Random Retrieval' and 'Blocked Retrieval' conditions (see figure 5.4). When computing the mean differences between follow up and post-training (T3), there was no significant differences between CAMG and TAMG in all memory conditions.

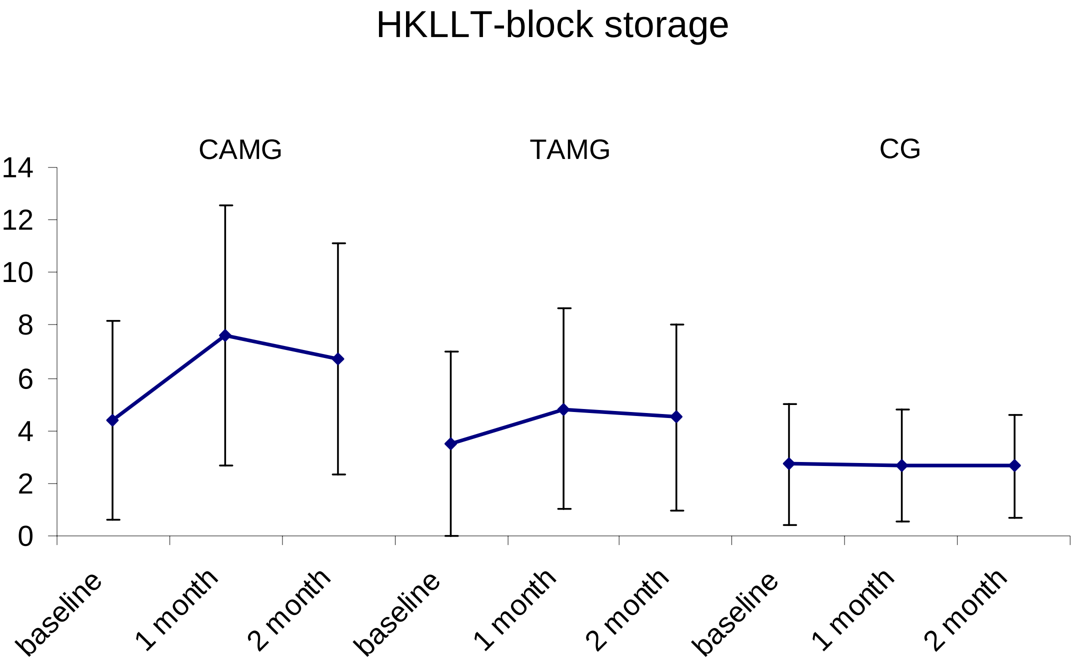


Figure 5.4 Overtime trend of HKLLT blocked storage scores during pre-training, post-training and follow up among CAMG, TAMG and CG.

5.6 Comparing self-efficacy in applying the learned memory strategies in their everyday activities as measured by FMQ in CAMG and TAMG

5.6.1 Within-group comparison

Table 5.7 shows the significant improvement during and after training, in CAMG and TAMG in ‘Frequency of forgetting’ and ‘Seriousness of forgetting’ of MFQ ($P < 0.01$). It should note that lower scores means better memory performance. ‘Retrospective functioning’ was, however, found to be improved during and after training in CAMG only.

On the other hand, ‘Mnemonic usages’ had changes in TAMG only, though CAMG demonstrated changes only during pre- and post-training (*P* < 0.01).

5.6.2 Across-group comparison

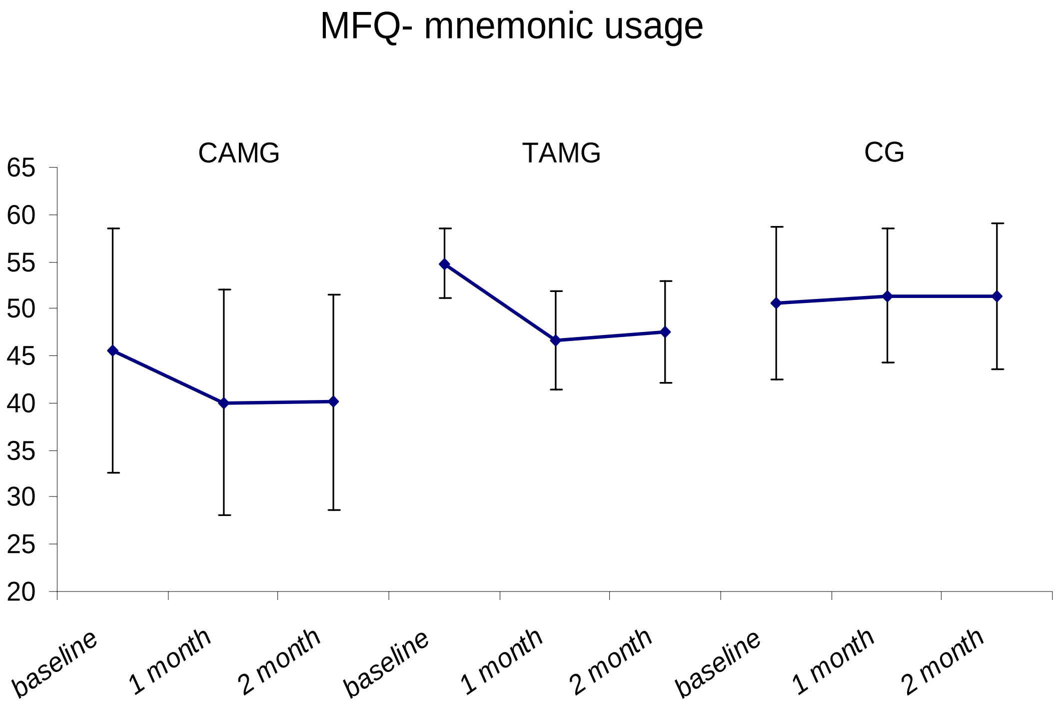


Figure 5.5 Overtime trend of MFQ mnemonic usages scores during pre-training, post-training and follow up among CAMG, TAMG and CG.

When comparing MFQ over time and across the three groups, it was found that there were significant changes in MFQ scores: ‘Frequency of forgetting’ ($F_{(2,80)}$ = 8.395,*P* = 0.000), ‘Seriousness of forgetting’ ($F_{(2,80)}$ = 6.47,P = 0.000) and ‘Mnemonics usage’($F_{(2,80)}$ = 10.185,P = 0.000), except ‘Retrospective functioning’ ($F_{(2,80)}$ = 2.112,P=0.082). (see

Sub-test items	**CAMG**			**TAMG**			**CG**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Frequency of forgetting	18.200**	14.867**	-3.333	11.917**	10.792**	-1.125	-1.700	-0.600	1.100
Seriousness of forgetting	11.800**	10.533**	-1.267	9.333**	9.083**	-0.250	-1.000	1.600	2.600
Retrospective functioning	2.833**	2.567*	-0.267	0.375	1.208	0.833	0.600	0.633	0.033
Mnemonics usages	-5.567**	-5.500	0.067	-8.167**	-7.250**	0.917	0.800	0.700	-0.100

Note: T1: *mean difference between post-pre training**;***

T2*: mean difference between follow up-pre training**;***

T3*：mean difference between follow up-post training*

** P< 0.05; ** P < 0.01*

Table 5. 7 Within-subjects comparison of MFQ scores mean difference between post- pre training and follow up among CAMG, TAMG and CG groups

appendix A21 for details). Post hoc Bofferroni test further indicated that there were significant differences between CAMG and CG as well as between TAMG and CG in MFQ score ($P < 0.05$ to $P < 0.01$). But CAMG was found to be better in 'mnemonics' and 'retrospective function' in MFQ (see figure 5.5).

5.7 Comparing self-efficacy as measured by questionnaire of memory training in CAMG and TAMG

5.7.1 Within-group comparison

Matched within group mean comparison between training session 5 and session 20 were performed using paired *t*-test. Table 5.8 demonstrates statistically significant difference in self-efficacy scores except on suggestions for improvement in CAMG. On the other hand, all the self-reported scores had similar changes in TAMG ($P<0.0001$).

5.7.2 Across-group comparison

Table 5.9 illustrates the main effect of mean difference between training session 20 and session 5. Significant differences between TAMG and CAMG were identified for self evaluation of own competence, evaluation of programme, indicating more significant improvement in TAMG than in CAMG ($P<0.0001$). There were no significant differences for self-confidence ($P=0.268$), suggestions for improvement ($P=0.942$), comments on content and design ($P=0.336$).

	CAMG (n=30)				TAMG (n=24)			
Subscore items	S5	S20	*t*	*P*	S5	S20	*t*	*P*
self-confidence	4.60 ± 1.39	5.43 ± 1.07	4.927	0.000	4.46 ± 1.09	5.58 ± 0.54	5.247	0.000
competence	4.75 ± 0.94	5.27 ± 0.88	3.151	0.004	4.26 ± 0.72	5.67 ± 0.56	8.928	0.000
self-evaluation	4.75 ± 1.07	5.26 ± 1.10	3.005	0.005	4.40 ± 0.62	5.61 ± 0.55	8.025	0.000
amelioration	3.11 ± 1.32	2.55 ± 1.45	-2.036	0.051	2.42 ± 1.68	1.84 ± 1.62	-5.884	0.000
software design	4.87 ± 0.94	5.42 ± 1.04	2.596	0.015	5.13 ± 0.86	5.37 ± 0.95	1.096	0.284

Note: S5: *mean value after accomplishing session 5 of training programme*

S20: *mean value after accomplishing session 20 of training programme*

Table 5. 8 Within-group paired samples mean comparison of self-efficacy questionnaire during training in CAMG and TAMG （$\bar{x}$ **±s**）

Groups	Self-confidence	Competence	Self-evaluation	Amelioration	Software design
CAMG	0.83 ± 0.92	0.53 ± 0.92	0.51 ± 0.93	-0.57 ± 1.51	0.55 ± 1.17
TAMG	1.13 ± 1.05	1.40 ± 0.77	1.21 ± 0.74	-0.58 ± 0.49	0.25 ± 1.12
t	1.12	3.736	2.99	-0.073	-0.972
P	0.268	0.000	0.004	0.942	0.336

S5: *mean value after accomplishing session 5 of training programme*

S20: *mean value after accomplishing session 20 of training program*

Table 5.9 Across-groups independent samples comparison of mean difference between S20 and S5 in self-efficacy report questionnaire（$\bar{x}$ ±s）

5.8 Relationships between subjects' learning strategies and memory process

According to HKLLT characteristic and design, correlation between learning strategies and memory process were performed respectively in random and blocked conditions. A highly significant correlation was observed between encoding and storing process of memory in CAMG and TAMG ($\gamma \geq 0.681$, $P < 0.01$). For CAMG in random condition (see Table 5.10), both semantic clustering and concrete concept were significantly correlated with encoding; abstract concept and concrete concept except semantic clustering were also significantly correlated with storing; correlation was shown only for retrieval in abstract concept. For CAMG in blocked condition (see Table 5.9), different level of correlations were observed between encoding and learning strategies including subjective organization, semantic clustering, primacy effect and abstract concept; only semantic clustering and primacy effect were significantly correlated with storing. In addition, subjective organization, primacy effect was correlated with retrieval respectively.

For TAMG in random condition (see Table 5.11), subjective organization, concrete /abstract concepts were significantly correlated with encoding; semantic clustering, concrete /abstract concepts were also significantly correlated with storing; correlation was shown only for retrieval in abstract concept. For TAMG in blocked condition (see Table 5.12), significant correlations were observed between encoding and learning strategies, including subjective organization, concrete/abstract concepts, representing similar correlation in random condition. Both semantic clustering and concrete concept correlated with storing. For retrieval, correlation was shown only in concrete concept.

	Random conditions			**Blocked conditions**		
Learning strategies	**Encoding**	**Storing**	**Retrieval**	**Encoding**	**Storing**	**Retrieval**
Encoding						
Storing	0.838**			0.873**		
Retrieval	0.104	0.298		0.100	0.054	
Subjective organization	0.171	0.071	-0.191	0.261**	0.334	0.436*
Semantic clustering	0.489**	0.307*	0.135	0.240*	0.504**	-0.165
Primacy effect	0.227	0.367	-0.007	0.356**	0.493**	0.375*
Recency effect	-0.230	-0.122	-0.081	-0.081	0.004	0.103
Concrete concepts	0.452**	0.352**	0.333	0.249	0.087	0.012
Abstract concepts	0.304	0.371*	0.541**	0.252**	0.357	0.140

*Note: * P< 0.05; **P< 0.01*

Table 5.10 Correlation matrix of HKLLT learning strategies scores with memory processes for CAMG

Recency effect did not correlate with any memory process in CAMG and TAMG..

To sum up, it is found that concrete concept was commonly correlated with encoding and storing process under random condition in both CAMG and TAMG (see Table 5.11). Furthermore, abstract concept was highly correlated with storing and retrieval process under random condition, and with encoding under blocked condition in both CAMG and TAMG. In addition, semantic clustering was commonly correlated with storing under random and blocked conditions respectively. Subjective organization and encoding were intercorrelated under blocked condition in the two groups.

	Random conditions			Blocked conditions		
Learning strategies	**Encoding**	**Storing**	**Retrieval**	**Encoding**	**Storing**	**Retrieval**
Encoding						
Storing	0.681**			0.930**		
Retrieval	0.089	0.273		0.070	0.131	
Subjective organization	0.209*	0.251	0.053	0.372**	0.011	0.103
Semantic clustering	-0.404	-0.526**	-0.004	-0.012	0.517**	-0.072
Primacy effect	-0.009	0.269	-0.017	-0.079	0.191	-0.125
Recency effect	0.025	-0.177	0.232	0.201	0.075	0.083
Concrete concepts	0.570**	0.410**	0.258	0.459**	0.479**	0.623**
Abstract concepts	0.743**	0.933**	0.470*	0.356**	0.302	-0.041

*Note: * P< 0.05; **P< 0.01*

Table 5.11 Correlation matrix of HKLLT learning strategies scores with memory processes for TAMG

	Random conditions (CAMG vs TAMG)			**Blocked conditions (CAMG vs TAMG)**		
Learning strategies	**Encoding**	**Storing**	**Retrieval**	**Encoding**	**Storing**	**Retrieval**
Subjective organization	TAMG			CAMG+TAMG		CAMG
Semantic clustering	CAMG	CAMG+TAMG		CAMG	CAMG+TAMG	
Primacy effect				CAMG	CAMG	CAMG
Concrete concepts	CAMG+TAMG	CAMG+TAMG		TAMG	TAMG	TAMG
Abstract concepts	TAMG	CAMG+TAMG	CAMG+TAMG	CAMG+TAMG		

Table 5.12 Correlation of learning strategies with memory processes for CAMG and TAMG in HKLLT random and blocked conditions

Chapter Six

DISCUSSION

The present study aimed to develop, implement and evaluate a computer-assisted memory rehabilitation programme which was based on a postulated EE & EL model. Specific investigation was geared towards comparing the therapeutic effects of training programmes delivered through computer-assisted and therapist-administered modes in influencing the three typical memory processes (encoding, storage and retrieval). The memory self-efficacy in patients with traumatic brain injury was also investigated so as to justify further the usability and functionality of the computer-assisted programme.

Instead of presenting the results of data analysis and relating them to individual hypotheses separately, this discussion chapter is structured into six parts so as to cover pertinent issues under investigation. The discussion will centre around the examination of the effect of errorless learning and the computer-assisted memory training, the combined effect of both EL and computer-assisted memory training (postulated enriched environment or EE), self–efficacy enhancement in therapist-administrated memory training, pertinent factors affecting memory training outcomes, and lastly implications of the present study.

6.1 The effect of errorless learning (EL) on memory

6.1.1 The effectiveness of two respective memory training programmes (Computer-assisted or CAMG, Therapist-administered or TAMG)

There have been evidences showing that prevention of errors during learning might be helpful in improving people's impaired memory performance, both in amnesia as well as in normal age-related memory decline (Kessels, Boekhorst & Postma, 2005). Errorless (EL) approaches might be proved to be beneficial for Chinese patients with traumatic brain injury too. In present study, this beneficial effect on memory performance was initially reflected from analyzing T1 (mean difference between post-training and pre-training) and T2 (mean difference between follow up and pre-training) in both CAMG and TAMG, in using within-group comparison. The summarized findings of memory-related outcomes indicate significant improvements in RBMT-CV (such as Picture, Story, Face, Message, total score etc), memory subscore of NCSE-CV, as well as HKLLT (Word learning, Recall in random and blocked conditions). The current findings are consistent with the results of previous studies involving patients with brain injury (Clare, et al., 2000; Evans, et al, 2000; Kalla, Downes & van den Broek, 2001; O'Carroll, et al, 1999; Squires, et al, 1997; Tailby et al, 2003). Part of the content in this study was similar to Evens et al's (2000) research design, such as in recalling arbitrary face-name association, the use of an errorless technique combined with an imagery strategy and a chunking strategy, the use of backward and forward chaining technique to remember telephone number, etc. Evens et al. (2000) also pointed out that when an imagery strategy was used in combination with an errorless learning strategy, free recall of names improved. Tailby et al.'s (2003) research design was also referenced in the present content design. The modified EL was applied in the present study, by encouraging participants to engage in elaborative processing during learning. They were assured that the learning tasks were not complex and that elaboration would be given. The following example of the encouragement was given to subjects in remembering Chinese idiom in the present study. In this condition, participants were given a verbal description of the target idiom at first and then asked to name the word (e.g. "I'm thinking of a four-word idiom beginning with "畫蛇" (drawing a snake), and this idiom described an ancient story related to drawing a snake but adding legs to it (畫蛇添足), meaning that there is no need to do redundant matters (寓意不要做無中生有的事). Subjects would be asked "What do you think the missing words might be?" Participants were given 30 seconds to respond and answer. A failure to respond was not accepted and participants were strongly encouraged to provide a correct response. Based on this arrangement, the modified EL was different from standardized EL. It was reported that memory performance resulting from learning under the modified errorless technique was significantly better than that under standard errorless conditions, as there was much to be gained from active as opposed to passive participation during study (Tailby et al., 2003). This benefit of training was reflected by neuropsychological test scores in the two memory training groups, and the carryover effect was found to be maintained after training, during 1-month follow up. While there was no loss of information over time with the standard technique (Evens et al., 2000), the best result was obtained with the modified technique which might provide sufficient elaborative cues during learning to enable self-generation of responses without error.

Recent studies demonstrated that errorless learning methods can be easily adapted for use in clinical settings, aiming at the remediation of daily life memory dysfunction (Clare et al., 2000). Several previous studies have looked at the effectiveness of this treatment method in “real-world” settings (such as the patient’s home environment) using therapy goals selected by the patient (Clare et al., 1999). Larger sample studies might produce more conclusive results with respect to the applicability of errorless-learning techniques in everyday-life settings (Camp, 2001). There is also evidence showing that the errorless learning principle is most effective in situations where implicit learning is possible (Evens et al., 2000). The present study results are also promising in this issue. In the present training programmes, there are many EL applications in simulated real settings. For example, the common locations of placing household commodities within a house, naming the function or usage of daily objects, visiting doctors, shopping with family members. These training activities aimed to transfer the errorless learning principles into everyday memory training, instead of well-controlled laboratory tasks. As there were significant changes in MFQ scores, namely the ‘Frequency of forgetting’, ‘Seriousness of forgetting’ for both CAMG and TAMG, and carryover effect during follow up (P<0.01). This suggests of the effectiveness of errorless learning strategies adopted in the present study. There were no significant difference between CAMG and CG, as well as between TAMG and CG. Thus, persons with TBI receiving no memory training may experience further deterioration in ‘Frequency of forgetting’ and ‘Seriousness of forgetting’.

6.1.2 The trend of treatment effect over time

To date, the effect of errorless learning over time has not been studied thoroughly. Some studies found that there were larger effects after relatively short-term delayed testing (1 and 48 hours respectively; Evens, et al., 2000; Hunkin, et al., 1998a & 1998b). For longer delays (i.e. weeks), the results were inconclusive. While others still found large effects even after 6 weeks in patients with head injury or encephalitis (Glisky, Schacter & Tulving, 1986a & 1986b), this study seemed to reflect similar effect as the delay could be up to one month after the training terminated.

Though most of main effect slightly declined over time, repeated measure of ANOVA showed that there was no significant difference when comparing scores between follow up and post-training for TAMG or CAMG. This encouraging result was in line with studies reported by Glisky et al. (1986a, 1986b), though the EL method adopted in this study was different from the method of vanishing cues (Glisky et al., 1986b). As there is considerable evidence that errorless learning should not be thought of as a unitary function (Squire, 1992), different methods might be beneficial. The results of a meta–analysis also showed that the errorless learning technique was more effective for amnesic patients than vanishing cues (Kessels et al, 2003).

The training content of the present study targeted at memory training and was tailor-made to suit the Chinese cultural background and the demand of daily functional needs. Basically, the main effect could be established in this 1-month memory training programme. After training, the gradual decline in main effect was noted in different groups and should not be undermined. For instance, the decline in NCSE-memory, RBMT-total score etc. was quite obvious after the training period. Why did this declining trend happen? According to errorless learning mechanism, mentioned in the literature review, it is speculated that there is a change in the relative influence of implicit and explicit memory on recall. On the short-delay training, reliance on implicit memory created a beneficial performance in the errorless condition. However, it was possible that some implicit memory effects might be short-lived, and thus the influence of implicit memory might have reduced during the follow up period, and patients had to rely to a greater extent on impoverished explicit memory in their activities of daily living (ADL). Therefore the influence of the errorless learning procedure was minimized. It is also entirely plausible that different systems (e.g. classical conditioning, visual and auditory priming, motor skills) were subject to different forgetting rates, so that the possible impact of learning would also depend upon the particular task involved. It will be necessary to continue to study the carryover effect that might be benefited from this innovative memory training method adopted in the present study.

6.1.3. The possible mechanisms of EL

Although errorless learning is a promising technique for use in rehabilitation practice, the underlying mechanisms are unclear. As previously mentioned see in chapter 2 (literature review), two theories have been proposed about the mechanism of errorless learning improving memory function. That is, it has been suggested that the beneficial effects of errorless learning operate through implicit memory (Baddeley & Wilson, 1994), whereas others implicate that it is explicit memory that is responsible for the enhanced memory performance after errorless learning (Hunkin et al., 1998). Others strongly supported that the benefits seen under errorless learning reflect the operation of residual explicit memory process, however a concurrent role for implicit memory processes was not ruled out (Tailby et al. 2003). Tailby, in addition, proposed that EL learning may be supported by different processes in different individuals. For instance, it is possible that EL learning relies primarily on implicit processes in very severely impaired patients who lack explicit memory abilities, but relies more on explicit process in those demonstrating only a mild impairment. Clearly the present study was not able to provide a definitive conclusion about the EL mechanisms. The answer to individual differences was again, inconclusive as there was no intension to stratify subjects according to different client types (those with severely or moderately impaired memory functions) due to insufficient number of participants.

Except for some procedural memory training (such as memorizing steps in cooking noodle) covered in the present study, the learning material developed in this study mainly covered semantic learning tasks. For example, immediate recall of phone numbers, food price, word recall, sentences-pair associate learning, correct object naming, and face-name recognition etc. Even if the training context was related to the Chinese culture, such as use of familiar Tang poems and ancient Chinese idioms etc, it was observed that participants were more likely to make an error by giving an immediate response without thinking about training content. For those who took more time to think about the answers, instead of taking impulsive response, and those who used the correct mnemonics usually made less error.

After training, improvement in sub-items scores of RBMT (for instances, Immediate Story, Picture and Message), implied that EL did require the involvement of explicit memory. This suggests that the effect of errorless learning might be related to spared implicit memory function, and it was also related to residual explicit memory functions. So, the effectiveness in this study seemed to support Tailby et al.'s (2003) notion that errorless learning could improve the impaired memory performance from integrating both the implicit and residual explicit memory together. Further research is thus required to clarify the relative contributions of implicit and residual explicit memory processing in EL learning.

Recently, an electrophysiological study of errorless learning revealed that stimulus-locked event-related potentials (ERPs) showed a modulation of a right frontal effect that differed in amplitude and topography for items learned under errorful and errorless conditions (Rodriguez-Fornells, Kofidis & Mu¨nte, 2004). In the response-locked ERPs, a typical error-related negativity (ERN) was observed to be most prominent for false alarm trials in the errorless condition, of medium amplitude for hits and false alarms in the errorful condition. This evidence-based experimental research seems to provide strong support of errorless-learning based memory performance and function in present study.

6.2 Computer application and its value in memory rehabilitation

6.2.1 Effectiveness of computer-assisted memory training

In the field of computer-assisted cognitive rehabilitation (CACR), the computer is playing an increasingly important role. CACR is also an instructional technique that results in improved learning in individuals with memory impairment. In spite of the methodological difficulties encountered when trying to compare directly effectiveness of computerized cognitive rehabilitation, the present findings demonstrated an overall positive trend for such computerized interventions in the treatment of persons with TBI. Participants were randomly assigned to computer-assisted (CAMG) or non computer-assisted treatment (i.e. TAMG) and underwent an equal duration in this study. Both forms of intervention were directed toward the remediation of memory deficits following TBI. Pre- and post-treatment and follow up assessment which consisted of neuropsychological measures (NCSE-CV, RBMT-CV and HKLLT) demonstrated to be sensitive to the memory dysfunction of traumatic brain injury. Findings indicated that both training groups demonstrated improved performance on neuropsychological outcome measures following intervention. The participants receiving computer-assisted treatment, however, showed more significant increase in subtest scores than those participants assigned to non-computer-assisted treatment (See Table 5.3, 5.4, 5.5, 5.6). Compared to control group, these positive findings also demonstrated the potential effect of computer-asissted rehabilitation to improve the memory test scores for patients with brain injury. This result was, in fact, in line with several previous reports (Glisky, Schacter & Tulving, 1986; Glisky & Schacter, 1988; Kerner & Acker, 1985; Middleton, Lambert & Seggar, 1991; Tam & Man, 2004). As discussed before, there are many advantages utilizing computers as tools in cognitive rehabilitation (see in chapter two, literature review), and these advantages seem to be further demonstrated that computer can be a good teaching medium (enriched environment) in the present study.

6.2.2 Comments on computer training content and design

It is recommended that rehabilitation professionals should place emphasis on both cognitive restriction and goal task-oriented activities in designing training programmes for people with cognitive disorder. A major goal of memory training design is to support the individual with TBI in performing life activities that they can no longer execute on their own as a result of the trauma. A selected task presumably is beyond the individual's capacity despite conventional intervention and repetition training. A selected task should be practical and meaningful for the individual and have relevance in his daily living. In content design, transferring memory training to actual life context (i.e. generalization) should be stressed. In the present study, each session in the training programme consisted of basic component memory skill training, typical daily task management utilizing/integrating the component memory skills, customized programmes and skill consolidation as well as application of training tasks in everyday activity. For example, digital memory training including simulated shopping, forward and backward recall would be helpful to remember telephone number, famous people's birthday, selecting food names and its price in menu according to request. Through this kind of training, participants could be anticipated to integrate training with daily life demand, and this ultimately can help them adapt better in the community.

According to participants' positive feedback through self-reported questionnaire, it was revealed that training design was a successful one. This questionnaire covered their evaluation on training methods, duration of training, the quality of computer images/pictures in manual, audio-visual effect etc. There was no significant difference in their comments on content and design in either within- or between-groups comparison (P=0.336). It suggested that all participants basically were satisfied with the training arrangement and training design. Although the main effect of mean difference between CAMG and TAMG declined a bit over time, subjects' suggestions for improvement for training pattern were also not significantly different in either within- or between-groups comparison (*P*=0.942).

Moreover, participants with TBI joining the memory training programme tended to respond positively, and with enthusiasm (especially those in CAMG). They had a keen appreciation for their struggle and effort required to accomplish the daily activities. Some comments were collected in revealing that these positive and optimistic experiences. This can be reflected in the following representative quotations:

> *"This is the first time in two years (since sustaining TBI) that I have a feeling of success"*.

> *"Everything I need so far has been right there on the screen. That makes it really easy. I'm used to the systems where you have to remember so much stuff …"*

> *"It helps me to recap what I have learnt for the past hour…, really like having an auxiliary brain that works for me and with me at my level."*

> *"Now I can do things on the computer at a level that I can understand …"*

The person with TBI was often well aware of the impact of his or her improved functioning on the family. In view of the importance of the family in a Chinese culture and society, it is opined to be very important to enhance trainees’ positive motivation, interest and enthusiasm during learning process.

> “*My family experienced great fear and worry after my car accident and when I had experienced a brain injury… There are so many ways that I learn to learn so as to cope with life within my limited abilities…As long as I have access and can use the computer, I and my family feel secure, and I know that I can always achieve better. It is really a great boost to me and my self esteem…*”

Chen, et al. (1997) thought that computer-based cognitive rehabilitation potentially would be more economical and more convenient (if conducted independently in the home) than more traditional forms of intervention, even if given the equivalent findings between the two modes of intervention. It is important to keep in mind that CACR is not intended as an alternative to a holistic rehabilitation programme; rather it is a treatment method focused on rehabilitation of cognitive functioning. A person with TBI needs a full range of rehabilitation and can take place in the acute, sub-acute, convalescent settings and even home environment. CACR must not be used to replace one-to-one human-touch kind of therapy, group therapy, emotional support, counseling or the holistic nature of rehabilitation for any persons who survive a TBI.

6.3 The combined effect of enriched environment (EE) and errorless learning (EL)

According to data analysis detailed in chapter five, the outcome scores from several measurements showed there were better improvement in CAMG when comparing across the two experimental groups and a CG. For example, CAMG demonstrated better results for memory process including encoding, storage, and retrieval in random and blocked conditions (as measured by HKLLT). Results of the present quasi-experimental study provided evidence that enriched environment and errorless learning mode (i.e. EE & EL) clearly had a positive effect on memory performance and memory process in TBI survivors. Not only all participants showed significant improvement in neuropsychological memory test scores following intervention, but it also was largely maintained for one month during follow up. In the subsequent sub-section, a more focused discussion of the impact EE and EL on memory process is made.

6.3.1 Impact of EL & EE model on the memory processes

It was found that both CAMG and TAMG demonstrated significant positive impact in memory processes scores as measured by HKLLT. Comparatively, the CAMG showed the more substantial improvement, as compared with TAMG and CG in encoding and storage process. Moreover, this preliminary study revealed that not only the errorless learning may be a better method to improve memory performance following brain injury, but also the added value of the enriched environment provided by human-computer interaction (HC). This combined effect may also affect the whole memory process, and effectively memory function recovery.

Group difference in outcome measures between CAMG and TAMG may be explained by the enriched environmental (EE) stimuli provided by the computer. In this study, computer-assisted memory rehabilitation provided the task-specific training approach that target memory deficits. The computer interventions were specifically designed for the creation of enriched environment for patients with TBI. Computer presented stimuli that were attractive, bright and colorful, might be helpful to engage and focus the client's attention in CAMG. This facilitating stimulus allowed the patients to work at their own pace in a non-threatening environment while the computer provided subjects feedback immediately in a clear, consistent and non-judgmental fashion. Finally, some patients might find working with a computer a novel, enjoyable, challenging experience that improved their motivation and the training outcomes (Tam & Man, 2004).

In this study, the intention of the researchers was to create a non-threatening, enjoyable and enriched environment. Cultural context was also considered in a number of ways to facilitate learning. For example, modified errorless learning material was displayed by computer screens relating to Chinese culture, society and to the history and structure of the Chinese language. The abundant use of delightful graphics in the package was also represented in the use of common Chinese characters in order for subjects to learn ancient Chinese idioms and Tong poems. In addition, patients may practice repeatedly on HCI interface by therapist instruction or under assistance of family members. It seems to suggest that patients of CAMG might perform more actively and attentively to learning tasks delivered to them.

In TAMG, although the content and the use of EL method were similar to CAMG, a static and passive reading of words was administered; and the booklet including pictures were not comparable with the vivid, colorful display on the computer screen and audio output generated from the computer. The absence of enriched stimuli (of the same nature, potency) may affect the outcome measures. In viewing the sub-tests of RBMT-CV, both Story Recall (immediate and delay) and Face had significantly differences after retraining in CAMG, but only the Face subtest was found significant in TAMG. Due to a lack of comparable enriched environmental stimulation in TAMG, the new information might be less consolidated than in CAMG situation, so the rapid forgetting happened. In addition, emotional and motivation factors may also play a part in this memory training process. It was observed that patients in CAMG performed more actively and attentively in learning tasks and these may facilitate memory functions too (see further discussion later).

.

6.3.2 Mechanism of effect of EE and EL on memory process

In the present study, the use of errorless learning (EL), instead of the errorful or "trial and error" learning method (Evens, 2000; Wilson & Baddeley, 1994; Hunkin et al., 1998), an enriched environment (EE) using the newly developed human-computer interface (HCI; Bergman, 2002; Gontkovesky et al., 2002) was suggested, so that it represented a new eclectic model. But the next question would be : How did this innovative modal effect on memory process?

As the specific nature of the memory problems remains unclear. Some researchers pointed out that it reflected an encoding problem (Blachstein, Vakil & Hoofien, 1993; Crosson et al., 1988; DeLuca, et al., 2000; Levin, et al., 1988), a consolidation deficit

(Vanderploeg et al., 2001), or deficit in retrieval (Baum et al., 1996; Crosson et al., 1988; Duchnick, Vanderploeg & Curtiss, 2002). A well-designed study indicated that impaired consolidation, rather than encoding or retrieval impairment was a primary deficit underlying the verbal learning and memory dysfunction in persons with TBI (Vanderploeg et al., 2001). Deluca and colleagues (2001) also pointed out the impaired acquisition hypothesis of memory dysfunction in patients with TBI, whereby memory impairment was primarily attributable to deficiencies in the initial acquisition of verbal information rather than in retrieval failure. Chan and Kwok (1999) suggested that if information could not be consolidated and transferred into long term memory effectively, the significant improvement of memory performance did not happen by repeated training. If there were no difference between patients with TBI and control in learning efficacy, it was impossible to tell that potential encoding deficit existed under consolidation and /or retrieval difficulties. The reasoning has significant implications for the rehabilitation and treatment of individuals with TBI.

The present study mainly concentrated on the effect of EE & EL model on memory process but it was not designed to study the individual memory process and related problems. Thus the results of HKLLT and the above-mentioned findings could only support Vonderploeg and Deluca's viewpoint. In other words, the memory problems of persons with TBI might be attributed to encoding and consolidation of information. Moreover, the present study implemented errorless learning principles, including repetition, positive enhancement, avoiding error through cued during training and simulated enriched environment stimulation. All these aimed to improve memory acquisition process. Acquisition is a functional behavior that can be observed and measured (Erickson & Scott, 1977) and includes encoding and consolidation (Deluca & Chiaravalloti, 2004). In this study, acquisition was successfully measured by using the general learning measure with three immediate recalls over three learning trials in HKLLT.

Figure 5.4 clearly shows the change in storage (blocked condition) over time. Though there was a slight decline, but it still maintained at a level higher than initial status, after 1 month post training. The current results revealed that it was suitable for the memory training that target encoding and consolidation (acquisition). In order to improve consolidation (storage) abilities in persons with TBI, there are two pertinent issues to address. First, it is crucial to control the amount of information initially acquired during training. As pointed out by DeLuca and colleagues (2000), a major limitation with much of the existing TBI-related memory literature was a failure to control for differences in initial acquisition between TBI patients and control groups. Because performance on recall and recognition tasks is dependent on the amount of information initially learned, it is important to control for level of initial learning between groups prior to making conclusions about memory deficits in forgetting or retrieval. In the present study, training course was limited to one topic in every session, such as visual-figure training, visual-verbal training, immediate and delay recall of correct words, sentence, Chinese idiom etc. For each training topic, it was divided into 3 levels and patients could choose according to the degree of difficulty. They were then given the repetitive training and tried to memorize through organization of information, as far as possible. According to

Bergman’s view (1998 & 2002), repetition training might not need to begin at the most fundamental level of a task or skill for remediation to occur, as was common conventional interventions. Rather, the “structured organized repeated use of a functional tool” apparently can be restorative in some instances. The present training effectiveness clearly showed the improvement in recall and recognition performance in individuals with TBI at follow up evaluation. In addition, plenty of repetitions for new information could provide the opportunity to improve the quality of encoding the information to be learned. This finding is supported by the work from the cognitive psychology literatures (Begg, Green, 1988; Belleza & Young, 1989). Belleza and Young (1989) showed that repetition alone did not improve recall; it was the improved organization of the encoded material resulting from the additional learning opportunities that improves memory performance. Second, human computer interaction (HCI) provided a good platform for active, self-generated repetitive learning in an enriched environment. Referring to chapter three (conceptual framework), it has been already explained on how to promote active learning by means of HCI, and it was carried out in the computer-assisted memory training process. As a frequent consequence of brain injury would be a reduction in cerebral arousal-activation, the programme content had been combined with more specific neuropsychological impairments, for example in attention, language and motivation so as to cope with this training need.

Moreover, some patients sustaining damage to the brain are likely to face a sudden and dramatic change in his or her normal pattern of environmental interaction. This might be due to loss or reduction of sensory or motor capacity that will limit opportunities for interaction. A reduced activation-arousal would necessarily impose a further limitation on capacity for meaningful interaction. However, it might be claimed that exposure to an enriched environment increases cognitive processing ability. The use of computer programmes to generate meaningful and attractive stimuli may provide the optimal "enriched" training environment for cognitive functional recovery and memory in particular, as demonstrated in the present study.

The present study found that persons with moderate to severe TBI seemed to have a significantly more rapid rate of forgetting of new information during training in TAMG than in CAMG. This finding was also consistent with consolidation problems found in persons with TBI. In addition, HKLLT assessment demonstrated that the rapid forgetting associated with TBI occurred virtually immediately. In other words, the forgetting occurred within the couple of minutes between Trial 5 of List A and Short- Delay Free Recall of HKLLT (vanderploeg et al., 2001). So it is necessary to ensure that repetition and enriched stimuli should be used to strengthen this consolidation process.

Single-photon emission computer tomography (SPECT) (with Tc^{99m}HMPAO) showed clearly that the associative encoding and/or consolidation of complex scenes was partially mediated by medial temporal lobe structures, but it also demonstrated that associative encoding and consolidation was sufficient to produce activation of hippocampal/ parahippocampal region, cingulate cortex and prefrontal cortex (Montaldi et al., 1998). These phenomena that have been labeled consolidation in the literature occur at widely varying time scales (Squire & Alvarez, 1995). According to Meeter and Murr (2004), consolidation, then, is the strengthening of connections within the neocortex to the extent that these connections suffice for retrieval. A different, potentially helpful way of explaining these results arises from consideration of a number of contemporary connectionist models of memory such as those of Murre (1997), McClelland, McNaughton, and O'Reilly (1995), in which the distinction is drawn between the role of the hippocampal/medial temporal lobe structures and the neocortex, with the hippocampal structures being involved in the temporary holding or linking of information which may or may not become consolidated in the neocortex over time with sufficient rehearsal or repetition. As Murre noted, within these models there were essentially three different kinds of learning; normal episodic learning followed by consolidation, learning by strengthening of existing neocortical connections, and learning by repetition, through which new cortico-cortical connections were formed. The hippocampus and associated medial temporal lobe structures are required for the first type of learning and may result in time and space specific (i.e. episodic) memories, but are not required for the latter two forms of learning, both of which are referred to as "implicit" learning, although only the first form is equivalent to what is more traditionally thought of as implicit memory (or priming), whilst the second form, the repetition learning, is more akin to the formation of semantic memories, with knowledge being consciously accessible (i.e. accessible on an explicit test), but not time/space specific. Amnesic patients, with impaired hippocampus/ medial temporal lobe functioning have to rely on the latter two forms of learning and the present study has demonstrated how susceptible implicit learning involving the strengthening of pre-existing neocortical associations (e.g. between a first word and a Chinese idiom) is to interference in trial-and-error type learning. Considering the visual imagery method for learning the Tang poem learning task, for instance, in part 3 of the memory training programme, this strategy was specifically designed to help patients derive some degree of perceptual cueing from the picture so that the poem sentence could in effect be cued by the picture itself. This arrangement then cued the completion of appropriate poem sentence. In this way it could be argued that the process involved the priming of a context with a corresponding description, which allowed the association to be made with the poem. These findings would certainly be consistent with many of the brain changes observed as a consequence of enrichment (see chapter two - literature review). All the cortical effects of environmental enrichment, and many of the other observed brain changes, can be seen as evidence that the enriched brain is more highly developed and operating in a more efficient manner (Rose et al., 1998). This training design and its effectiveness implied that focusing attention on maximizing learning from the environment may have long-lasting benefits in memory performance.

In addition, visual recognition skill may also be a crucial factor to improve memory process, such as in RBMT-CV face recognition test (Clare et al., 1999; Clare et al., 2000). Tam and Man (2004) also found that the visual presentation of a computer-assisted memory training programme led to significant improvement in the memory of persons with post-head injury amnesia. Their findings demonstrated that visual presentation group showed the greatest percentage improvement comparatively. Therefore, visual presentation might be the crucial factor to improve performance in RBMT-CV as the test required semantic and procedural memory skills that attractive/remarkable visual stimuli could help the information registration and recalling. In the present study, presentation the attractive/remarkable visual stimuli of the human-computer interfaces, multi-sensory feedbacks and tailor-made training designs could enhance the subjects to strategically recognize prominent visual features of the programme content. Moreover, the stimuli presented by computers were deliberately attractive, bright and colorful, thus encouraging the subjects to engage in and focus their attention on the activity (Burda, Starkey & Dominguez, 1994; Smart, 1998). This would facilitate them to generalize these visual strategies to recall the training contents and tasks that were mainly presented in visual formats. The results of the Face subscore in RBMT-CV showed that there were significant differences between CAMG and TAMG on an over-time trend. Meanwhile, there were also similar changes in subtest of Story Recall (story-immediate and story-delay) between CAMG and TAMG. In other words, it indicated that the visual recognition played an important role in CAMG. In CAMG, the practice of story-telling with graphics might help to input the information into the brain through various perceptive channels such as visual and auditory; while in TAMG, as therapist's story-telling only involved the auditory, but not the visual channel. It might be more difficult for TAMG patients to remember the information if they did not concentrate in listening to the verbal message. Understanding the relationship between such factors, learning, and subsequent recall and recognition performance will greatly enhance memory ability. This does not only provide targeted rehabilitation efforts, but also can identify patients with TBI who may or may not benefit from certain types of intervention strategies.

In sum, based on previous research, the effect of EE & EL model in memory training can be actualized through the following ways: encoding and storage can be seen as a neuroanatomical, cognitive process and errorless learning can input information to be remembered through the necessary cues, repetition/practice and reinforcement. Thus further processing of information in limbic system and hippocampal areas turns it into long term memory. Different brain parts responsible for different kinds of memory can form a network memory, and thus improve learning abilities, reduce forgetting, and enhancing functional application. During this process, neuroplasticity also plays an important role. In other words, EE & EL model facilities the damaged brain's processing of memory signals. We hope that benefits gained during training can be applied to work or social life through the incorporation of additional learning opportunities, the increased independence can be achieved with the application of strategies that maximize learning.

6.4 Enhancement of self-efficacy in therapist-administered memory training programme

6.4.1 Enhancement evidence of self-efficacy

Another important finding in present study was self-efficacy enhancement. Self-efficacy scores (as reported in MFQ, self-reported efficacy questionnaire) demonstrated that there was statistically significant improvement through within-group comparison during training and follow up periods. On the other hand, group differences were obvious for improvements in self-efficacy when conducting across-groups comparison.

Analysis of the MFQ data indicated that subjects with TBI reported a more substantial recent improvement in memory functioning. There were significantly differences in the perceived general ‘Frequency of forgetting’, ‘Seriousness of forgetting’ factors and ‘Mnemonics usages’ (except retrospective functioning factor) among subjects in CAMG, TAMG and CG. Moreover, it was found that the therapist-administered memory training group (TAMG) showed more statistically significant improvement than computer-assisted memory training ($P < 0.0001$). Some research findings suggested that subjects with TBI may have difficulties in self-report their memory functioning (Kinsella et al., 1996). They found that each MFQ scale was highly correlated with the other three scales, suggesting that patients with TBI were not able to differentiate memory functioning accurately. While the patients might have had a general concept of their memory functioning, it appeared that they might have had difficulties in relating this retrospectively to specific instances. Meanwhile, the group differences in self-report efficacy scores were also noted. It was found that significant differences between TAMG and CAMG were identified for self evaluation of own competence, evaluation of the training programme, indicating more significantly improvement in TAMG than in CAMG ($P < 0.0001$). As the questionnaire measurement reflected patients’ application of memory in everyday activities, the results also revealed that patients with brain injury would demonstrate significant improvements on specific everyday memory tasks following training based on errorless learning and enriched environment principles. There was a positive trend for patients to report self-confidence for memory performance following intervention, and although this was not statistically significant between CAMG and TAMG. It does suggest that patient’s perceptions of the memory problems may have been influenced by the intervention. This aspect deserves closer investigation in future studies.

6.4.2 Some explanations for self efficacy enhancement

Feedback and persuasion. Self-efficacy refers to the belief in one’s capability of performing a specific task (Tam, 2000). Self-efficacy is a key to the willingness to commit oneself to a highly demanding undertaking, it is the belief in one’ s capacity to realize the physical, intellectual, and emotional resources needed to succeed through systematic training (Zhang & Espinoza, 1997; Fall, 1994). Tam (1996) had implemented a computer skills training programme for trainees with physical disabilities and found that self-efficacy is one of the best predictors of the success of the training. In Tam and Man’s another report (2004), the participants who were divided into four groups (self-paced group, feedback group, personalizes group and visual presentation) begun the training with similar initial self-efficacy levels in performing the memory tasks, they showed various self-efficacy improvements from the results. It was found that, except the feedback group that showed statistically significant self-efficacy improvement, the other three groups and the control group showed insignificant self-efficacy changes. Researchers suggested that feedback should be a crucial factor to improve the participant’s self-efficacy in applying the memory strategies.

The results further support the argument that feedback can be a crucial factor in improving the self-efficacy of subjects in applying learning strategies (Clark, 1997; Escari, Guzman, 1999; Tam & Man, 2004). Self-efficacy was increased during the course of the experiment for those participants who had received feedback, but decreased for those who had not. In fact, the results of previous studies showed that praise for effort was critical because such feedback or praise promotes perceptions of self-efficacy and contributes to enhancing skills (Anderson, 1998; Bandura, 1992; Daniels & Larson, 2001; Schunk & Gunn, 1985). In the present study, it was easier that feedback was given in face-to-face mode. The TAMG group received relatively more immediate and personal feedback on their successful performance that would facilitate positive self-appraisals of efficacy than the CAMG. First, systematic instructional strategies were planned beforehand to ensure participant could be presented objectively and logically during the training programme. They were assured that the learning tasks were not complex. Positive feedback (praise) on progress (compared to an individual subject's baseline) was given explicitly and frequently if they had achieved the expected level of mastery of a particular learning task or component(s). Second, consistent persuasion instructions were given to individual trainees throughout the training. These techniques were implemented to facilitate appropriate outcome expectancy and goal-setting. Also, persuasion could affect changes in their internal self-attributions to the achievement of computer skills. This was done by identifying the level of ability of individual subjects and then explaining to them that the training task requirements were within their abilities. The following are examples of the encouragement given to participants of memory training programme in the present study.

> "*You did well and you can remember it!"*
>
> *"You have demonstrated your learning ability already, now you can show me how to recall this story"*

The practice revealed that feedback and praise provided by therapists in TAMG had played indeed an important role to improve the participant's self-efficacy in applying the memory strategies. This reasoning was supported by previous literature findings (Clark, 1997; Escarti & Guzman, 1999; Tam & Man, 2004).

Motivation and Attitude. Associated with increases in self-efficacy, there might be gains in other coping mechanisms that were necessary for successful training performance and rehabilitation outcomes, e.g., motivation (Miyake & Matsuda, 2002; Zhang & Lu, 2002). Therefore, enhancing self-efficacy is important in the rehabilitation of persons with brain injuries. Studies had also shown that perceived self-efficacy exerted a substantial independent effect on performance. A positive attitude toward functional tasks was better predicted by perceived self-efficacy than by actual ability. People may perform poorly because they lack the ability, or they may have the ability but lack the perceived self-efficacy to make optimal use of their skills (Bong, 2002; Collins, 1982). Also, if a person has better self-efficacy regarding his/her own functional independence and adjustment, this will facilitate the generalization of functional skills and ultimately lead to independence. On the whole, positive self-efficacy can lead to the intrinsic and extrinsic mobilization of a person's resources to achieve maximal rehabilitation outcomes.

In this study, self efficacy questionnaires, like other neuropsychological test, were administered to provide an indication of the participants' mood, behaviour and memory functioning, All the measures of MFQ and self-reported efficacy questionnaire were completed at initial assessment and repeated during and following the intervention. All patients and their relatives were asked about their views of the intervention. For example, changes in self-confidence, memory performance, self-evaluation involving satisfactory, functionality as well as suggestion for training course and software design. Some were enthusiastic and felt that they had been helped considerably by the training course. Others were very aware of the alleviation of memory disorder and in this context the positive effects of the intervention seemed of more significance. A few participants seemed to be very pleased to receive visits, but they only remembered little about the intervention or felt that they had really improved. It was of interest to establish whether changes in performance on targeted tasks were accompanied by changes in the perceptions of participant in future studies.

The quantity and quality of human interactions. Face-to-face interview, which specifically allowed personal relationships to develop, would make the training process more effective and efficient. The results in the present study supported this viewpoint that some subjects with TBI preferred face-to-face therapist-administered training. These subjects felt that they would gain more genuine human interaction and feedback to develop better learning skills and self-confidence than in other types of training. From the above discussions, we postulated that, personal contact was crucial to enhancement of self efficacy. An on-site instructor provided more positive communication and immediate feedback on client performance, as well as more content or individually specific knowledge (Crump, Caskey & Ferrell, 1998). It was anticipated that the face-to-face interactions would have a strong effect on the subjects' behavioural intentions, their persistence in performing the tasks, and the effort they spent in their training, thus enhancing their performance outcomes and self-efficacy. Abrahamson (1998) also recommended that personal contact and interaction between and among instructors and students could be improved to enhance the learning experience. From this perspective, it is worthwhile to further investigate the empirical relationship between the quantity and quality of human interactions and the process and outcomes of cognitive skills training. In the face-to-face training, subjects might also hold more positive perceptions of the therapist, the process of interaction, and the quality of discussions (Ocker & Yaverbaum, 1999); and all of these could contribute to the quality of the training programme (Johnson, Aragon & Shaiket, 2000).

To summarize, the fact that the face-to-face therapist administered programme (TAMG) enhanced the self-efficacy of the subjects could be attributed to its “direct” and “regular” in-person performance feedback. The computer-assisted method (CAMG), which integrated the attributes of computer-assisted methods and “at need” therapist support, also led to positive training outcomes in learning skills and psychological well-being that might relate to the subjects’ increased sense of achievement obtained through successful training outcomes. This is a further evidence of the importance of “human-touch” as a significant complement to technology-based therapy.

6.5 Some influential factors to be considered

6.5.1 Demographic characteristics of subjects

Chen et al. (1997) pointed out that demographic characteristics of subjects, such as differences in brain organization, location of lesion, extent or magnitude of neurological damage, chronicity, age at injury, rate of improvement immediately following injury, and premorbid level of functioning, were easily confounded with treatment effects, and made it difficult to evaluate treatment outcomes. These demographic characteristics were controlled strictly and had been based on inclusion criteria in this study. As reported earlier, there were no statistically significant difference on gender, brain injury sites and educational level among three groups by means of Chi Square and ANOVA test, so, the effect these factors on outcome were not included in further analysis.

6.5.2 Severity of neurological damage and its complications

It was clear that patients' severity of brain injury, attention level, physical condition would directly affect the training outcome. The patients' conditions were not only affected by the brain injury, but also by other chronic illness such as heart disease, hypertension, lung diseases and kidney problems and so on. Through stringent selection criteria, the present study had minimized the impact of those mentioned confounding variables. If the selected patients deteriorated in physical and mental conditions due to complications and other reasons, they would be excluded from the training programme. In fact, there were altogether six drop outs from the present study due to this reason.

6.5.3 Other cognitive deficits

Patients' cognitive conditions, such as attention and concentration, comprehension, reasoning and judgment etc, could influence directly memory training and measures outcomes. In general, attention is a prerequisite of memory. In order to reduce effect of other cognitive deficits, inclusion criteria for appropriate level of attention and verbal expression had been spelt out, such as attention span needed to be lasting for at least 5 minutes and patients should be medically stable, having fair verbal comprehension and expression power, with abilities to attend to and follow task instruction.

6.5.4 Some inhibiting acetylcholinesterase drugs

Some drugs that inhibit acetylcholinesterase release or increase the availability of acetylcholine, such as Exelon, Aricept, Huperzine A, can improve cognitive dysfunction. All of the participants in this study were treated by these chemical drugs. So, it was difficult to exclude the drug effects to the study outcomes. The researchers could only minimize the usage or observe the side effects of the prescribed drugs.

6.5.5 Spontaneous recovery

Some neuropsychological test score had statistically improvement for CG through within group comparison, such as the mean difference of NCSE subscores in ‘Orientation’ and ‘Comprehension’ measured between follow up and pre-training. Similar changes in CG over time (T1, T2 and T3) were found in ‘random encoding’, ‘random and block retrieval’ of HKLLT memory process measures. It implied that some memory performance and process existed and explanation can be due to spontaneous recovery. It is not also surprising that the CG patient’s surrounding environment continues to stimulate them like peers in the training groups (CAMG and TAMG) and in the same manner. In addition, most clinical research had been conducted using group designs that required the use of a control or no-treatment group. In fact, it was quite difficult to form a reasonable control group in this clinical trial, because withholding treatment was ethically problematic. However, the outcome comparison across groups was not affected because there were few changes in subscores in subjects of CG.

6.5.6 Generalization of training content

Without generalization, the learning demonstrated on the practiced task seemed irrelevant to overall recovery, irrelevant to progress with other similar computer programmes, and irrelevant to the performance of useful daily activities in real-life situations (Kerner & Acker, 1985; Franzen & Haut, 1991). In the present training programmes, there are already many built-in EL-based applications in simulated real settings. For example, the common locations of placing household commodities within a house, naming the function or usage of daily objects, visiting doctors, shopping with family members. These training activities aimed to transfer the errorless learning principles into everyday memory training, instead of well-controlled laboratory tasks. As there were significant changes in MFQ scores, namely the ‘Frequency of forgetting’, ‘Seriousness of forgetting’ for both CAMG and TAMG, and carryover effect during follow up ($P<0.01$). In present study, most of the participants were also involved in daily practice, application of memory strategies in everyday activities was encouraged and supervised by their relatives. Therapists would provide counseling for them when they encountered difficulties in home and community or at work. This may be an important factor to maintain main effect obtained through rehabilitation in hospital. Practice has had an impact on the level of maintenance observed at least for some of the participants during follow up. Bäckman (1992) and Woods (1996) thought that generalization of the clinical implication was that continued input following intervention might be likely to be necessary in many cases to ensure that gains were maintained for long time. Of course, more solid evidence of generalizing the training to other similar daily living activities, in different environment demands another well-planned study.

6.5.7 The effect of learning strategies on memory process

The relationship between learning strategies and memory process has, in fact, been researched widely (Au, Chan & Chiu, 2003; Chan et al., 2000; Efklides, et al, 2002; Vanderploeg, Crowell & Curtiss, 2001). Chan et al. (2000) found a similar pattern of memory deficits in individuals with acute and chronic schizophrenia using HKLLT test, with both groups demonstrating an encoding deficit but relatively intact retention ability. Au et al. (2003) also suggested that the best predictor of normal versus impaired group membership was the rate of forgetting in the first 10 minutes for the random condition, and the total retention for the blocked condition. The relationship may vary in different learning period. In this study, we decided that the focus would be on studying the relationship between memory strategies and processes after patients received training (that is, training effect of the programme). So only the data received in post-treatment period had been analyzed but not the data in pre-treatment nor the follow-up period. In the present study, the learning strategies of HKLLT included a) subjective organization; b) semantic clustering; c) primacy effect; d) recency effect; e) concrete concepts; and f) abstract concepts. In order to ascertain the relationship of HKLLT learning strategy factors scores with memory process, correlation between each learning factor score and encoding, storage, and retrieval during training was studies in CAMG and TAMG respectively. It was found that abstract/concrete concepts, semantic clustering and subjective organization were commonly correlated with encoding and storing under random condition in both CAMG and TAMG. In CAMG, all learning strategies factors (except recency effects) correlated with memory processes (encoding, storage and retrieval respectively). Less significant correlation was also found between retrieval and learning strategies in both the CAMG and TAMG. These findings revealed that learning strategies also had an impact on the improvement of memory performance for different training groups. But, it is worthy asking "why so many learning strategies correlated with memory encoding and storage process, especially for abstract concepts?"

The following discussion might offer some explanations to this relationship:

1. It might be related to the software design of the training content. In the present research, there was a 20-session training which were categorized into four parts (please refer to Chapter 4, research methodology). In addition to the concrete conceptual content such as the use of pictures, sound, there were also learning strategies that involve words that required semantic association, and digit memory (e.g. telephone numbers, menu) which demanded abstract reasoning and elaboration processing. While the performances of these learning strategies and skills had improved, they would surely affect the encoding and storage processes. This reasoning is also consistent with hypothesis of acquisition impairment following brain injury (DeLuca et al., 2000; Vanderploeg et al., 2001). The changes of learning factor score in HKLLT and subtest of RBMT-CV may reflect either an encoding strategy, a consolidation strategy, or acquisition statement. Thus the therapeutic intervention probably played an important role in these changes.

2. The influence of a traditional Chinese culture. In HKLLT, the abstract concepts for testing were achieved by some target words such as family members, countries, music and occupation which were very familiar to Chinese. In Mainland China, the family

members and their relatives live in harmony, help each other and overcome difficulties in common due to traditional Chinese cultural influences (Confucianism). This social environment also provides better conditions for participant understanding their familiar with abstract target words of HKLLT, so it might not be surprising that the score of abstract concept had more significant positive correlation with memory process.

3. The influence of training mode and learning motivations. Under an enriched environment provided by HCI, patients in CAMG had shown great enthusiasm for participating in the therapeutic training.

6.5.8 The impact of social –cultural background

The term culture refers broadly to values, attitudes, and behaviors that characterize groupings of people who are influenced by their culture of origin, religion, race, and socioeconomic status (Kaslowa, Wooda & Loundyb, 1998). Due to culture's diversity, it is often a challenge for patients to find an approach that is respected in their own culture and the dominant culture when developing strategies for handling memory deficits. As previously mentioned, the present study used the tailor-made training software as well as selection of appropriate neuropsychological tests for subjects with TBI and associated memory disorders. Implementation was based on having consideration of Chinese cultural background. The cultural background against which the 20-session package was designed was found to be efficacious for Chinese patients in the present study.

6.5.9 The sensitivity and specificity of neuropsychological evaluation (NPE)

When memory tests are developed, in addition to reliability, validity studies, issues such as sensitivity, and specificity are also considered so that NPE can reflex according to the context of a specific culture. As mentioned earlier, RBMT-CV, NCSE-CV and HKLLT were chosen as standardized neuropsychological outcome measuring tools in present study. Although the HKLLT is based upon the model of the CVLT, The HKLLT emphasizes the evaluation of organization strategies in learning and memory process. The result showed that HKLLT was suitable for Chinese subject's native language, and was found to be a more comprehensive way to measure memory changes in different training methods in the present study. It did not possess specificity in reflecting memory performance improvement, but also distinguished sensitivity difference between CAMG and TAMG. In addition, learning strategies of HKLLT could also be reflected sensitively in the influences of enriched environment and emotional and motivation factors.

NCSE-CV, RBMT-CV was also able to pick up the differences among different training modalities. For example, Attention subscore in NCSE-CV was the only subscore that did not change over time and this finding was consistent across the three groups. In opposition, there were significant improvement in Memory subscore for both CAMG and TAMG. These finds demonstrated that NCSE-CV could reflect that inclusion criteria were controlled very well. The reliability and validity of outcome measure tools adopted by this study had been introduced in chapter 4 (research methodology) in detail and will not repeat here. But Evans and colleagues (2000) suggested that RBMT-CV was particularly suitable for use in multi-center study. There was no exception in the present study and this was reflected in the sensitivity of RBMT-CV in detecting any gentle memory changes post training.

6.6 Implications of the present study

As medical technology and techniques have expanded, more injured- and more catastrophically injured - survive TBI and require extensive and costly lifelong care. At the same time increasingly restrictive health care economics have forced a shift in the locus of brain injury rehabilitation from extensive hospital stays as an inpatient at a rehabilitation hospital to time-limited outpatient day programs within the community. These pragmatic realities necessitate an increased emphasis on the rapid acquisition of functional skills to achieve maximal independence of individuals with TBI.

The current environment of brain injury rehabilitation demands an efficient, cost-effective way for persons with acquired brain injury to regain independence rapidly in crucial life activity areas. The computer-assisted cognitive rehabilitation is helpful for this situation. Its development would complement the reality of functional improvement cater to their real needs at different stages of recovery and adjustment in their social environment. The development of cognitive rehabilitation programme would have a strong impact in PR China where the largest disabled population is found and the need of cognitive rehabilitation is pressing. The self-administered questionnaire investigation showed that although health care professionals generally still consider face-to-face therapy a crucial service mode (Dou et al., 2004). Online cognitive rehabilitation is also considered a suitable service option, for example, for home-based programmes and the potential for fully online/remote service delivery should be investigated. It is anticipated that the results in this study may be pioneering the evidence-based development of similar cognitive rehabilitation in mainland China. Integrating the western research findings on cognitive rehabilitation with the contemporary Chinese mode of service delivery system serves as a useful guide to lead the future development of cultural relevant computer-assisted cognitive rehabilitation services (CRS) in China.

Another important implication is the consideration of cost-effectiveness. The cost of home-based rehabilitation is less than that of hospitals or community centre. Computer networking can be established with the pervasive use of computers in the home, home-based computer-assisted cognitive rehabilitation has become more economical mode. Therefore this development of new rehabilitation model may be especially suitable for Chinese situation in the viewpoint of the cost-effectiveness as developing country.

The present study has shown evidence of the effectiveness of the application of computer technology in memory rehabilitation. The results of the present study may be generalized to other computer-assisted cognitive skill training, such as attention and concentration, reaction ability, visuomotor ability, reasoning and judgment etc. The findings also support the feasibility of computer cognitive rehabilitation service delivery in terms of cost-effectiveness, usability, and applicability. Since this newly developed successful computer-assisted cognitive rehabilitation programmes has been validated, its application can be further generalized to other client populations with similar cognitive rehabilitation needs, such as persons with mental retardation, stroke, normal age-related memory decline etc. Moreover, the technological developments and experiences gained from this study could be generalized to other computer-assisted clinical applications such as work skills training (e.g., interactive instructions for work task training).

Although the errorless learning technique is not a mnemonic strategy in a strict sense for it addresses the learning process rather than serving as a memory aid, the principle may be of assistance in everyday settings such as at home, school, office etc. That is, if one experiences memory failure (such as not remembering the name of a familiar person), one is intuitively tempted to guess until the correct name comes up, resulting in incorrect responses. The results of this study and previous research clearly demonstrated that these might actually interfere with the memory traces (and thus produce higher error rates), and that the prevention of errors during learning or rehearsing information consequently results in a better memory performance.

6.7 Limitation of research

The present study shares similar limitations to other clinical research on patients with traumatic brain injury.

1. The sample size was small and there might be a lack of adequate controls for comparison. There were genuine difficulty in obtaining true random sampling, difficulty in forming homogeneous treatment groups and the failure to include analyses of confounding variables' effects, such as intelligence, educational background and types of brain injury, etc.
2. There was only monotony cognitive remediation approach, but no other treatment approaches (for example errorless versus errorful learning) or other models for comparison.
3. Duration of both training and follow up period was comparatively short in duration. Sensitivity of outcome measures may be affected.

4. In this study, normal subject group had not been set up. So no comparison can be shown. Although there are some literatures showing data for normal subject, as the training method is not similar, comparison cannot be made.
5. It is also realized that the computer is a non-personal entity that offers no emotional support to individuals during the rehabilitation process. This might bring a confounding effect to the comparison between computerized and standard methods that may have more human interaction.

6.8 Conclusion

In conclusion, this study supported the hypothesis that that positive treatment effects would be exhibited in subjects with TBI going through the two memory rehabilitation programmes respectively (i.e. computer-assisted or CAMG; and therapist-administered or TAMG) but not in a control group (CG). Several significant findings were obtained and summarized as below:

1. The errorless learning is likely to be an effective method to improve memory performance and function following brain injury. This learning mode is of similar effectiveness for CAMG, TAMG and the effect can be maintained for a month.
2. The mode of memory retraining of errorless learning under a Chinese cultural background, combined with enriched environment provided by human computer interaction, may affect the whole memory process including encoding, storage and retrieval. However, CAMG training has demonstrated better effectiveness than TAMG retraining, especially in improving the memory function of encoding, and storage in the memory process.
3. In addition, enhancement of self-efficacy was also identified in all of participants.

Furthermore, it was found that there were more significant changes in TAMG than in CAMG for self evaluation of own competence and positive evaluation of programme.

4. The significant positive correlation was found between the encoding, storage of the memory process and some learning strategy factors including semantic clustering, subjective organization ability, concrete and abstract concepts.

REFERENCES

Abrahamson, C.E. (1998). Issues in interactive communication in distance education. *College Student Journal, 32(1),* 33-42.

Aggleton, J.P., Brown, M.W. (1999). Episodic memory, amnesia, and the hippocampal-anterior thalamic axis. *Behavoural Brain Science*, *22(3),* 425-444; discussion 444-489.

Anastasi, A. (1988). *Psychological testing* (6th eds). New York: MacMillan.

Anderson, A. A. (1998). The effects of sociocognitive writing strategy instruction on the writing achievement and writing self-efficacy of students with disabilities and typical achievement in an urban elementary school. *Dissertation Abstracts International, 58 (11-A),* 4182.

Aras, M.D., Kaya, A., Cakc, A., Gokkaya, K.O. (2004). Functional outcome following traumatic brain injury: the Turkish experience. *International Journal of Rehabilitation Research, 27(4),* 257-260.

Armstrong, C. (1989). Luria's theory of brain function recovery with applications to the use of computers in cognitive retraining. *Cognitive Rehabilitation, 1,* 10-15.

Au, A., Chan, A.S., & Chiu, H. (2003). Verbal learning in Alzheimer's dementia. *Journal of the International Neuropsychological Society, 9,* 363–375.

Bäckman, L. (1992). Memory training and memory improvement in Alzheimer’s disease: Rules and exceptions. *Acta Neurologica Scandinavica, Supplement* 139, 84-89.

Baddeley, A. (1986). *Working memory.* Oxford University Press.

Baddeley, A. (1992). Working memory. *Science, 255,* 556–559.

Baddeley, A., Wilson, B. (1994).When implicit learning fails: amnesia and the problem of error elimination. *Neuropsychologia, 32*, 53-68.

Baddeley, A.D. (1999). working memory. In Alan, D., Baddeley (Eds), *Essential of Human Memory* (PP 45-70). UK: Psychology Press Ltd.

Baddeley, A.D., Harris, J., & Sunderland, A. (1987). Closed head injury and memory. In H.S. Levin, J. Grafman et al. (Eds.), *Neurobehavioral recovery from head injury* (pp. 295–317). New York: Oxford University Press.

Baddeley, A.D., Hitch, G.J. (1994). Development in the concept of working memory.

Neuropsychology, 8(4), 485-493.

Bandura, A. (1992). Social cognitive theory. In: R. Vasta (editor), *Six theories of child development: Revised formulations and current issues* (pp. 1-60). London: Jessica Kingsley Publishers.

Barker, L.J. (2003). Computer-assisted vocabulary acquisition: The CSLU vocabulary tutor in oral-deaf education. *Journal of Deaf Studies and Deaf Education, 8,* 187-198.

Barnes, M.P.(1999). Rehabilitation after traumatic brain injury. *British Medical Bulletin, 55(4),* 927-943.

Baum, K.M., Vanderploeg, R.D., Curtiss, G. (1996). Patterns of verbal memory deficits in traumatic brain injury using the CVLT. *The Clinical Neuropsychologist, 10,* 340.

Begg, I., Green, C. (1988). Repetition and trace interaction: superadditivity. *Memory and Cognition, 16,* 232-242.

Belleza, F.S., Young, D.R. (1989). Chunking of repeated events in memory. Journal of *Experimental Psychology Learning Memory Cognition , 15,* 990-997.

Bellus, S.B., Kost, P.P., Vergo, J. P. (1998). Improvements in cognitive functioning following intensive behavioural rehabilitation. *Brain Injury, 12,* 139–145.

Bennett, T.L., Dittmar, C., Ho, M.R. (1997). The Neuropsychology of traumatic brain injury. In Horton, A.M., Wedding, D., Webster, J. (eds.), *The Neuropsychology Handbook: Behaviour and Clinical Perspective* (pp.123-172) .(2nd edition). New York: Springer Publishing Company.

Ben-Yishay, Y., Diller, L. (1993). Cognitive remediation in traumatic brain injury: update and issue. *Archives of Physical Medicine and Rehabilitation, 74,* 204-213.

Bergland, M.M., Thomas, K.R. (1991). Psychosocial issues following severe head damage in adolescence: individual and family perceptions. *Rehabilitation Counselling Bulletin, 35(1),* 5-22.

Bergman, M.M. (1998). A proposed resolution of the remediation-compensation controversy in brain injury rehabilitation. *Cognitive Technology*, 3, 45–51.

Bergman, M.M. (2000). Successful mastery with a cognitive orthotic in people with traumatic brain injury(TBI). *Applied Neuropsychology, 7*, 76-82.

Bergman, M.M. (2002). The benefits of a cognitive orthotic in brain injury rehabilitation. *Journal of Head Trauma Rehabilitation, 17(5),* 431-435.

Bernstein, L. (1973). A study of some enriching variables in a free-environment for rats. *Journal of Psychosomatic Research,* 17, 85-88.

Berrol, S. (1990). Issues in cognitive rehabilitation. *Archives of Neurology, 47,* 219–220.

Blachstein, H., Vakil, E., Hoofen, D. (1993). Impaired learning in patients with closed-head injuries: An analysis of components of the acquisition process. *Neuropsychology, 7,* 530-535.

Bliss, T.V.P., Collingridge, G.L. (1993). A snaptic model of memory: long term potientiation in the hippocampus. *Nature, 361,* 31-39.

Bong, M. (2002). Predictive utility of subject-, task-, and problem-specific self-efficacy judgments for immediate and delayed academic performances. *Journal of Experimental Education, 70(2)***,** 133-162.

Bracy, O. L.,Oakes, A. L., & Cooper, R. S. (1999). The effects of cognitive rehabilitation therapy techniques for enhancing the cognitive/ intellectual functioning of seventy and eighth grade children. *International Journal of Cognitive Technology, 4,* 19-27.

Brett, A.W., Laatsch, L. (1998). Cognitive rehabilitation therapy of brain-injured students in a public high school setting. *Pediatric Rehabilitation, 2,* 27–31.

Brown, N., Darling, P., Hardman, J. (1997). Negotiating the possible: Issue and strategies for survivors with newly acquired brain injury. *The Journal of Cognitive Rehabilitation, 15(4),* 20-23.

Burda, P.C., Starkey, T.W., Dominguez, F. (1994). Computer-assisted cognitive rehabilitation of chronic psychiatric inpatients. *Computers in Human Behavior, 10,* 359-368.

Calof, A.L. (1995). Intrinsic and extrinsic factors regulating vertebrate neurogenesis. *Current Opinion of Neurobiology, 5,* 19–27.

Camp, C.J.(2001). From efficacy to effectiveness to diffusion: Making the transitions in dementia intervention research. *Neuropsychological Rehabilitation, 11,* 495-517

Carlesimo, G.A., Sabbadini, M., Loasses, A., et al. (1997). Forgetting from long-term memory in severe closed-head injury patients: Effect of retrieval conditions and semantic organization. *Cortex*, *33*, 131-142.

Carney, N., Chesnut, R.M., Maynard, H., Mann, N.C., Patterson, P., Helfand, M. (1999). Effect of Cognitive Rehabilitation on Outcomes for Persons with Traumatic Brain Injury: A Systematic Review. *Journal of Head Trauma and Rehabilitation*, *14(3)*, 277-307.

Cavaco, S., Anderson, S.W., Allen, J.S., Castro-Caldas, A., & Damasio, H. (2004). The scope of preserved procedural memory in amnesia. *Brain*, *127(8)*, 1853-1867.

Chan, A., Ho, S., Poon, W. S. (2002). Neuropsychological sequelae of patients treated with microsurgical clipping or endovascular embolization for anterior communicating artery aneurysm. *European Neurology*, *47*, 37–44.

Chan, A.S., Kwok, I.C. (1999). Hong Kong List Learning Test. *Manual & Preliminary Norm.* Hong Kong: Easy Press Printing.

Chan, A.S., Kwok, I.C., Chiu, H., Lam, L., Pang, A., & Chow, L. (2000). Memory and organizational strategies in chronic and acute schizophrenic patients. *Schizophrenic Research*, *41*, 431–445.

Chan, A.S., Shum, D., Cheung, R. (2003). Recent Development of cognitive and neuropsychological assessment in Asian countries. *Psychological Assessment*, *15(3)*, 257–267

Chan, C.H.C., Lee, T.M.C., Wong, V., Fong, K., & Lee, C. (1999). Validation of the Chinese version of neurobehavioral cognitive status examination. *Archives of Clinical Neuropsychology*, *14(1)*, 71.

Chen, S.H.A., Thomas, J. D., Gluekauf, R.F., & Bracy, O.L. (1997). The effectiveness of computer-assisted cognitive rehabilitation for persons with traumatic brain injury. *Brain Injury*, *11*, 197–209.

Cherry, K.E., Simmons, S.S., Camp, C.J. (1999). Spaced retrieval enhances memory in older adults with probable Alzheimer’s disease. *Journal of Clinical Geropsychology*, *5(3)*, 159-175.

Chiu, H., Lee, H.C., Chung, W.S., et al. (1994). Reliability and Validity of the Cantonese version of mini-mental state examination: a preliminary study. *Journal of Hong Kong College Psychiatrist*, *4*, 425-428.

Cicerone, K.D., Dahlberg, C., Kalmar, K., Langenbahn, D.M., Malec, J.F., Bergquist, T.F., Felicetti, T., Giacino, J.T., Harley, J.P., Harrington, D.E., Herzog, J., Kneipp, S., Laatsch, L., Morse, P.A. (2000) Evidence-based cognitive rehabilitation: recommendations for clinical practice. *Archives of Physical Medicine and Rehabilitation*, *81*, 1596-1615.

Clare, L., Wilson, B.A., Breen, K., & Hodges, J.R. (1999). Errorless learning of face-name associations in early Alzheimer's disease. *Neurocase*, *5*, 37-46.

Clare, L., Wilson, B.A., Carter, G., Breen, K., Gosses, A., & Hodges, J.R. (2000). Intervening with everyday memory problems in dementia of Alzheimer type: an errorless learning approach. *Journal of Clinical and Experimental Neuropsychology* , *22*, 132-146.

Clark, S.C.(1997). Judging contingencies accurately: the effects of feedback, practice, and self-efficacy. *Dissertation Abstracts International*, *58*, 2177.

Cockburn, J. (1996). The pragmatic and ecological perspective: Evaluation of memory disorders. *European Review of Applied Psychology*, *46 (3)*, 201–205.

Cockburn, J., Haggard, P., Cock, J., Fordham, C. (2003). Changing patterns of cognitive-motor interference (CMI) over time during recovery from stroke. *Clinical Rehabilitation*, *17*, 167-173.

Cockburn, J., Wilson, B.A., Baddeley, A.D., & Hiorns, R. (1990). Assessing everyday memory in patients with perceptual deficits. *Clinical Rehabilitation*, *4 (2)*, 129–135.

Collins, J. L. (1982). Self-efficacy and ability in achievement behavior. Paper presented at *the annual meeting of the American Educational Research Association*, New York.

Cope, D.N. (1995). The effectiveness of traumatic brain injury rehabilitation: a review. *Brain Injury*, *9(7)*, 649-670.

Corrigan, P.W., Yudofsky, S.C. (2000). C*ognitive Rehabilitation for Neuropsychiatric Disorders*. Washington, D.C: American Psychiatric Press, Inc.

Cowan, N. (1996). Short-term memory, working memory, and their importance in language processing. *Topics in Language Disorders*, *17*, 1-18.

Craik, F.I.M., Jennings, J.M. (1992). Human memory. In F.I.M. Craik & T.A. Salthouse (Eds.), *The handbook of aging and cognition* (pp51-110). Hillsdale, NJ: Erlbaum..

Crosson, B., Novack, T.A., Trenerry, M.R., & Craig, F.M. (1988). California Verbal Learning Test (CVLT) performance in severely head-injured and neurologically normal adult males. *Journal of Clinical and Experimental Neuropsychology, 10*, 754-768.

Crump, W.J., Caskey, J.W. & Ferrell, B.G. (1998). Effect of a remote facilitator on small-group problem solving: potential uses of two-way video technology in decentralized medical education. *Teaching and Learning in Medicine*, *10(3)*, 172-177.

Daniels, J.A. & Larson, L.M. (2001). The impact of performance feedback on counseling self-efficacy and counselor anxiety. *Counselor Education and Supervision, 41*, 120-130.

Delis, D.C., Kramer,J., Kaplan, E., & Ober, B.A. (1987). *California Verbal Learning Test.* San Antono, TX: The Psychological Corporation.

Deluca, J., & Chiaravalloti, N.D. (2004). Memory and learning in adults. In G. Goldstein and S.R. Beers (eds.), *Comprehensive handbook of psychological assessment, Volume 1. Intellectual and neuropsychological assessment* (pp.217-236). Hopoken, New Jersey: John Wiley & sons, Inc.

DeLuca, J., Schultheis, M.T., Madigan, N.K., Christodoulou, C., & Averill, A. (2000). Acquision versus retrieval deficits in traumatic brain injury: Implications for memory rehabilitation. *Archives of Physical Medicine and Rehabilitation*, *81(10)*, 1327-1333.

D'Esposito et. al. (1995). The clinical profiles, recovery and rehabilitation of memory disorder. *NeuroRehabilitation*, *5*, 141-159.

Devany, S.C., Devens, M. (1994). Employment problems following traumatic brain damage: families assess the causes. *Neurorehabilitation*, *4(1)*, 53-57.

Diamond, M. C., Linder, B., Johnson, R., Bennett, E. L., & Rosenzweig, M. R. (1975). Differences in occipital cortical synapses from environmentally enriched, impoverished and standard colony rats. *Journal of Neuroscience Research*, *1*,109–119.

Dikmen, S., Machamer, J. and Temkin, N. (1993). Psychosocial outcome in patients with moderate to severe head damage: 2-year follow-up. *Brain Injury*, *7(2)*, 113-124.

Dittmar, C. (1997). Outpatient rehabilitation program for clients with persistent mild to moderate symptoms following traumatic brain injury. *Applied Neuropsychology*, *4(1)*, 50-54.

Dou, Z.L., Man, D.W.K., Tam, S.F., (2003). The development of tele-cognitive rehabilitation. *Chinese Journal of Physical Medicine and Rehabilitation, 25(9)*, 568-571.

Dou, Z.L., Man, D.W.K., Tam, S.F. et al. (2004). Community-based cognitive rehabilitation service for population with traumatic brain injury in China. *International Journal of Rehabilitation Research, 27(1)*, 81-84.

Drane, D. L., Yuspeh, R. L., Huthwaite, J. S., Klinger, L. K., & Hendry, K. M. (1998). Older adult norms for the cognistat (NCSE). *Archives of Clinical Neuropsychology*, *14*, 47-48.

Ducharme, J.M. (2003). "Errorless" rehabilitation strategies of proactive intervention for individuals with brain injury and their children. *Journal of Head Trauma Rehabilitation*, *18(1)*, 88-104.

Duchnick, J.J., Vanderploeg, R.D., & Curtiss, G. (2002). Identifying Retrieval Problems Using the California Verbal Learning Test. *Journal of Clinical and Experimental Neuropsychology*, *24(6)*, 840-851.

Easton, A., Ridley, R.M., Baker, H.F., et al. (2002). Unilateral lesions of the cholinergic basal forebrain and fornix in one hemisphere and inferior temporal cortex in the opposite hemisphere produce severe learning impairments in rhesus monkeys. *Cerebral Cortex, 12(7)*,729-736.

Efklides, A., Yiults, E., Kangellidou, T., Kounti , F., Dina1, F., & Tsolaki, M. (2002). Wechsler Memory Scale, Rivermead Behavioral Memory Test, and Everyday Memory Questionnaire in Healthy Adults and Alzheimer Patients. *European Journal of Psychological Assessment*, *18 (1)*, 63–77.

Engelhart, C. I., Eisenstein, N., Johnson, V., Wolf, J., Williamson, J., Steitz, D., Girard, V., Paramatmuni, K., Ouzounian, N., & Losonczy, M. (1999). Factor structure of the Neurobehavioral Cognitive Status Exam (COGNISTAT) in healthy, and psychiatrically and neurologically impaired elderly adults. *The Clinical Neuropsychologist, 13*, 109-111.

Engle, R.W. (1996). Working memory and retrieval: An inhibition resource approach. In J.T.E. Richardson (Ed.), *working memory and human cognition* (pp.1130-1149). New Youk: Oxford University Press.

Erickson, R.C., Scott, M.L. (1977). Clinical memory testing: a review. *Psychological Bulletin*, *84*, 1130-1149.

Escarti, A., Guzman, J. F. (1999) . Effects of feedback on self-efficacy, performance, and choice in an athletic task. *Journal of Applied Sport Psychology*, *11*, 83–96.

Evans, J., Wilson, B.A., Schuri, U., Andrade, J., Baddeley, A. Bruna, O., Canavan, T., Sala, S.D., Green, R., Laaksonen, R., Lorenzi, L., & Taussik, I. (2000). A comparison of “errorless” and “trial-and-error” learning methods for teaching individuals with acquired memory deficits. *Neuropsychological Rehabilitation*, *10*, 67-101.

Falkenberg, T., Mohammed, A.K., Henriksson, B. (1992). Increase expression of brain-derived neurotrophic factor mRNA in rat hippocampus is associated with improved spatial memory and enriched environment. *Neuroscience Letter*, *138(1)*, 153–156.

Fall, M. (1994). Self-efficacy: an additional dimension in play therapy. *International Journal of Play Therapy*, *3*, 21- 32.

Figurov, A., Pozzo-Miller, L.D., Olafsson, P. (1996). Regulation of synaptic responses to high-frequency stimulation and LTP by neurotrophins in the hippocampus. *Nature*, *381*, 706–709.

Fillingham, J.K., Hodgson, C., Sage, K., & Ralph, M.A.L. (2003). The application of errorless learning to aphasic disorders: A review of theory and practice. *Neuropsychological Rehabilitation*, *13(3)*, 337-363.

Fletcher, P.C., & Henson, R.N.A. (2001). Frontal lobes and human memory: Insights from functional neuroimaging. *Brain*, *124*, 849-881.

Franzen, M., Haut, M. (1991).The psychological treatment of memory impairment: a review of empirical studies. *Neuropsychology Review*, *2*, 29–63.

Fulop, G., Sachs, C. J., Strain, J., & Fillit, H. (1992). Usefulness of the Neurobehavioral Cognitive Status Examination in the hospitalized elderly. *International Psychogeriatrics*, *4(1)*, 93-102.

Fuster, J.M. (1997). Network m emory. *Trends in Neurosciences, 20(10)*, 451-459.

Gaffan, D. (2001). What is a memory system? Horel's critique revisited. *Behavoural Brain Research*, *127(1-2)*, 5-11.

Giles, G.M., Shore, M. (1989). A rapid method for teaching severely brain injured adults how to wash and dress. *Archives of Physical Medicine and Rehabilitation*, *70*, 156–158.

Gilewski, M.J., Zelinski, E.M., Schaie, K.W. (1990). The Memory Functioning Questionnaire for assessment of memory complaints in adulthood and old age. *Psychology and Aging*, *5*, 482–490.

Glisky, E.L. (1995). Computers in memory rehabilitation. In A.D. Baddeley, et al. (eds.), *Handbook of memory disorders*(pp557-575). Chichester: John Wiley & Sons.

Glisky, E.L., Schacter, D.L.(1987). Acquisition of domain-specific knowledge in organic amnesia: training for computer-related work. *Neuropsychologia*, *25*, 893–906.

Glisky, E.L., Schacter, D.L. (1988). Long term retention of computer learning by patients with memory disorders. *Neuropsychologia, 26*, 173-178.

Glisky, E.L., Schacter, D.L., Tulving, E. (1986a). Computer learning by memory-impaired patients: Acquisition and retention of complex knowledge. *Neuropsychologia*, *24*, 313-328.

Glisky, E.L., Schacter, D.L., Tulving, E. (1986b). Learning and retention of computer-related vocabulary in memory-impaired patients: Method of vanishing cues. *Journal of Clinical and Experimental Neuropsychology*, *8*, 292-312.

Goldstein, F.C., Levin, H.S. (1995). Neurobehavioral outcome of traumaticbrain injury in older adults: Initial findings. *Journal of Head Trauma Rehabilitation*, *10(1)*, 57-73.

Gontkovsky, S.T., McDonald, N.B., Clark, P.G., Ruwe, W.D. (2002). Current directions in computer-assisted cognitive rehabilitation. *NeuroRehabilitation*, *17*, 195-199.

Gonzalez-Lima, F., Ferchmin, P.A., Eterovic, V.A. (1994). Metabolic activation of the brain of young rats after exposure to environmental complexity. *Developmental. Psychobiology*, *27(6)*, 343–351.

Grandmaison, E., Simard, M. (2003). A critical review of memory stimulation programs in Alzheimer’s disease. *Journal of Neuropsychiatry and Clinical Neuroscience*, *15*, 130–144.

Green, R.C., Green, J., Harrison, J.M. et al. (1994). Screening for cognitive impairment in older individuals: validation study of a computer-based test. *Archives of Neurology, 51*, 779-786.

Greenwood, R.S., Parent, J.M.(2002) . Damage control: The influence of environment on recovery from brain injury. *Neurology*, *59*, 1302–1303.

Griesbach, G.S., Hovda, D.A., Molteni, R., et al. (2004). Voluntary exercise following traumatic brain injury: brain-derived neurotrophic factor upregulation and recovery of function. *Neuroscience, 125(1)*, 129-139.

Gunther, V.K., Schafer, P., Holzner, B.J., et al.(2003). Long-term improvements in cognitive performance through computer-assisted cognitive training: a pilot study in a residential home for older people. *Aging Mental Health, 7(3),* 200-206.

Gutman, S.A. (2001). *Quick reference: Neuroscience for rehabilitation professionals* (P 214-218). Thorofare, NJ : SLACK Incorporated.

Hagen, C., Malkmus, D., Durham, P.（1982）. *Levels of Cognitive Functioning*. Downey, Calif: Ranchos Los Amigos Hospital.

Hall, K.M., Cope, D.N. (1995). The benefit of rehabilitation in traumatic brain injury: a literature review. *Journal of Head Trauma Rehabilitation*, *10*, 1–13.

Hamm, R.J., Temple, M.D., O'Dell, D.M., et al. (1996). Exposure to environmental complexity promotes recovery of cognitive function after traumatic brain injury. *Journal of Neurotrauma*, *13(1),* 41-47.

Harrell, M., Parente, F., Bellingrath, E.G., Lisicia, G. (1992). *Cognitive Rehabilitation of memory: A Practical Guide* (pp.76-87). Gaithersburg, Maryland: Aspen Publishers, Inc.

Hertzog, A.R., Rodgers, W.L. (1989). Age differences in memory performance and memory ratings as measured in a sample survey. *Psychology and Aging*, *4*, 173–182.

Hertzog, C., Hultsch, D.F., Dixon, R.A. (1989). Evidence for the convergent validity of two self-report metamemory questionnaires. *Development Psychology, 25,* 687-700.

Hicks, R.R., Zhang, L., Atikson, A., Stevenon, M., Venerracion,M., & Seroogy, K.B.

(2002). Environmental enrichment attenuates cognitive deficits, bit does not alter neurotrophin gene expression in the hippocampus following lateral fluid percussion brain injury. *Neuroscience, 112(3)*, 631-637.

Horel, J.A.(1978). The neuroanatomy of amnesia. A critique of the hippocampal memory hypothesis. *Brain, 101(3)*, 403-445.

Hunkin, N., Squires, E., Parkin, A., et al. (1998). Are the benefits of errorless learning dependent on implicit memory?. *Neuropsychologi*a, *36*, 25–36.

Hutchinson, J. (1997). Functional treatment approaches to memory impairment following brain injury. *Topics in language disorders, 18(1)*, 45-57.

Ickes, B.R., Pham, T.M., Sanders, L.A., Albeck, D.S., Mohammed, A.H., & Granholm, A.C. (2000). Long-term environmental enrichment leads to regional increases in neurotrophin levels in rat brain. *Experimental Neurology, 164,* 45-52.

Johnson, P., Thomas, S.N., Shein, F. (1994). Development of a computer-based program for the remediation of cognitive communication skills in young people with brain injuries. *Journal of Cognitive Rehabilitation*, *12*, 10–16.

Johnson, R. & Gravie, C. (1985). The BBC computer for therapy of intellectual impairment following acquired brain damage. *Occupational Therapy*, *48*, 46-48.

Johnson, S.D., Aragon, S.R. and Shaik, N. (2000). Comparative analysis of learner satisfaction and learning outcomes in online and face-to-face learning environments. *Journal of Interactive Learning Research*, *11*, 29-49

Jonides, J. (1995). Working memory and thinking. In E.E. Smith & D.N. Osheron (Eds.), *Invitation to cognitive science: thinking* (pp.215-265). (2nd Eds). Cambridge, MA: MIT press.

Jonson, M.K. (1992). MEM: Mechanisms of recollection. *Journal of Cognitive Neuroscience, 4(3),* 268-280.

Jordan, B.D. (2000). Cognitive rehabilitation following traumatic brain injury. *Journal of the American Medical Association, 283(23),* 3123-3124.

Kalla, T., Downes , J.J., & van den Broek, M. (2001). The pre-exposure technique: Enhancing the effects of errorless learning in the acquisition of face-name associations. *Neuropsychological Rehabilitation*, *11*, 1-16.

Kang, H., Schuman, E.M. (1995). Long-lasting neurotrophin induced enhancement of synaptic transmission in the adult hippocampus. *Science, 267,* 1658–1662.

Kaslowa, N.J., Wooda, K.A. & Loundyb, M.R. (1998). A cultural perspective on families across the life cycle: patterns, assessment, and intervention outline. *Comprehensive Clinical Psychology*, *10,* 173-205.

Kelly, J.P. (1999). Traumatic brain injury and concussion in sports. *Journal of the American Medical Association*, *282,* 989-991

Kempermann, G., Kuhn, H. G. & Gage, F. H. (1997).More hippocampal neurons in adult mice living in an enriched environment. *Nature, 386,* 493–495.

Kern, R.S., Green, M.F., Mintz, J., et al. (2003). Does 'errorless learning' compensate for neurocognitive impairments in the work rehabilitation of persons with schizophrenia?. *Psychological Medicine*, *33,* 433-442.

Kern, R.S., Green, M.F., Mitchell, S., et al. (2005). Extensions of errorless learning for social problem-solving deficits in schizophrenia. *American Journal of Psychiatry, 162(3),* 513-519.

Kern, R.S., Liberman, R.P., Kopelowicz, A., et al. (2002). Applications of errorless learning for improving work performance in persons with schizophrenia. *American Journal of Psychiatry*, *159(11)*, 1921-1926.

Kerner, M., Acker, M. (1985). Computer delivery of memory retraining with head injured patients. *Cognitive Rehabilitation, 3,* 26–31.

Kessels, R.P.C., Boekhorst , S.T., & Postma, A. (2005). The contribution of implicit and explicit memory to the effects of errorless learning: A comparison between young and older adults. *Journal of the International Neuropsychological Society*, *11,*144-151.

Kessels, R.P.C., de Haan, E.H.F. (2003a). Mnemonic strategies on order people: a comparison of errorless and errorful learning. *Age and Ageing, 32,* 529-533.

Kessels, R.P.C., & de Haan, E.H.F. (2003b). Implicit learning in memory rehabilitation: A meta-analysis on errorless learning and vanishing cues methods. *Journal of Clinical & Experimental Neuropsychology*, *25(6),* 805-814.

Kinsella, G., Murtagh, D., Landry, A., Homfray, K., Hammond, M., O'beirne, L., Dwyer, L., Lamont , M., and Ponsford, J. (1996). Everyday memory following traumatic brain injury. *Brain injury, 10(7),* 499- 507.

Kixmiller, J.S. (2002). Evaluation of prospective memory training for individuals with mild Alzheimer's disease. *Brain Cognition*, *49*, 237-241.

Kolb, B., Forgie, M., Gibb, R. (1998). Experience, and the aging brain. *Neuroscience and Biobehaviour Review*, *22*, 143-159.

Koplmsan, M.D., Wilson, B.A., Baddley, A.D. (1989). The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology*, *11*, 724-744.

Kosslyn, S.M., Beharmann, M., & Jeannerod, M., (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia*, *33 (11)*, 1335-1344.

Lamarre, C.J., Patten, S.B. (1994). A clinical evaluation of the Neurobehavioral Cognitive Status Examination in a general psychiatric inpatient population. *Journal of Psychiatry and Neuroscience*, *19(2)*, 103-108.

Lawton, M.P. & Brody, E.M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist*, *9*, 179-186.

Lazaro, F., Butler, R. (2000) . In-patient neuropsychiatric brain injury rehabilitation. *Psychiatric Bulletin* , *24*, 264-266

Lee, S.S., Powell, N.J., Esdaile, S. (2001). A functional model of cognitive rehabilitation in occupational therapy. *Canadian Journal of Occupational Therapy*, *68(1)*, 41-50.

Levin, H.S., Goldstein, F.C. (1986). Organization of verbal memory after severe closed head injury. *Journal of Clinical and Experimental Neuropsychology*, *8*, 643-656.

Levin, H.S., High, W., Eisenberg, H.M. (1988). Learning and forgetting during posttraumatic amnesia in head injured patients. *Journal of Neurology, Neurosurgery, and Psychiatry*, *51*, 14-20.

Lezak, M.D. (1983). *Neuropsychological Assessment* (PP123-130).(2nd Ed). New York: Oxford University Press.

Luria, A.R. (1980). *Higher cortical functions in man* (2nd Edition). New York:Plenum.

Lynch, B. (2002). Historical review of computer-assisted cognitive retraining. *Journal of Head Trauma Rehabilitation*, *17(5)*, 446-457.

Lynch, W. J. (1992). Ecological validity of cognitive rehabilitation software. *Journal of Head Trauma Rehabilitation*, ***7***, 36–45.

Man, D.W.K., Li, R. (2001). Assessing Chinese adults' memory abilities: validation of the Rivermead Behavioural Memory Test. *Clinical Gerontologist*, *24*, 27-36.

Man, D.W.K., Tam, S.F., Hui-Chan, C.W.Y. (2003). Learning to live independently with an expert system in memory rehabilitation. *NeuroRehabilitaton*, *17*, 1-7.

Man, D.W.K., Tam, S.F., Hui-Chan, C.W.Y. (2003). Learning to live independently with an expert system in memory rehabilitation. *NeuroRehabilitaton*, *18*, 21-29.

Marsh, N.V., Sleigh, J.W., (2002). Neuropsychiatric functioning after traumatic brain injury. *Current Opinion in Psychiatry*, *15(3)*, 301-306.

Martin, S.J. (2000). Untangling the web. *Journal of Cognitive Rehabilitation*, *18(2)*, 2-3.

McClelland, J.L., McNaughton, B.L., & O'Reilly, R.C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, *102*, 419.

Mcglynn, S.M. and Schacter, D. L.(1989). Unawareness of deficits in neuropsychological syndromes. J*ournal of Clinical and Experimental Neuropsychology*, *11*, 143-205, 1989.

McGuire, B.E. (1990). Computer-assisted cognitive rehabilitation. *Irish Journal of Psychology*, *11*, 299–308.

McGuire, T.W., Kiesler, S., & Siegel, J.(1987). Group and computer-mediated discussion effects in risk decision making. *Journal of Personality and Social Psychology*, *52*, 917-930.

McLellan, D.L. (1991). Functional recovery and the principles of disability medicine, in: Swash, M., and Oxbury, J. (eds), *Clinical Neurology* (pp.768–790). Churchill Livingstone: Edinburgh, UK.

McMilliam, T., Robertson, I.H., Brock, D., Chorlton L. (2002). Brief mindfulness training for attentional problems after traumatic brain injury: a randomized control treatment trial. *Neuropsychological Rehabilitation*, *12(2)*, 117-125.

Meeter, M., Murre, J. M. J. (2004). Consolidation of Long-Term Memory: Evidence and Alternatives. *Psychological Bulletin*, *130(6)*, 843-857.

Miller, L. (1992). Back to the future: legal, vocational, and quality-of-life issues in the long-term adjustment of the brain-damaged patient. *Journal of Cognitive Rehabilitation, 10(5),* 14-20.

Miyake, M. & Matsuda, F. (2002). Effects of generalized self-efficacy and negative social comparison feedback on specific self-efficacy and performance. *Psychological Reports, 90,* 301-308.

Montaldi, D., Mayes, A.R., Barnes, A., Pirie, H., Hadley, D.M., Patterson, J., Wyper D.J. (1998). Associative encoding of pictures activates the medial temporal lobes. *Human Brain Mapping, 6,* 85–104.

Murre, J.M.J. (1997). Implicit an explicit memory in amnesia: Some explanations and predictions by the TraceLink Model. *Memory, 5*, 213–232.

Muure, J.M.J. (1997). Implicit and explicit memory in amnesia: Some predictions by the TranceLink model. *Memory, 5*, 55-82.

Neistadt, M.E. (1990). A critical analysis of occupational therapy approaches for perceptual deficits in adults with brain injury. *American Journal of Occupational Therapy, 44(4),* 299-304.

Neuro-Rehabilitation Working Group. (1998). Validation of Rivermead Behavioural Memory Test-Cantonese Version . *Hong Kong Journal of Occupational Therapy, 9,* 18-24.

NIH Consensus Developmental Panel. (1999). Rehabilitation of persons with traumatic brain injury. *The Journal of The American Medical Association, 282(10),* 974-983**.**

Northern California Neurobehavioral Group (1988). *Manual for the Neurobehavioral Cognitive Status Examination.* Fairfax, CA: Author.

O'carroll, R.E., Russell, H.H., Laweir, S.M., & Johnstone, E.C. (1999). Errorless learning and the cognitive rehabilitation of memory impaired schizophrenic patients. *Psychological Medicine, 29,* 105-112.

Ocker, R.J., Yaverbaum, G. J. (1999). Asynchronous computer-mediated communication versus face-to-face collaboration: results on student learning, quality and satisfaction. *Group Decision and Negotiation, 8(5),* 427-440.

Packard, M.G. , Knowlton, B.J. (2002). Learning and memory functions of the Basal Ganglia. *Annual Review of Neuroscience, 25,* 563-593.

Passineau, M.J., Green, E.J., Dietrich, W.D. (2001). Therapeutic effects of environmental enrichment on cognitive function and tissue integrity following severe traumatic brain injury in rats. *Experimental Neurology*, *168*, 373–384.

Paul, E.M., Joseph, V., Todd, T. (2002). Management of head trauma: critical care review. *Chest*, *122(2)*, 699-711.

Paylor, R., Morrison, S.K., Rudy, J.W. (1992). Brief exposure to an enriched environment improves performance on the Morris water task and increases hippocampal cytosolic protein kinase C activity in young rats. *Behav. Brain Res*, *52(1)*, 49–59.

Perna, R.B., Bekanich, M.,Williams, K.R. (2000). Cognitive rehabilitation: what is problem?. *The Journal of cognitive rehabilitation*, *18(4)*, 16-21.

Pew, R.W. (2003). Evolution of Human –computer interaction: From memex to Bluetooth and beyond. In J.A. Jacko & A. Sears (Eds), *The Human –Computer Interaction Handbook Fundamentals, Evolving Technologies and Emerging Applications* (pp. 1-17). Mahwah, New Jersey, Lawrence Erlbaum Associaties, Inc.

Pierce, S.M., Mayer, N.H., and Whyte, J. (2001). Computer-assisted exercise systems in traumatic brain injury: cases and commentary. *Journal of Head Trauma Rehabilitation*, *16*, 406–413.

Poldrack, R.A., Rodriguez, P. (2004). How do memory systems interact? Evidence from human classification learning. *Neurobiology of Learning and Memory*, *82(3)*, 324-32.

Ponds, R. W. H. M., Jolles, J. (1996). Memory complaints in elderly people: The role of memory abilities, metamemory, depression, and personality. *Educational Gerontology*, *22*, 341–357.

Povlishock, J.T., Katz, D.I. (2005). Update of neuropathology and neurological recovery after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *20(1)*, 76-94.

Prevey, M.L., Delaney, R.C., De l'Aune, W., et al. (1991). A method of assessing the efficacy of memory rehabilitation techniques using a "real-world" memory task: learning a computer language. *Journal of Rehabilitation Research Development*, *28(4)*, 53-60.

Prigatano, G.P. (1986). *Neuropsychological rehabilitation after brain injury* (pp. 29-50). Baltimore: Johns Hopkins University press.

Raymond, M.J., Malia, K.B., Bewick, K.C. (1996). A comprehensive approach to memory rehabilitation following brain injury. *The journal of Cognitive Rehabilitation*, *14(6)*, 18-23.

Renner, M.J. & Rosenzweig, M.R. (1987). *Enriched and Impoverished Environments: Effects on Brain and Behavior.* Springer Press, New York.

Revell, A.J., Caskie, G.I.L., Willis, S.L., & Schaie, K.W. (2001). Memory functioning questionnaire (MFQ): Replication and exploration of factor solutions in older adults. *Poster presented at the 54th Annual Scientific Meeting of the Gerontological Society of America*. Chicago, IL, November 16.

Rose, F.D., Attree, E.A., Brooks, B.M., Johnson, D.A. (1998). Virtual environments in brain damage rehabilitation: A rationale from basic neuroscience. In Riva ,G., Wiederhold, B., Molinari, E. (Eds) ,*Virtual Environments in Clinical Psychology and Neuroscience*. Ios press, Amsterdam, Netherlands

Rosenzweig, M.R., Bennett, E.L., Hebert, M. & Morimoto, H. (1978). Social grouping cannot account for cerebral effects of enriched environments. *Brain Research, 153*, 563-576.

Roy, D., & Pentland, A. (2002). Learning Words from Sights and Sounds: A Computational Model. *Cognitive Science, 26(1)*, 113-146.

Sargeant, R., Webster, G., Salzman.T. (2000). Enriching the environment of patients undergoing long term rehabilitation through group discussion of the news. *Journal of Cognitive Rehabilitation*, *18(1)*, 20-23.

Schacter, D.L., Glisky, E.L., MCG lnn, S.M. (1990). Impact of memory disorders on everyday life: awareness of deficit and return to work. In Cicerone, K. D. , Tupper D. E. (eds.) ,*The Neuropsychology of Everyday Life: Assessment and Basic Competencies* (pp. 231–257). Boston : Martinus Nijhoff, .

Schunk, D.H. & Gunn, T.P. (1985). Modeled importance of task strategies and achievement beliefs: effect on self-efficacy and skill development. *Journal of Early Adolescence, 5*, 247-258.

Schwamm, L.H., Van Dyke, C., Kiernan, R.J., Merrin, E.L., & Mueller, J. (1987). The Neurobehavioral Cognitive Status Examination: Comparison with the Cognitive Capacity Screening Examination and the Mini-Mental State Examination in a neurosurgical population. *Annals of Internal Medicine*, *107*, 486-491.

Sidman, M., Stoddard, L.T. (1967). The effectiveness of fading in programming simultaneous form discrimination for retarded children. *Journal of Experimental Analysis of Behaviour*, *10*, 3–15.

Sivak, M., Hills, C.S., Olson, P.L. (1984). Computerized video tasks as training techniques for driving related perceptual deficits for persons with brain damage: a pilot examination. *International Journal of Rehabilitation Research*, *7,* 389-398.

Smart, S. (1998). Computers as treatment: the use of the computer as an occupational therapy medium. *Clinical Rehabilitation*, *2,* 61-69.

Smith, E.E. Jonides, J., & Koeppe, R.A. (1996). Dissociating verbal and spatial working memory using PET. *Cerebral Cortex*, *6*, 11-20.

Sohlberg, M.M., Mateer, C.A. (1989). Training use of compensatory memory books: a three stage behavioural approach. *Journal of Clinical and Experimental Neuropsychology*, *11*, 871-891.

Squire, L.R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys and humans. *Psychological Review*, *99*, 195–231.

Squire, L.R., Cohen, N.J., Nadel, L. (1983). The medial temporal region and memory consolidation: A new hypothesis. In Weingartner, H., Parker, E. (eds.), *Memory Consolidation* (pp. 185-210). Hillsdale, NJ: Erlbaum.

Squire, L.R., Knowlton, B., & Musen, G. (1993). The structure and organization of memory. *Annual Review of Psychology* , *44*, 453-495.

Squires,E.J., Hunkin,N.M., Parkin, A.J. (1997). Errorless learning of noval associations in amnesia. *Neuropsychologia*, *35*, 1103-1111.

Stuss, D. T. and Benson, D. F.(1986). *The Frontal Lobes*. Raven Press, New York.

Sunderland, A., Harris, J.E., Baddeley, A.D. (1983). Do laboratory tests predict everyday memory? A neuropsychological study. *Journal of Verbal Learning and Verbal Behaviour*, *22*, 341-357.

Tailby, R., & Haslam, C. (2003). An investigation of errorless learning in memory-impaired patients: improving the technique and clarifying theory. *Neuropsychologia*, *41(9)*, 1230-1240.

Tam, S.F. (1996). Self-efficacy as a predictor of computer skills learning outcomes of individuals with physical disabilities. *Journal of Psychology, 130* , 51-58.

Tam, S.F. (2000). The effects of a computer skill training programme adopting social comparison and self-efficacy enhancement strategies on self-concept and skill outcome in trainees with physical disabilities. *Disability and rehabilitation* , *22(15)*, 655- 664.

Tam, S.F., Man, D.W.K. (2004). Evaluating computer-assisted memory retraining programmes for people with post-head injury amnesia. *Brain Injury, 18(5)*, 461-470.

Tam, S.T., Man, D.W.K., Hui-Chan, C.W.Y., et al. (2003). Evaluating the efficacy of tele-cognitive rehabilitation for functional performance in adults following brain injury. *Occupational Therapy International, 10(1)*, 20-38.

Taub, E., Uswatte, G., & Elbert, T. (2002). New treatments in neurorehabilitation founded on basic research. *Nature Reviews Neurosciences, 3*, 228-236.

Terrace, H.S. (1963). Discrimination learning with and without “errors”. *Journal of Experimental Analysis of Behaviour, 6*, 1–27.

Terrace, H.S. (1966). Stimulus control. In: Honig W.K. (ed.), *Operant behaviour: areas of research and application* (pp. 271–344). New York: Appleton Century Crofts.

Thone, A.I.T. (1996). Memory rehabilitation- recent development and future directions. *Restorative Neurology and Neuroscience, 9*, 125-140.

Toedter, L. J., Schall, R. R., Reese, C. A., Hyland, D. T., Berk, S.N., & Dunn, D. S. (1995). Psychological measures: Reliability in the assessment of stroke patients. *Archives of Physical Medicine and Rehabilitation, 76*, 719-725.

Torasdotter, M., Metsis, M., Henriksson, B.G. (1998). Environmental enrichment results in higher levels of nerve growth factor mRNA in the rat visual cortex and hippocampus. *Behaviour & Brain Research, 93(1–2)*, 83–90.

Tulving, E. (2000). Concepts of memory. In E. Tulving & F.I.M. Craik (Eds.), *The Oxford handbook of memory* (pp. 37). New York: Oxford University press.

Vanderploeg, R.D., Crowell, T.A., Curtiss, G. (2001). Verbal learning and memory deficits in traumatic brain injury: encoding, consolidation, and retrieval. *Journal of Clinical and Experimental Neuropsychology, 23(2)*, 185-195.

Van Praag, H., Kempermann, G. & Gage, F. H. (1999). Running increases cell proliferation and neurogenesis in the adult mouse dentate gyrus. *Nature Neuroscience, 2*, 266–270.

Van-Praag, H., Kempermann, G., Gage, F.H. (2000). Neural consequences of environmental enrichment. *National Neuroscience Review*, *1*, 191-198.

Wagner, A.K., Kline, A.E., Sokoloski, J. (2002). Intervention with environmental enrichment after experimental brain trauma enhances cognitive recovery in male but not female rats. *Neuroscience Letters*, *334*, 165-168.

Wang, Z.C., Chang, Y.L. (2001). Strength clinical research and advocate standardize treatment following brain injury. *Chinese Journal of Neurosurgery, 17(3)*, 122-134.

Wechsler, D. (1987). *Wechsler Memory Scale-revised manual*. New York: The Psychological Corporation.

Wilson, B.A. (1989). Models of cognitive rehabilitation. In R.L.L. Wood, P. Eames (eds.), *Models of Brain injury rehabilitation* (pp.117-141). London: Chapman and Hall Ltd.

Wilson, B.A. (1992). Memory therapy in practice. In B.A. Wilson, N. Moffat (eds.), *Clinical Management of Memory Problems* (pp. 120–153). London: Chapman & Hallpp.

Wilson, B.A. (1995). Management and remediation of memory problems in brain-injured adults. In Baddeley, A.D., Wilson B.A., Watts F.N. (eds.), *Handbook of Memory Disorders* (pp. 451-480). Chichester: Wiley and Sons.

Wilson, B.A. (1997). Cognitive rehabilitation: how it is and how it might be. *Journal of the International Neuropsychological Society*, *3*, 487–496.

Wilson, B.A. (1998). Recovery of cognitive functions following nonprogressive brain injury. *Current Opinion in Neurobiology, 8*, 281-287.

Wilson, B.A. (1999). *Case Studies in Neuropsychological Rehabilitation* (pp. 26-42). Oxford: Oxford University Press.

Wilson, B.A. (1999). Memory rehabilitation in brain injured people. In Stuss, D., et al. (eds.), *Cognitive Neurorehabilitation* (pp.333-346). Cambridge: Cambridge University Press.

Wilson, B.A. (2000). Compensating for cognitive deficits following brain injury.

Neuropsychology Review, 10 (4), 233-243.

Wilson, B.A. (2002). Towards a comprehensive model of cognitive rehabilitation *Neuropsychological rehabilitation, 12(2),* 97-110.

Wilson, B.A., Baddeley, A., Evans, J., & Shiel, H. (1994). Errorless learning in the rehabilitation of memory impaired people. *Neuropsychological Rehabilitation, 4,* 307–326.

Wison, B.A., Cockburn, J., Baddeley, A.D. (1985). *The Rivermead Behavioral Memory Test*. Bury St. Edmunds: Thames Valley Test Company.

Wilson, B.A., Evans, J.J., Emslie, H., & Malinek, V. (1997). Evaluation of NeuroPage: a new memory aid. *Journal of Neurology, Neurosurgery, and Psychiatry, 63,* 113-115.

Wilson, B.A., Moriat, N. (1992). *Clinical Management of Memory Problems* (pp.243-247). (2nd ed.). London: Chapman and Hall.

Wood, J. (2001). Can software support children's vocabulary development? *Language Learning & Technology, 5,* 166-201.

Woods, R.T. (1996). Psychological 'therapies' in dementia. In R.T.Woods (Ed.), *Handbook of the clinical psychology of ageing* (pp. 575-600). Chichester, UK: John Wiley & Sons Ltd.

Woolf, C.J., Clifford, J., Salter, M.W. (2000). Neuronal plasticity: increasing the gain in pain. *Science, 288,* 1765-1768.

Wright, I., & Limond, J. (2004). A Developmental Framework for Memory Rehabilitation in Children. *Pediatric Rehabilitation, 7(2),* 85-96.

Xu, S., Wu, Z. (1986). The construction of "The Clinical Memory Test". *Acta Psychologica Sinica, 18,* 100–108.

Xu, T.,You, C.J., Huang, X.L., Ou- Yan, D.L., Lu, M., Huang, G.R., & Li, W.X.(2002). A preliminary evaluation of the reliability and validity of Neurobehavioral Cognitive Status Exam in Chinese patients. *Chinese Journal of Physical Medecine & Rehabilitation , 24 (8),* 1-4.

Ylvisaker, M., Hartwick, P., Stevens, M. (1991). School re-entry following head damage: managing the transition from hospital to school. *Journal of Head Trauma Rehabilitation, 6(1),* 10-22.

You, C.J., Han, S.H, Xu, T. (2003). Reliability and Validity of Rivermead Behavioral Memory Test in Chinese Patients. *Chinese Journal of Rehabilitation, 8(6)*, 344-347.

Young, D., Lawlor, P.A., Leone, P. (1999). Environmental enrichment inhibits spontaneous apoptosis, prevents seizures and is neuroprotective. *Nature & Medicine*, *5(4)*, 448–453.

Zasler, N.D. (1991). Pharmacological aspects of cognitive function following traumatic brain injury. In Kreutzer, J.S., et al. (eds.), *Cognitive Rehabilitation for Persons with Traumatic Brain Injury: A Functional Approach* (pp.87-94). Bartimore: Paul H. Brookers Publishing.

Zhang, A. & Lu, Q. (2002). The regulation of self-efficacy and attributional feedback on motivation. *Social Behavior and Personality*, *30*, 281-288.

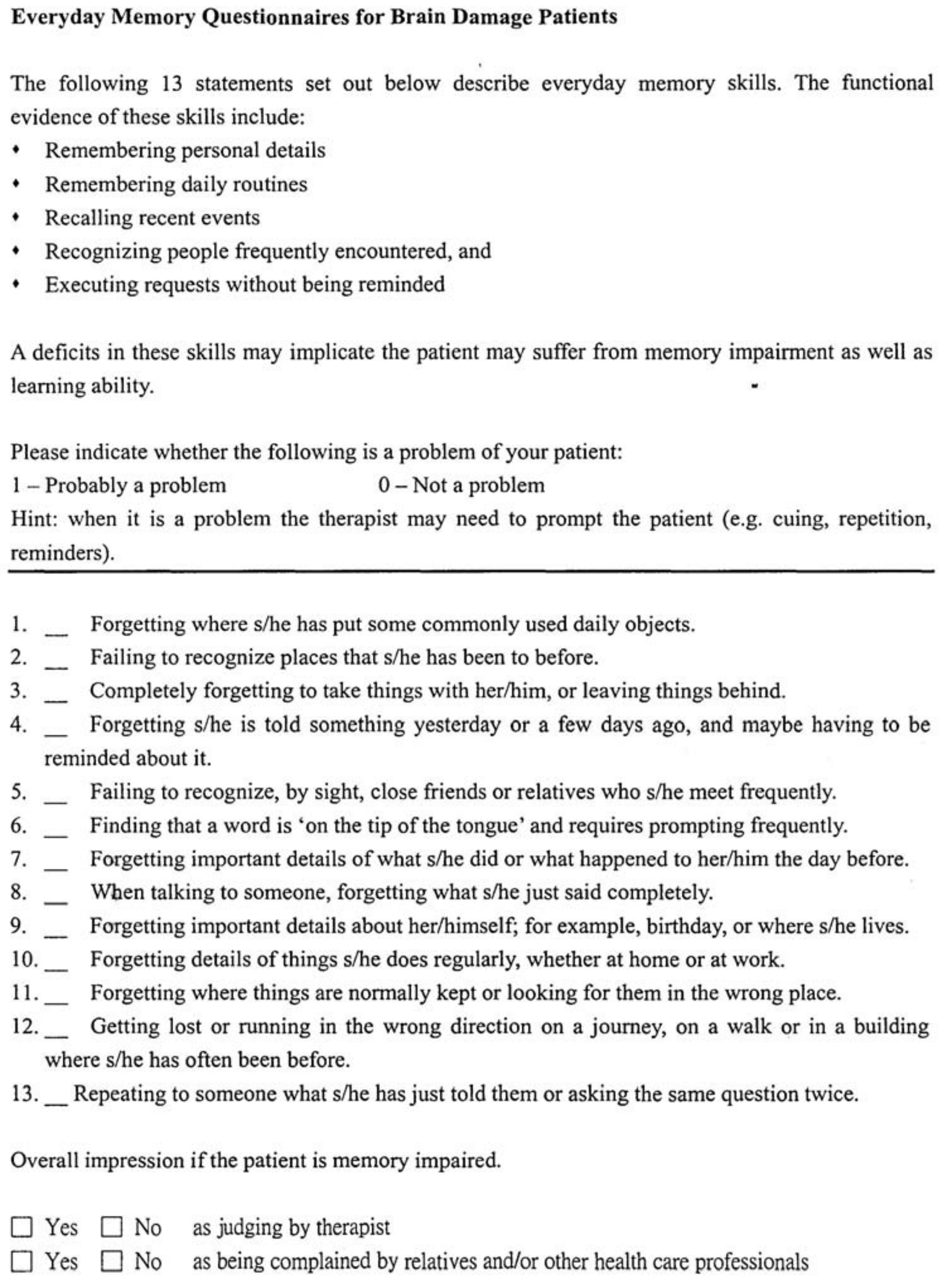
Zhang Y, Espinoza S. (1997). Affiliations of computer self-efficacy and attitudes with need for learning computer skills. *Journal of Educational Computing Research*, *17*, 371- 383.

Zhu G, Wang X.R. (1994). The factor analysis of epidemiology in 292 cases with traumatic brain injury. *Acta of Third Military University(Chinese)*, *16(2)*, 137-138.

Zola-Morgan, S.M., Squire, L.R. (1990). The primate hippocampal formation: Evidence for a two time limited role in memory storage. *Science*, *250*, 288-290.

LIST OF APPENDICES

The Everyday Memory Questionnaires for Brain Damaged Patients



Everyday Memory Questionnaires for Brain Damage Patients

The following 13 statements set out below describe everyday memory skills. The functional evidence of these skills include:

- Remembering personal details
- Remembering daily routines
- Recalling recent events
- Recognizing people frequently encountered, and
- Executing requests without being reminded

A deficits in these skills may implicate the patient may suffer from memory impairment as well as learning ability.

Please indicate whether the following is a problem of your patient:
1 – Probably a problem 0 – Not a problem
Hint: when it is a problem the therapist may need to prompt the patient (e.g. cuing, repetition, reminders).

---

1. __ Forgetting where s/he has put some commonly used daily objects.
2. __ Failing to recognize places that s/he has been to before.
3. __ Completely forgetting to take things with her/him, or leaving things behind.
4. __ Forgetting s/he is told something yesterday or a few days ago, and maybe having to be reminded about it.
5. __ Failing to recognize, by sight, close friends or relatives who s/he meet frequently.
6. __ Finding that a word is ‘on the tip of the tongue’ and requires prompting frequently.
7. __ Forgetting important details of what s/he did or what happened to her/him the day before.
8. __ When talking to someone, forgetting what s/he just said completely.
9. __ Forgetting important details about her/himself; for example, birthday, or where s/he lives.
10. __ Forgetting details of things s/he does regularly, whether at home or at work.
11. __ Forgetting where things are normally kept or looking for them in the wrong place.
12. __ Getting lost or running in the wrong direction on a journey, on a walk or in a building where s/he has often been before.
13. __ Repeating to someone what s/he has just told them or asking the same question twice.

Overall impression if the patient is memory impaired.

☐ Yes ☐ No as judging by therapist
☐ Yes ☐ No as being complained by relatives and/or other health care professionals

腦損傷患者日常記憶問卷

姓名：_________ 性別：_______ 年齡：_________ 文化程度：_____________
電話：_________ 住址：____
臨床診斷：_______________ 評定時間：________________

下面 13 個句子描述了日常記憶技能，這些技能包括 1）記住個人的一些細節，2）記住日常生活常規，3）回憶近期發生的事件，4）再認經常遇見的人，5）不需要提醒即可執行一些請求。

這些技能方面的缺陷意味著患者可能有記憶和學習能力的障礙。請用下列方式測試您的受試者是否有問題。

1 分：可能有問題　　0 分：無問題

注：當出現問題時，檢查者可以通過 1）線索 2）重複 3）提醒等提示病人

1. ____ 把常用的日常用品忘記放在哪兒。
2. ____ 難以辨別以前去過的地方。
3. ____ 完全忘掉隨身帶的東西,或事後丟失了。
4. ____ 忘記昨天或幾天前說過的事,關於那事不得不提醒才能想起來。
5. ____ 通過眼睛也認不出經常碰面的至親好友。
6. ____ 話到嘴邊,常需要提示才能說出來。
7. ____ 忘記所做或在此之前發生的事情的重要細節。
8. ____ 當與別人交談時,完全忘掉剛說過的話。
9. ____ 忘記有關自己的一些重要事情的細節，如生日、居住地等。
10. ____ 忘記在家中或工作單位有規律地做一些事情的細節。
11. ____ 忘記一些東西正常放置的地方,常在錯誤的地方尋找它們。
12. ____ 旅行時迷路或朝著錯誤方向跑,在以前常去的建築物裏走來走去。
13. ____ 向別人重複剛說過的話,或不斷地問同一個問題。

總體印象:病人是否有記憶障礙：

□ 是　　□ 否　　由治療師判斷

□ 是　　□ 否　　由親戚和/或其他專業人士判斷

Rancho Los Amigos Level of Cognitive Functioning Scale

Level I - No Response: Total Assistance

Complete absence of observable change in behavior when presented visual, auditory, tactile, proprioception, vestibular or painful stimuli.

Level II - Generalized Response: Total Assistance

- Demonstrates generalized reflex response to painful stimuli.
- Responds to repeated auditory stimuli with increased or decreased activity.
- Responds to external stimuli with physiological changes generalized, gross body movement and/or not purposeful vocalization.
- Responses noted above may be same regardless of type and location of stimulation.
- Responses may be significantly delayed.

Level III - Localized Response: Total Assistance

- Demonstrates withdrawal or vocalization to painful stimuli.
- Turns toward or away from auditory stimuli.
- Blinks when strong light crosses visual field.
- Follows moving object passed within visual field.
- Responds to discomfort by pulling tubes or restraints.
- Responds inconsistently to simple commands.
- Responses directly related to type of stimulus.
- May respond to some persons (especially family and friends) but not to others.

Level IV - Confused/Agitated: Maximal Assistance

- Alert and in heightened state of activity.
- Purposeful attempts to remove restraints or tubes or crawl out of bed.
- May perform motor activities such as sitting, reaching and walking but without any apparent purpose or upon another's request.
- Very brief and usually non-purposeful moments of sustained alternatives and divided attention.
- Absent short-term memory.
- May cry out or scream out of proportion to stimulus even after its removal.
- May exhibit aggressive or flight behavior.
- Mood may swing from euphoric to hostile with no apparent relationship to environmental events.
- Unable to cooperate with treatment efforts.
- Verbalizations are frequently incoherent and/or inappropriate to activity or environment.

Level V - Confused, Inappropriate Non-Agitated: Maximal Assistance

- Alert, not agitated but may wander randomly or with a vague intention of going home.
- May become agitated in response to external stimulation, and/or lack of environmental structure.
- Not oriented to person, place or time.
- Frequent brief periods, non-purposeful sustained attention.
- Severely impaired recent memory, with confusion of past and present in reaction to ongoing activity.
- Absent goal directed, problem solving, self-monitoring behavior.
- Often demonstrates inappropriate use of objects without external direction.
- May be able to perform previously learned tasks when structured and cues provided.
- Unable to learn new information.
- Able to respond appropriately to simple commands fairly consistently with external structures and cues.
- Responses to simple commands without external structure are random and non-purposeful in relation to command.
- Able to converse on a social, automatic level for brief periods of time when provided external structure and cues.
- Verbalizations about present events become inappropriate and confabulatory when external structure and cues are not provided.

Level VI - Confused, Appropriate: Moderate Assistance

- Inconsistently oriented to person, time and place.
- Able to attend to highly familiar tasks in non-distracting environment for 30 minutes with moderate redirection.
- Remote memory has more depth and detail than recent memory.
- Vague recognition of some staff.
- Able to use assistive memory aide with maximum assistance.
- Emerging awareness of appropriate response to self, family and basic needs.
- Moderate assist to problem solve barriers to task completion.
- Supervised for old learning (e.g. self care).
- Shows carry over for relearned familiar tasks (e.g. self care).
- Maximum assistance for new learning with little or nor carry over.
- Unaware of impairments, disabilities and safety risks.
- Consistently follows simple directions.
- Verbal expressions are appropriate in highly familiar and structured situations.

Level VII - Automatic, Appropriate: Minimal Assistance for Daily Living Skills

- Consistently oriented to person and place, within highly familiar environments. Moderate assistance for orientation to time.
- Able to attend to highly familiar tasks in a non-distraction environment for at least 30 minutes with minimal assist to complete tasks.
- Minimal supervision for new learning.
- Demonstrates carry over of new learning.
- Initiates and carries out steps to complete familiar personal and household routine but has shallow recall of what he/she has been doing.
- Able to monitor accuracy and completeness of each step in routine personal and household ADLs and modify plan with minimal assistance.
- Superficial awareness of his/her condition but unaware of specific impairments and disabilities and the limits they place on his/her ability to safely, accurately and completely carry out his/her household, community, work and leisure ADLs.
- Minimal supervision for safety in routine home and community activities.
- Unrealistic planning for the future.
- Unable to think about consequences of a decision or action.
- Overestimates abilities.
- Unaware of others' needs and feelings.
- Oppositional/uncooperative.
- Unable to recognize inappropriate social interaction behavior.

Level VIII - Purposeful, Appropriate: Stand-By Assistance

- Consistently oriented to person, place and time.
- Independently attends to and completes familiar tasks for 1 hour in distracting environments.
- Able to recall and integrate past and recent events.
- Uses assistive memory devices to recall daily schedule, "to do" lists and record critical information for later use with stand-by assistance.
- Initiates and carries out steps to complete familiar personal, household, community, work and leisure routines with stand-by assistance and can modify the plan when needed with minimal assistance.
- Requires no assistance once new tasks/activities are learned.
- Aware of and acknowledges impairments and disabilities when they interfere with task completion but requires stand-by assistance to take appropriate corrective action.
- Thinks about consequences of a decision or action with minimal assistance.
- Overestimates or underestimates abilities.
- Acknowledges others' needs and feelings and responds appropriately with minimal assistance.
- Depressed.
- Irritable.

- Low frustration tolerance/easily angered.
- Argumentative.
- Self-centered.
- Uncharacteristically dependent/independent.
- Able to recognize and acknowledge inappropriate social interaction behavior while it is occurring and takes corrective action with minimal assistance.

Level IX - Purposeful, Appropriate: Stand-By Assistance on Request

- Independently shifts back and forth between tasks and completes them accurately for at least two consecutive hours.
- Uses assistive memory devices to recall daily schedule, "to do" lists and record critical information for later use with assistance when requested.
- Initiates and carries out steps to complete familiar personal, household, work and leisure tasks independently and unfamiliar personal, household, work and leisure tasks with assistance when requested.
- Aware of and acknowledges impairments and disabilities when they interfere with task completion and takes appropriate corrective action but requires stand-by assist to anticipate a problem before it occurs and take action to avoid it.
- Able to think about consequences of decisions or actions with assistance when requested.
- Accurately estimates abilities but requires stand-by assistance to adjust to task demands.
- Acknowledges others' needs and feelings and responds appropriately with stand-by assistance.
- Depression may continue.
- May be easily irritable.
- May have low frustration tolerance.
- Able to self monitor appropriateness of social interaction with stand-by assistance.

Level X - Purposeful, Appropriate: Modified Independent

- Able to handle multiple tasks simultaneously in all environments but may require periodic breaks.
- Able to independently procure, create and maintain own assistive memory devices.
- Independently initiates and carries out steps to complete familiar and unfamiliar personal, household, community, work and leisure tasks but may require more than usual amount of time and/or compensatory strategies to complete them.
- Anticipates impact of impairments and disabilities on ability to complete daily living tasks and takes action to avoid problems before they occur but may require more than usual amount of time and/or compensatory strategies.

- Able to independently think about consequences of decisions or actions but may require more than usual amount of time and/or comepensatory strategies to select the appropriate decision or action.
- Accuratoly estimates abilities and independently adjusts to task demands.
- Able to recognize the needs and feelings of others and automatically respond in appropriate manner.
- Periudic periods of depression may occur.
- Irritability and low frustration tolerance when sick, fatigued and/or under emotional stress.
- Social interaction behavior is consistently appropriate.

Original Scale co-authored by Chris Hagen, Ph.D., Danese Malkmus, M.A., Patricia Durham, M.A. Communication Disorders Service, Rancho Los Amigos Hospital, 1972, Revised 11/15/74 by Danese Malkmus, M.A., and Kathryn Stenderup, O.T.R.

Rancho Los Amigos 認知功能分級
(修正版)

I 級－沒有反應：完全依賴

- 病人對於視覺、聽覺、觸覺、本體覺、位置覺及痛覺等刺激均無任何可見的行爲反應。

II 級－一般反應：完全依賴

- 對於疼痛刺激呈現一般的反射性反應；
- 對於反復的聽覺刺激發生反應，表現爲出現或多或少的活動；
- 對於外界刺激發生生理上的變化；
- 出現全身的、粗大的肢體活動和/或無目的的聲音；
- 以上出現的各種反應可能有相同的表現，而與刺激的形式、部位無關；
- 反應的出現可能明顯延遲。

III 級－局部反應：完全依賴

- 給予疼痛刺激有回避或發音；
- 頭轉向或遠離聲音刺激；
- 強光刺激視野區時會眨眼；
- 追蹤視野區內移動的物體；
- 牽拉引起不舒服的各種導管或束縛等物品；
- 對於簡單指令出現不協調的反應；
- 出現與刺激形式直接相關的反應；

- 可能對某些人（尤其是親人和朋友）有反應而對其他人無反應。

Ⅳ級－混亂/煩躁反應：大量依賴

- 處於警覺和活動增強階段；
- 有目的的試圖移除束縛或插管或爬出床外；
- 可以完成運動功能，如坐、伸手取物、走，但沒有任何明顯的目的性或遵循他人的要求；
- 出現持續的選擇性注意和分別注意，但持續時間很短並且通常沒有目的性；
- 短時記憶缺陷；
- 對於刺激的反應表現爲不協調的哭喊或尖叫，甚至在刺激除去後仍然存在；
- 可能出現攻擊或逃跑行爲；
- 出現欣快與敵對情緒的波動，且與環境事物無明顯關係；
- 不能夠配合治療；
- 出現較頻繁的語言，但語言混亂且/或與行爲或環境無關。

Ⅴ級－混亂、不適當的非煩躁反應：大量依賴

- 警覺、無煩躁狀態，但可能隨意的到處走或有不明確的回家意圖；
- 對於外界刺激，和/或缺乏外在結構的刺激可能出現煩躁反應；
- 無人物、地點、時間定向力；
- 出現頻繁的短時間的、無目的的連續注意；
- 嚴重的近期記憶障礙，對過去和現在行爲活動的反應發生混淆；
- 缺乏目標定向能力、解決問題能力以及沒有自我監護行爲；
- 不給予外界指導的情況下，則經常呈現不恰當的使用物品；
- 當提供結構或線索時能夠執行以前的學習任務；
- 不能學習新資訊；

- 能夠恰當的執行簡單的指令，且與外在結構和線索取得相當的一致；
- 對於缺乏外在結構的簡單命令表現爲隨意的、無目的的反應；
- 當提供外在結構和線索時能夠進行短時間的社交的、無意識水平的交談；
- 當沒有提供外在結構和線索時，談話則表現爲用詞不當，呈現爲閒扯。

VI 級－混亂、恰當的反應：中度依賴

- 出現不協調的人物、時間、地點定向力；
- 給予適度的指導能夠在沒有分散注意力的環境下，專注非常熟悉的活動可達 30 分鐘；
- 遠期記憶比近期記憶更深更詳細；
- 能夠模糊的識別一些工作人員；
- 能夠在最大的幫助下，使用記憶輔助工具；
- 對於自我、家庭和基本需要出現恰當的反應；
- 給予適度的幫助能夠克服解決問題時遇到的障礙；
- 督導學習以往能力（如自我照顧）；
- 呈現對再學習的熟悉任務的保留（如自我照顧）；
- 需要最大程度的幫助學習沒有保留或僅有極少保留的新知識；
- 意識不到損傷、殘疾和安全風險；
- 遵從簡單的指導；
- 在非常熟悉的和有結構的情形下有恰當的語言表達。

VII 級－自發的、恰當反應：日常生活技能小部分依賴

- 在非常熟悉的環境下出現協調的人物、地點定向力，但對時間定向力需要適度的幫助；
- 給予最小程度的幫助，能夠在不分散注意力的環境下專注非常熟悉活動至少

30 分鐘；

- 對新的學習只需要最小程度的督導；
- 呈現出對新學習的保留；
- 啓動並有步驟地完成熟悉的個人和家務常規，但對於做過的事情僅有表淺的回憶；
- 能夠監督常規的個人和家庭日常生活活動的每個步驟的精確性和完整性，且能夠在最小的幫助下修正計畫；
- 對自身狀況有粗淺的認識，但不能意識特定的障礙、殘疾以及意識不到自己在安全的、精確的、完整的執行家庭、社區、工作、休閒生活活動時能力限制；
- 在常規的家庭和社區活動時需要最小的安全監督；
- 不切實際的計畫未來；
- 考慮不到某項決定或行動的後果；
- 高估自己的能力；
- 意識不到他人的需求和感受；
- 敵對/不合作情緒；
- 不能夠識別不恰當的社會交往行爲。

VIII 級－有目的的、適當反應：監護性幫助

- 人物、地點、時間定向力協調一致；
- 在易分散注意力的環境下獨立的參與、完成熟悉的任務達 1 小時；
- 能夠回憶並且整合過去和最近的事件；
- 使用記憶輔助具可以回憶日常生活計畫表，按列表去做，並在監護性幫助下記錄重要資訊供 以後使用；
- 在監護性幫助下啓動並有步驟地完成熟悉的個人、家務、社區、工作和休閒活動，並且在需要時給予最小的幫助即能夠修正計畫；

- 學習新的任務/活動時無需幫助；
- 意識到並承認自身的障礙和殘疾干擾了任務的完成，但是需要監護性幫助進行恰當的行爲矯正；
- 給予最小的幫助能夠考慮某一決定或行爲的後果；
- 高估或低估自己的能力；
- 承認他人的需求和感受並在最小的幫助下表現出恰當的回應；
- 沮喪；
- 急躁；
- 挫折耐受能力低/易生氣；
- 喜歡爭辯；
- 以自我爲中心；
- 沒有特點的依賴/獨立；
- 能夠識別和承認出現的不恰當的社會交往行爲，並且在最小的幫助下進行行爲矯正。

IX 級－有目的的、恰當反應：根據要求提供監護性幫助

- 在任務和準確的完成之間遊移不定，連續堅持至少兩個小時；
- 當被要求時，使用記憶輔助具可以回憶日常生活計畫表，按列表去做，並在監護性幫助下記錄重要資訊供 以後使用；
- 獨立地啓動並有步驟地完成熟悉的個人、家務、社區、工作和休閒活動，並且在幫助下根據要求完成不熟悉的個人的、家庭的、社區的、工作的和休閒任務；
- 意識到並承認自身的障礙和殘疾干擾了任務的完成，並能採取恰當的矯正行動。但在監護性幫助下，在問題發生之前可預見它並採取行動避免；
- 當被要求時能夠在幫助下思考決定或行動的後果；
- 準確的估計自己的能力，但要在監護性幫助下調整任務的需要；

- 承認他人的需求和感受並在監護性幫助下表現出恰當的反應；
- 沮喪可能繼續存在；
- 可能容易急躁；
- 對挫折承受的能力低；
- 在監護性幫助下能夠對社會交往的適當性進行自我監督。

X 級－有目的的、恰當反應：修正性的獨立

- 能夠在各種環境下同時處理多項任務，但可能需要定時的休息；
- 能夠獨立的獲取、創造、維護自己的記憶輔助具；
- 獨立地啓動並有步驟地完成熟悉的和不熟悉的個人的、家務的、社區的、工作的和休閒活動, 但可能需要比正常更多的時間和/或代償策略來完成它們；
- 預見障礙和殘疾對完成日常生活活動能力的影響，並在問題出現之前採取措施避免發生，但可能需要比正常更多的時間和/或代償策略；
- 能夠獨立的思考決定或行動的後果，但可能需要比正常更多的時間和/或代償策略來選擇恰當的決定或行動；
- 準確的估計自己的能力，並獨立的調整以適應任務的需要；
- 能夠識別他人的需求和感受，並自動的以恰當的方式回應；
- 沮喪情緒可能會定期出現；
- 當不舒服、疲勞和/或精神緊張時則易怒， 挫折耐受能力低；
- 呈現一致的恰當的社會交往行爲。

The subjects' General Information Record

Subject Record number: ________________

Age: ______________________

Home address:

____

D.O.B: ___/___/______

Gender: ☐ male ☐ female

Confirmed medical diagnoses :

Duration of loss of conscious (in days):

____

Months following injury: ______________

Acute hospital stay (days) : _____________

Rehab hospital stay (days): _____________

Cognitive functional state:

Memory: ___________________

Attention: _________________

Orientation: ________________

Decision-making: ___________

Calculation: _______________

Reasoning: _________________

Language: _________________

Others: _____________________

Education level :

- ☐ primary
- ☐ secondary
- ☐ post-secondary
- ☐ graduated

Computer knowledge :

- ☐ with basic operation Knowledge
- ☐ online experiences
- ☐ little knowledge of computer operation

Name: ____________________________

Record date: (D) ___/(M) ___/(Y) ____

Computer phobia

☐ yes ☐ no

Mobility

☐ normal ☐ left side ☐ right side

Walking aids

- ☐ not need ☐ wheelchair
- ☐ walks with help of one person
- ☐ independent (may use aid, e.g., stick)

Verbal communication:

- ☐ complete sentence
- ☐ single worded
- ☐ utterances

Vision:

- ☐ normal
- ☐ deficit (L/ R/ bilateral), specify :
- ☐ need corrective eyewear
- ☐ blind (L/ R/ bilateral)

Hearing:

- ☐ normal
- ☐ deficit (L/ R/ bilateral), specify :
- ☐ need hearing aids
- ☐ deaf (L/ R/ bilateral)

CT scan or MRI:

____

____

____

____

____

腦外傷患者基本情況記錄表

一般情況:

姓名__________　　臨床診斷 ______________________________
性別　男 ___　女 ____　　年齡 _______　文化程度 ________________
聯繫電話 _____________　　家庭住址______________________________
受傷時間 _____________　　傷後意識喪失持續時間
受傷時 Glasgow 昏迷評分_____　　傷後住院時間

傷後康復情況: 是　否

康復開始時間 _______　康復持續時間 ___________
康復方法 ___________________

目前存在功能障礙: 是　否

肢體運動功能________　需要助行器　是　否
言語能力
視力
聽力

認知功能：

遺忘 _______　　注意力不集中
理解困難 __________　　計算力困難
定向力差 ___________　　解決問題能力差
其他

電腦的使用情況：

電腦基本操作知識　有　無
上網經歷　有　無
電腦恐懼症　有　無

影像學檢查:　是　否

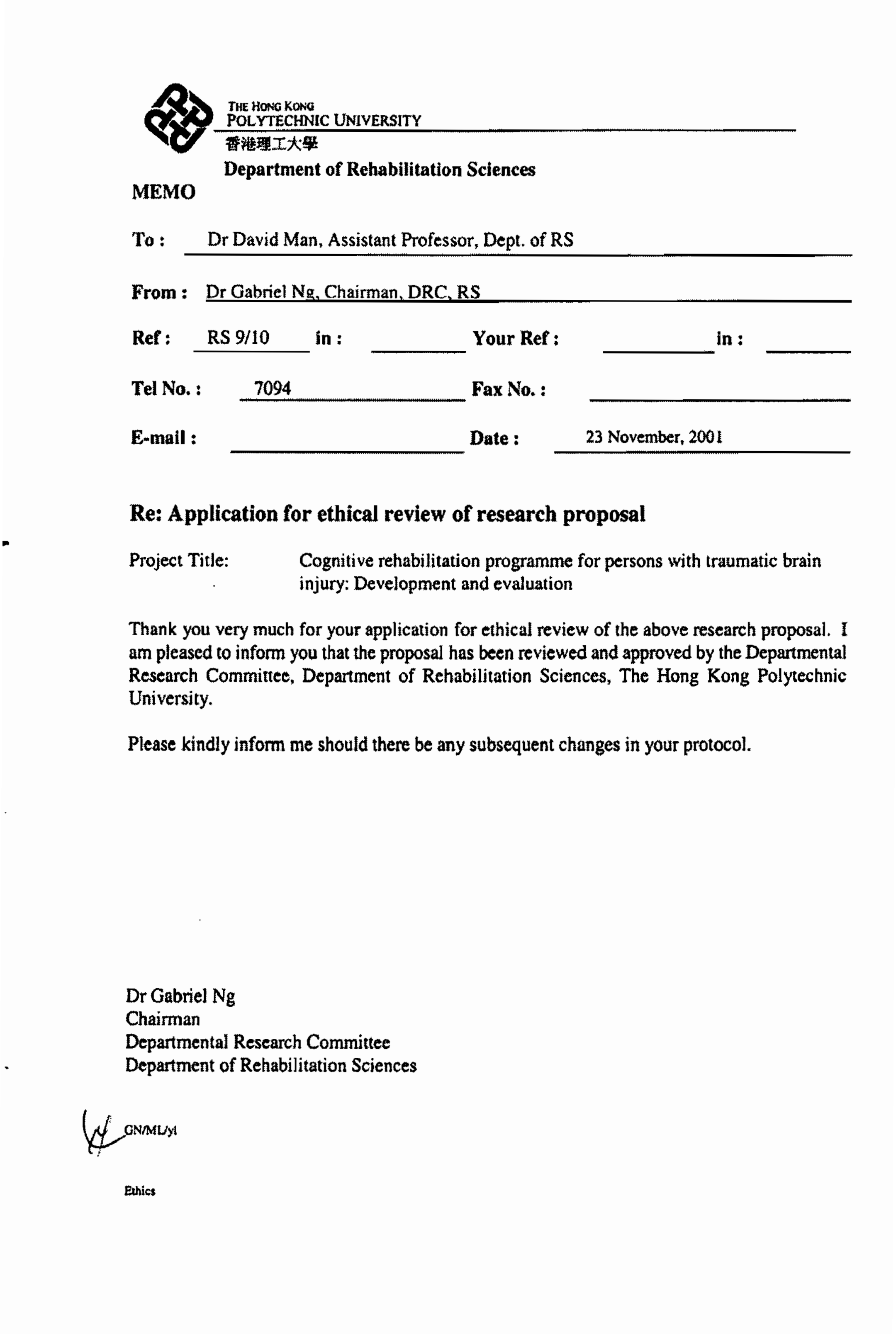
CT 或 MR 檢查所見(報告)

____

____

記錄者簽名:

Appendix A4: Ethical approval of the present study



THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學
Department of Rehabilitation Sciences

MEMO

To : Dr David Man, Assistant Professor, Dept. of RS

From : Dr Gabriel Ng, Chairman, DRC, RS

Ref : RS 9/10 **in :** **Your Ref :** **in :**

Tel No. : 7094 **Fax No. :**

E-mail : **Date :** 23 November, 2001

Re: Application for ethical review of research proposal

Project Title: Cognitive rehabilitation programme for persons with traumatic brain injury: Development and evaluation

Thank you very much for your application for ethical review of the above research proposal. I am pleased to inform you that the proposal has been reviewed and approved by the Departmental Research Committee, Department of Rehabilitation Sciences, The Hong Kong Polytechnic University.

Please kindly inform me should there be any subsequent changes in your protocol.

Dr Gabriel Ng
Chairman
Departmental Research Committee
Department of Rehabilitation Sciences

GN/ML/yl

Ethics

The Informed Consent Form

I, ___________________________________ (Chinese ID No.________________), understand the aim and arrangement of the research of Cognitive Rehabilitation Programmes for persons with traumatic brain injury: Development and evaluation， consent to participate in the experiment which will consist of 20 cognitive rehabilitation sessions. I also understand that my personal information will not be disclosed to people who are not related to this study and my name or photograph will not appear on any publications resulted from this study.

Signature of participant: ___________________________ Date: _______________

Signature of witness:______________________________ Date: _______________

I, DOU Zulin, certify that I have fully explained to the above-mentioned subject the nature of the experiment, the known risks involved in participating in this study, and the fact that he/she has the right to withdraw from the study at any time without giving reasons, and the withdrawal will not lead to any punishment or prejudice against him/her.

Signature of researcher: _______________________________

Date: ____

知情同意書

本人___________________________（中國身份證號碼:_______________________）現聲明自願參加此項認知康復治療研究項目，接受共２０次的記憶障礙訓練。本人明白這項研究的目的及程式，並證明負責人已將這些項目解釋清楚。本人也明白在這項研究中，所有個人資料會絕對保密，本人根據意願可以隨時退出此項研究，而不會受到任何處罰。

簽名:____________________________________

見證人簽名:______________________________

日期:_____________________________________

本人竇祖林現聲明，本人已把這項研究的目的、程式與方法，向上述有關人士解釋清楚。

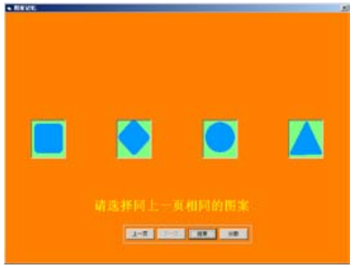
研究負責人簽署：______________________________________

日期：____

The Brief Introduction of Memory Training Programme

Session one Visual-Figural Tasks

A. Immediate recall objects



请选择同上一页相同的图案

This sub-session involves memory training of pictured objects, colors and shapes. There are totally different pictured objects being presented for four times.

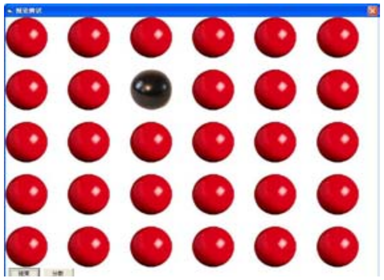
1. The client is given with a pictured object.
2. The client should memorize the pictured object and then select the same pictured object which was shown in previous slide.
3. Reinforcement should be given after completion of each task.

B. Immediate matching of patterns

This sub-session involves matching of patterns. The client is given with a pattern and he/she should recognize it and select the same pattern as shown before.

Six different objects would be presented in total.

C. Basic attention training



The sub-session involves basic attention training, client should take notice of the red ball, which changes to black color (change back to original color immediately).

1. A series of red balls are arranged in columns and rows on the screen.
2. Client should be aware of the red balls presented.
3. A red ball would suddenly change to black with an auditory prompt.
4. Client should find out which ball has changed color.

The task is repeated until client demonstrates correct response.

Therapist should guide the client and decide the times of practice throughout the process.

Appendix A6: The Brief Introduction of Memory Training Programme

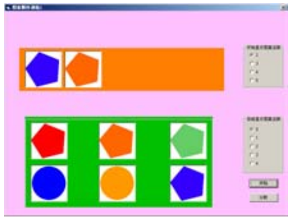
D. Sustain attention & categorization exercise

This sub-session involves sustained attention and categorization. Objects are presented on a moving transmission belt. Client is asked to sort out the objects into categories (vegetable or fruit) within a time limit.

1. There is a moving belt, which carries objects on the screen.
2. Client should drag the objects into the appropriate basket before they are carried away.

Session Two Sequencing Tasks

A. Immediate recall of objects-1



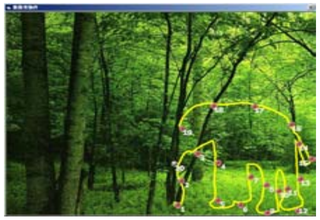
Client would select demonstrated objects and arrange them from left to right according to their shapes, colors and positions. Combination of figures ranges from 2 to 5.

Client may select level of difficulties from receiving 1 cue to 4 cues. Therapist should adjust training time and frequency, speed etc. based on client's ability.

B. Immediate recall of objects-2

There would be 10 pictures of real objects on the screen, such as banana, car, TV machine, baby, dog etc. The software would randomly display different combinations of this figure (from 1 figure to 5 figures). Client should give correct answer according to the combination and sequence of pictures as displayed by the software. Time of displaying the pictures is adjustable (1-8 seconds).

C. Attention training (counting)



Dots (1-20) will be displayed on the screen and client have to click the numbers (from small number to large number) so that lines will link up those digit dots if the task is correctly done, an animal can be seen at last. There are totally 4 animals, e.g. elephant, zebra, pie and monkey.

Session Three Digital counting Tasks

A. Counting-1		5 piles of carrot(s) [1-5 carrot(s) in each pile] would be displayed at the top of the screen. At the bottom of the screen, there will be a group of rabbit(s). Client should click the correct carrot to answer voice or written questions according to the number of rabbit(s)
B. Counting-2		Some figures, which consist of several kinds of objects, such as airplanes, carrots, clocks, etc. would be displayed at the left of the screen. At the right side, one of the objects from the left would be displayed. Client has to count the number of that object and select the correct answer in digits list. (Select 1 out of 3 digit)
C. Counting-3		A figure of cubes in unknown amount is displayed at the middle of screen. Client should count the number of cubes in the figure and select the correct answer from either left or right digits of the screen.
D. Counting-4		There would be a 'no number' playing card (with a question mark) at the middle of the screen and client should select a correct number answer from either left or right digits of screen.
E. Counting-5		A lot of combination of objects (from 3 to 5 different objects) would appear at the screen section above. Client should find out which objects appears the least and the most. Then client needs to arrange all objects at the screen section below in the order from the least to the most or vice versa.

Session Four Figural-auditory task

A. Immediate recall of related words	Client is given words to remember verbally by a therapist. Each presentation of words increase in length of sequence (starts with 3 and stop when 2 contiguous mistakes occurred). After therapist's presentation, client should report the words verbally. e.g. sofa, shoe, banana, bake, envy, etc.

B. Delayed recall of related words

1. Client should remember as many as he/she can when therapist reads out the words (from 2 to 5). Client is asked to recall verbally after 30 seconds of therapist's presentation.
   Downgrading: Client can listen one more time and choose the read words out of presented words on the screen (4-10).
2. Same with task 1, but this time words are changed to sentences. After therapist's presentation, one minutes of music would be broadcasted. Client should recall the previous sentences verbally.
   Downgrading: Client can listen one more time and choose the read sentences out of presented sentences on the screen (1 out of 3).
3. Still the same exercise, now presented with short paragraphs to increase difficulty. Also, therapist should adjust the difficulty according to client's ability.

C. Auditory exercise

Client is given several kind of sounds (from clock, phone, or radio) to remember. Then a sound would be broadcasted randomly, client is asked to find out the presented audio stimulus.

Session Five Working Memory Tasks: position and structure

A. Matching

Some pictures and digits are shown on the screen, one of them is also shown in the lower screen, each presentation of numbers increases in length of sequence (e.g., from two to six), with each sequence being exposed for the same length of time. After presentation, client should point out the right position of the matching picture or digit which is presented randomly.

B. Puzzle training-1

The client is given with several pictures and each of them is a part of concrete objects. Each presentation of pictures increased in number (from 3 to 5). The client should put the pictures back into appropriate positions and thus form a completed picture of concrete object. There are totally 3 puzzles.

C. Puzzle training-2

The client is given some pictures around a circle, which are half of a concrete object. The computer would then present an object in the centre of circle randomly. The client should click 2 half of pictures, which can form the integrity object alike one in the center.

D. Picture difference

Two pictures are shown on the screen. Totally, 3 to 5 differences would be presented between two pictures. The client should find out the differences on the picture.

Session Six Working Memory tasks: calculation and correspond

A. Calculation-1

This sub-session divides into 3 parts. Client is given a calculating form which is missed a part of it (quotient, sign, or digits). Client should select the appropriate answer to complete the form by mathematical calculation. e.g.,

10, 20, 11, 50, 35, which one is the correct answer of 8+3 = ?

+, -, x, /, which one is the correct answer of 8_?_3 = 11

5, 6, 8, 11, 25, which one is the correct answer of 3 ×? =99

B. Calculation-2

3 dices with different number would be placed on the desk at the left of the screen. Besides, 6 combinations of digits would be shown on the right of the screen. Client should select the correct combination of digits on the right side by counting dices. The game is repeated many times.

C. Corresponding-1

请记住上方图案

Client is given with six animals' pictures with numbers on the upper side. Each presentation of the pictures increase in length of sequence (e.g., from two to six), with each set being exposed for the same length of time. Client should select same animal's pictures (from 2 to 6) into the appropriate box with corresponding digits from given 10 animal's pictures. The training time and frequency can be varied with subsequent trials of the task.

D. Correspoinding-2

Same with correspoind-1, but this exercise is shown that the pictures are marked with different corresponding symbols.

E. Comparison

工人在工厂做工，农民怎么样？

办公室里工作

篮球场上打篮球

农场里种田

驾驶汽车

A sentence with a picture that describes a relationship is shown on the screen, another sentence with question is also shown on the same time, client should figure out the corresponding relationship between two sentences by comparing one of four key words with picture, then, client click key words to select a correct answer.

e.g. You can see the sun in daytime, then what can you see at night? Worker works in factory, where is the farmer work? Water can be found in glass, then what can be found in bowl? etc.

Session Seven Semantic memory Tasks: number

A. Immediate recall of phone number

872521

请打出正确的数字

Client is asked to enter his/her phone number. The screen will then present the number, with the last integer missing in length of sequence. Client should give the missing integer by writing, typing, or reciting orally. In response to client's correct answer, the missing integer will appear on the screen again until the client can remember all the digits of the number. The back word chaining memory is trained in the submission.

B. Immediate recall of food price

Client is given a menu to remember. Time given to remember is reduced from 1 minute to 30 seconds gradually while the number of food needed to remember is increasing. The client should remember as much price of foods as possible. Then, the client matches the price and the food correctly.

C. Food price recall-2

大众餐厅

菜名	价钱
竹笋蒸猪肉	4.5
炒白菜	10.5
红烧豆腐	9
清蒸鸡蛋	11
四川辣椒肉饼	3
清蒸排骨	20
烧乳鸽	5.5

配对:请点击菜名和该菜原本的价钱

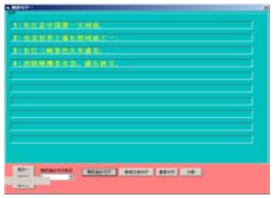
Same as immediate recall of food price, client should remember as many food's price as possible first, the client should select two kinds of his/her favorite food and indicate their prices. This procedure is repeated many times until all of food prices are remembered.

D. Budgeting games		Client should select the objects according to an assigned budget and number of objects. Therapist should adjust the shopping criteria based on the client's ability
E. Immediate recall of important date		Client is given some important dates of birth (2-8 person's birthday are presented in same time) to be remembered. Those dates will then vanished temporarily, some new pictures with person birthdays will be presented on the screen (5 to 30 photographs according to difficulty level) and client should match these dates with someone photographs

Session Eight Semantic memory Tasks: visual -verbal

A. Immediate recall of correct words		Client is given an object picture with four options of Chinese characters naming an object but only one of them is correct. Client is asked to select the correct word. e.g. lamp basketball, bicycle, telephone, etc
B. Correct object naming		An object related to daily life picture is displayed at the left of the screen. At the right side, 4 named words of Chinese characters are presented. One of them is only correct written. Client should select the correct written word. e.g. rose, fire, fox etc.
C. Immediate recall of related correct words		Client is given a series of words in sequence (combined with Chinese characters) randomly according to willing, Each presentation of sequence increases in number of words (from 1 to 7). Client should identify the presented the words and insert the appropriate words into correct position. e.g. danger, cigarette, attention, elephant, nurse, etc
D. Immediate recall of related Chinese idioms		Same as task c, the difference is the general word is changed into 4 Chinese idioms.
E. Immediate recall		

of sentence

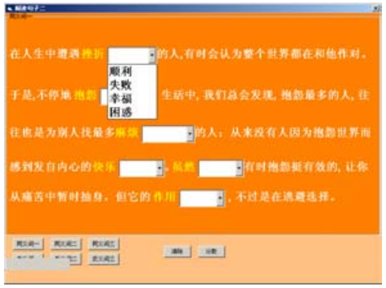


Client and therapist choose a short article. The computer will then select a random sentence from the article and to be read first. Client should point out the assigned sentence in the article when therapist is reading out that shown sentence in the article. The number of sentence needed to be pointed out is adjustable according to client's ability. There are totally 3 articles for utilization with different length in this task. e.g.

a. Beijing, Guangzhou, Shanghai will be affected by this policy.

b. the demand of such goods in Asia is near 600 billion US dollars.

F. Transfer of word character



在人生中遭遇挫折 的人,有时会认为整个世界都在和他作对。

于是,不停地抱怨 生活中,我们总会发现,抱怨最多的人,往

往也是为别人找最多麻烦 的人;从来没有人因为抱怨世界而

感到发自内心的快乐 ,虽然 有时抱怨挺有效的,让你

从痛苦中暂时抽身,但它的作用 ,不过是在逃避选择。

Client is given 2 articles. Some of the words in the article are highlighted with sharp color. In article 1, client should select a appropriate word from given 4 synonym to replace the original word, which have the same meaning as the highlighted word. In another article, client should select a appropriate word from given 4 antonym to replace the original word, which has the opposite meaning in that article. e.g.

a. punish (replace by word with same meaning) --- reward, arrange, time, amerce

b. expansive (replace by word with opposite meaning) --- low price

Session Nine Visual-Verbal Tasks-3

A. Face & name

Client is given several named photos (from 3 to 7) to remember. After presentation, client should put the correct names under the photos which are mixed up randomly later.

B. Naming-1

Client is given a picture of panda. Then, client should click the appropriate body part on the picture at therapist's command.

e.g., eye, nose, mouth, upper limb, etc

C. Naming-2

Same with task 2, but this time the picture changes into a little girl.
e.g., eye, nose, mouth, upper limb, etc

D. Animal & food matching

Foods are shown at the left side. At the right side, a person or animal is displayed randomly. Client should click the appropriate food for the displayed animal or person. e.g.,

monkey with banana;
cat with mouse;
dog with meal, etc

Session Ten The review of session 1-9

A. visual memory test

Assessment to test the rote memory skills through work on immediate span of visual memory. A random list of pictures is demonstrated on the screen and client should select the displayed pictures from 12 pictures. The numbers of trails and the picture number (from 2 to 8) can be adjusted. e.g. chair, flower, girl, etc

B. Auditory memory test

Assessment to test the rote memory skills through work on immediate span of auditory memory. A random list of words/sentences is sequentially read by therapist, and the client must read it out loudly with therapist. The test can be conducted within or without disturbance. The number of trials, words/sentence per trail, and word list (from 2 to 5) can be input.
e.g. computer, tree, telephone, etc
Sentence: The date of vote is coming soon.

C. Delayed memory test

Assessment to test the ability of delayed memory of words. 2 to 5 words are sequentially displayed on the screen. The client should click the displayed words in the bottom of the screen after 30 seconds. The number of trails and word list can be varies with client's ability.
e.g., professional service, magazine, insurance, etc

D. Digital memory test

Assessment to test the ability of immediate recall of digits. 3 or 5 digits are sequentially displayed on the screen. The client should click the displayed words in the bottom of the screen immediately after the presentation. e.g.
 *-2, 48, 668, 4987, etc

E. Calculating test

Assessment is to test the basic mathematical ability. The task is same with task 6a. But this time, the missing part of the calculating form is occurred randomly. e.g.

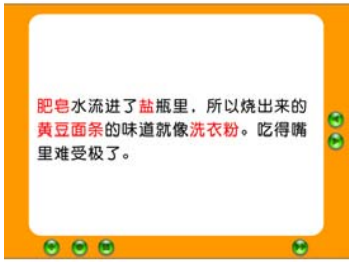
3?5=8;
8-3=?
5 × ?=25, etc

Session Eleven Mnemonics-1 Association

A. Matching game

There are pictures presented in two columns on the screen. Every two of them are connected by a certain internal relationship. Client is asked to match up the 2 appropriate pictures. The difficulty can be adjusted by changing interference.
e.g. mother- daughter; teacher- book; child- toy; etc.

B. Immediate recall words in sentence



肥皂水流进了盐瓶里，所以烧出来的黄豆面条的味道就像洗衣粉。吃得嘴里难受极了。

Client is given five words (with pictures) to remember, then a sentence with the five words in. Client is asked to pick out the presented words in the previous page. The difficulty can be adjusted by numbers of words (from 5 to 9), and given choices (from 7 to 12). e.g.
That the soap water has gone into the salt bottle results in that the bean noodle cooked tastes like washing powder.

C. Fill in the blank

Client is given the sentences which are practiced in task 11b to remember. This time, client should remember the words which are highlighted in red color, then client fill in the blank.
e.g. That the _____water has gone into the _____ bottle results in that the _____ _____ cooked tastes like _____.

D. Picture description

Client is given five pictures and asked to look at the pictures and describe them with their imagination.
e.g. A picture with helicopter on the sky and shark in the sea.

Session Twelve Mnemonics-2 Categorization

A. Immediate recall words by categorization

There are words on the screen (From 12 to 18), client is asked to divide them into 3 categories and put the words of the same category together. Difficulty can be adjusted by inserting words never shown up before. e.g.
Transportation: car; ship; plane, etc
Materials of construction: hardcore; wood, cement, etc
Commodity: groove; watch; cloth, etc

B. Food categorization

This practice is about further categorization. Client is asked to divide 16 dishes into snack & staple food, soup, seafood, and meat.
e.g. Fish, lobster, pig, cake, rice, etc.

C. Find the food matching animals

There are 5 kinds of food on the left part of screen. On the right part of the screen will be an animal randomly. Displayed. Client is asked to select the most appropriate food for the animal.

Session Thirteen Mnemonics-3 Story

A. Chinese idioms learning

This is a practice about 4-word and 7-word Chinese idiom. The first two words of the idiom have been given as a hint. Client is asked to pick out a right choice (select 1 out of 3-4) to complete the idiom. If the client has interest in the idiom, he/she can read about the story of the idiom.

B. Story articles in sequencing

Client is told an ancient Chinese idiom story and then asked to arrange the 3 pictures into a right order according to the story heard.

Session Fourteen Mnemonics-4 Figural- imagination task

A. The Tang poems learning


低头思？？。

○爱妻 ○故乡 ○家乡 ○父母

Client is given some uncompleted poems of the Tang Dynasty and asked to pick out the right choice to complete them (1 out of 4).

B. Context imaging


一双细长的眼睛里，浅浅的褐色的瞳仁一闪一闪的，充满着善良，洋溢着慈爱。

1. There is a picture on the screen and also 4 sentences under the picture. Client is asked to pick out a sentence that best describes the picture.
2. Contrary to task 1, client is given a sentence and asked to pick out a picture that the sentence best describes.
3. Client is given many words and asked to pick out the words presented in the previous two practices. e.g.,

I am standing alone with tears in eyes.

C. Situational drawing


远处是群峰绵延的山的世界，绿满沟壑，碧透山涧，尽是山峦叠嶂，林木参天。

Give the client a paragraph of words and ask him/her to draw a picture according to the words. Then, check the answer with him/her and show him/her the focal object in the picture. Show him/her the focal object again and ask him/her to pick out a choice that best describes the object (select 1 out of 4). At last, client is given many words and asked to pick out the words presented in the previous two practices.
e.g., Many high trees with red foliage beside with a river. Far away, there are many mountains.

Session Fifteen Integrated memory training tasks

A. Placement habitation training

In our daily life, some articles are usually put somewhere they used to be, for example, slippers are usually on the shoe cabinet. This practice is about placement habitation. The scenes include sitting room, bathing room, and kitchen. There is a picture of scene on the screen and under the picture are some random articles. Client is asked to rightly place the articles. The red circles in the picture and the words under the picture are the hints.

e.g. Newspaper, keys, toothpaste, fryer, chopping knife, etc.

B. Association between words and numbers

The pronunciations of some Chinese words are similar to those of some numbers. Client is shown some examples to remember and later asked to pick out words that represent the numbers (select 1 out of 4).

Client is shown some combinations and later asked to immediately recall the numbers. e.g.

3 - Mountain; 10 - stone; 15 - food, 57 - weapon; 84 - bus, etc.

Session Sixteen Application of memory skills in Activities of Daily Life – 1

A. Understanding the application of commodity

1. Client is given the picture of a commodity, he/she is asked to pick out the correct answer for the name of the commodity (select 1 out of 3-4) and depict its function.
2. Contrary to Task 1, client is given a sentence depicting a certain commodity and asked to pick out the appropriate picture of the commodity (select 1 out of 3-4).
3. Client is given a sentence depicting a certain commodity and asked to pick out the appropriate picture, but this time the answer could be more than one answer. e.g.
   a. The one can received TV signal and we can watch news program with it. (TV, computer, microwave oven)
   b. The one can keep food in low temperature and fresh. etc.

B. Cooking instant noodles

First, client is asked to watch the demonstration of cooking instant noodles and told the points for attention, and then asked to complete 12 pieces of multiple-choice according to the demonstration. e.g.

a. before staying cooking, how many bowls of water we should have? (three, four, five)
b. should we put the shred beside the boiling fryer?
c. can we hold the fryer by hand? etc.

Session Seventeen Application of memory skills in Activities of Daily Life – 2

A. Labeling training-1

We often stick labels at the surfaces of cupboards and drawers to help us recall the inside articles and stored positions. This practice is about it. Client is asked to put the articles in special places according to requirements and then give the article a label. e.g.
Put the brush in the middle of the drawer, then give it a label. etc.

B. Labeling training-2

Client is asked to click the three drawers of the shoes cabinet, and observe things in each drawer.
After that, client should identify the location of the assigned article, and put labels at appropriate places. The scenes of this task include 3 exercises, shoe cabinet, refrigerator and bookcase. e.g.,
the items to be labeled are: slippers, fish, apple, dictionary, newspaper, etc.

C. Objects seeking

Now, the shoes cabinet, refrigerator and bookcase are all with labels, client is asked to pick out the assigned articles.
e.g. “Find out the slippers for me please” etc.

Session Eighteen Application of memory skills in community-1

A. Video tape of patients visiting hospital

First, client is asked to watch a video tape of of patients visiting the third affiliated hospital, Sun Yat-sen University. Client can practice with the virtual environment. e.g.,
The bus routes, orientation of the buildings, procedures of visiting doctor, etc.

B. Recall the content of the video

Client is asked to answer questions according to the video tape with errorless strategy. e.g.,

1. Which No of bus is going to hospital? (18, 33, 45, 296)
2. What is the name of this hospital?
3. Where is the rehabilitation department? (3, 4, 8)
4. Can you recall the content of the conversation between patient and doctor?
5. What kind of drugs is given?

Session Nineteen Application of memory skills in community-2

A. Video tape of shopping in market

A video tape which is demonstrated shopping in a indoor market was shown. Client can practice such activity with the virtual environment. The content of the video included: route from home to market, orientation of the market, appropriate steps of shopping, etc.

B. Recall the content of the video

Client should answer a list of questions related to the video with errorless strategy. e.g.,

1. Where is the place for shopping?
2. How can we go to the market?
3. Where can we buy frozen food?
4. How can we pay for the foods?
5. What can we do after shopping?

Session Twenty The review of session 11-19

A. The comprehensive application of mnemonics

Client is asked to use the previous mnemonics randomly. New combination would be given to avoid repetition.

B. Review of poem of the Tang Dynasty practice

Repeated practice of idioms or poems is required to confirm the application of mental images. Additional exercise of 3 to 5 new poems would be presented.

C. Applications in daily life and community

1. Client is asked to prepare a set of meal included one soup and two dishes. After that, client should report the procedures of the meal preparation.
2. Client should list out the planning of visiting grandmother during Lunar Chinese New Year. The content should include appointment making, gifts preparation, traveling, dinner, etc.

COGNISTAT

(THE NEUROBEHAVIORAL COGNITIVE STATUS EXAMINATION)

NAME:______________________________

AGE:______ DATE OF BIRTH:__________

HANDEDNESS (circle): Left Right

NATIVE LANGUAGE:_________________

TOTAL YEARS EDUCATION:____________

OCCUPATION _______________________

DATE LAST WORKED:_________________

DATE OF INJURY (if any):____________

EXAM LOCATION:____________________

DATE:______________TIME.____________

COGNITIVE STATUS PROFILE

	LOC	ORI	ATT	LANGUAGE			CONST	MEM	CALC	REASONING	
				COMP	REP	NAM				SIM	JUD
							--6--			--8--	--6--
†AVG. RANGE	ALERT	--12--	-(S)8-	-(S)6-	--(S)--	--(S)--	-(S)5-	--12--	-(S)4-	-(S)6-	(S)5-
					--12--	--8--					
		--10--	--6--	--5--	--11--	--7--	--4--	--10--	--3--	--5--	--4--
MILD	- IMP-	-8-	--4--	--4--	--9--	--5--	--3--	--8--	--2--	--4--	--3--
MODERATE		--6--	--2--	--3--	--7--	--3--	--2--	--6--	--1--	--3--	--2--
SEVERE		--4--	--0--	--2--	--5--	--2--	--0--	--4--	--0--	2	1
Write in lower scores											

ABBREVIATIONS

ATT	-	Attention	JUD	-	Judgment	ORI	Orientation
CALC	-	Calculations	LOC	-	Level of Consciousness	REP	- Repetition
COMP		Comprehension				S	- Screen
CONST	-	Constructions	MEM	-	Memory	SIM	Similarities
IMP	-	Impaired	NAM	-	Naming		

* The validity of this examination depends on administration in strict accordance with the Cognistat Manual.

† For adolescents and individuals older than 65, see normative information on pages 12 and 13 of the Cognistat Manual (updated edition from 2001)

Note: Not all brain lesions produce cognitive deficits that will be detected by Cognistat. Normal scores, therefore, cannot be taken as evidence that brain pathology does *not* exist. Similarly, scores falling in the mild, moderate, or severe range of impairment do not *necessarily* reflect brain dysfunction (see section of the Cognistat Manual entitled "Cautions in Interpretations").

Appendix A7a: The Neurobehavioral Cognitive Status Examination

I. LEVEL OF CONSCIOUSNESS: Alert____ Lethargic____ Fluctuating ____
Describe patient's condition: ____________________

II. ORIENTATION (Score 0, 1, 2, 3 or 4 points)

		Response	Score
A. Person	1. Name (0 pts.)	____	____
	2. Age (2 pts.)	____	____
B. Place	1. Current location (2 pts.)	____	____
	2. City (2 pts.)	____	____
C. Time	1. Date: month (1 pt.) ____ day of month (1 pt.) ____ year (2 pts.)____		____
	2. Day of week (1 pt.)	____	____
	3. Time of day within one hour (1 pt.)	____	____

Total Score____

III. ATTENTION

A. Digit Repetition

1. Screen: 8-3-5-2-9-1 (Response:____) Pass____ Fail____

2. Metric: Score 1 for each correct sequence repetition; discontinue after 2 misses at one level.

	Response		Response		Response		Response
3-7-2	____	5-1-4-9	____	8-2-5-3-9	____	2-8-5-1-6-4	____
4-9-5	____	9-2-7-4	____	6-1-7-3-8	____	9-1-7-5-8-2	____

Total Score____

B. Four Word Memory Task (Clock Time____)
Give the four unrelated words from Section VI: robin, carrot, piano, green.
(Alternate list: table, orange, lion, glove.) Have patient repeat the four words twice correctly (see Manual).
Record the number of trials required to do this:____

IV. LANGUAGE

A. Speech Sample
Fishing Picture (Record patient's response verbatim.)

____
____
____
____

B. Comprehension (Be sure to have at least 3 other objects in front of the patient for this test.) If a, b, and c are successfully completed, praxis for these tasks is assumed normal.

1. Screen. 3-step command: "Turn over the paper, hand me the pen, and point to your nose."
Pass____ Fail____

2. Metric (Score 1 or 0.) If incorrect, describe behavior.

	Response	Score
a. Pick up the pen.	____	____
b. Point to the floor.	____	____
c. Hand me the keys.	____	____
d. Point to the pen and pick up the keys.	____	____
e. Hand me the paper and point to the coin.	____	____
f. Point to the keys, hand me the pen, and pick up the coin.	____	____

Total Score____

C. Repetition

1. Screen: The beginning movement revealed the composer's intention
____
Pass____ Fail____

2. Metric: (Score 2 points if first try correct; 1 point if second try correct; 0 if incorrect on third try.)

	Response	Score
a. Out the window.	____	____
b. He swam across the lake.	____	____
c. The winding road led to the village.	____	____
d. He left the latch open.	____	____
e. The honeycomb drew a swarm of bees.	____	____
f. No ifs, ands, or buts.	____	____

Total Score____

D. Naming

1. Screen: a) Pen .... b) Cap or Top .... c) Clip .... d) Point, Tip, or Nib ....

Pass ____ Fail

2. Metric (Score 1 or 0)

	Response	Score		Response	Score
a. Shoe	______	____	e. Horseshoe	______	____
b. Bus	______	____	f. Anchor	______	____
c. Ladder	______		g. Octopus	______	____
d. Kite	______	____	h. Xylophone	______	____

Total Score ____

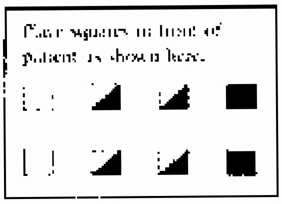
V. CONSTRUCTIONAL ABILITY

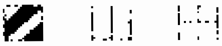
A. Screen: Visual Memory Task (Present stimulus sheet for 10 seconds, then have patient draw the two figures from memory. Must be perfect to pass. The examiner may wish to have patients who fail the screen copy the two figures.)

Pass ____ Fail ____

B. Metric: Design Construction (Score 2 if correct in 0-30 seconds, 1 if correct in 31-60 seconds, 0 if correct in greater than 60 seconds or incorrect.)

Place squares in front of patient as shown here.



Design	Record incorrect attempts below	Time	Score
1. Design 1		____	____
2. Design 2		____	____
3. Design 3		____	____

Total Score ____

VI. MEMORY (Score 3 points if recalled without prompting; 2 points if recalled with category prompt; 1 point if recognized from list; 0 if not recognized.) (Check if correct) (Clock time: ________)

Words	Check	Category Prompt	Response to Cue	List (Circle Choice)	Score
Robin		Bird	______	Sparrow, robin, bluejay	
Carrot	____	Vegetable	______	Carrot, potato, onion	____
Piano	____	Musical instrument	______	Violin, guitar, piano	____
Green		Color	______	Red, green, yellow	

Incorrect initial and/or confabulated response(s): .... Total Score ____

VII. CALCULATIONS

A. Screen: 5 x 13 Response ____ Time ____ (Must be correct within 20 seconds to pass.)

Pass ____ Fail ____

B. Metric: (Score 1 point if correct within 20 seconds.) Problems may be repeated, but time runs continuously from first presentation.

	Response	Time	Score
1. How much is 5 + 3?	____	____	____
2. How much is 15 + 7?			____
3. How much is 31 - 8?	____	____	____
4. How much is 20 - 6?	____	____	____

Total Score ____

VIII. REASONING

A. Similarities: (Explain: "A coat and a shirt are alike because they are both articles of clothing." If patient does not respond, encourage; if patient gives differences, score 0.)

1. Screen: Painting, Music (Must be abstract—only "art," "artist," or "forms of art" are acceptable.)

.... Pass ____ Fail

2. Metric (Score 2 points if abstract; 1 point if imprecisely abstract or concrete; 0 if incorrect.) See Manual for examples. Check if correct abstract response is given.

	Check	Abstract Concept	Other Responses	Score
a. Rose-Tulip	____	Flowers		
b. Bicycle-Train	____	Transportation		
c. Watch-Ruler		Measurement		____
d. Corkscrew-Hammer		Tools	______	

Total Score ____

VIII. **Judgment**

1. Screen: What would do if you were stranded in the Denver Airport with only $1.00 in your pocket?

Pass___ Fail___

2. Metric: (Score 2 if correct; 1 if partially correct; 0 if incorrect.)

   a. What would you do if you woke up one minute before 8:00 a.m. and remembered that you had an important appointment downtown at 8:00 o'clock?

   Score___

   b. What would you do if while walking beside a lake you saw that a two year old child was playing alone at the end of a pier?

   Score___

   c. What would you do if you came home and found that a broken pipe was flooding the kitchen?

   Score___

Total Score_____

IX. MEDICATIONS

List all medications taken either regularly or as needed and indicate dosages:

1. _____ 2. _____ 3. _____ 4. _____

5. _____ 6. _____ 7. _____ 8. _____

X. GENERAL COMMENTS

Motor, sensory or perceptual deficits: tremor, apraxia, dysarthria, visual field cut, impaired visual acuity, hearing loss, etc.:

"Process features": distractibility, frustration, exhaustion, pain, sleep deprivation, nature of cooperation, etc.:

The patient's impression of his or her performance:

Space for Visual Memory Test

神經行爲認知狀況測試

姓名及性別（男 / 女）：_____　　　職業：

年齡及出生日期：___________　　　住址：

母語：______________　　　檢查人：

偏手傾向（圈出來） 左 、 右　　　檢查時間：

教育程度：____________　　　檢查地點：

臨床診斷：____________　　　受傷日期：

……………………………………………………………

認知程度概況

	意識能力	定向能力	專注能力	語言能力			結構組織能力	記憶能力	計算能力	推理能力	
				理解能力	復述能力	命名能力				類似性	判斷能力
正常	清醒						−6−			−8−	−6−
		−12−	-(S)8-	-(S)6-	-(S)-	-(S)-	-(S)5-	−12−	-(S)4-	-(S)6-	-(S)5-
					−12−	−8−					
		−10−	−6−	−5−	−11−	−7−	−4−	−10−	−3−	−5−	−4−
輕微	受損	−8−	−5−	−4−	−9−	−5−	−3−	−8−	−2−	−4−	−3−
中度		−6−	−3−	−3−	−7−	−3−	−2−	−6−	−1−	−3−	−2−
嚴重		−4−	−1−	−2−	−5−	−2−	−0−	−4−	−0−	−2−	−1−
寫下更低的分 數											

（S）：篩查合格

＊　此項測試的準確性取決於是否嚴格地依照 NCSE 手冊進行。

※　病人如果超過 65 歲，在測試其組織能力、記憶力及類似性時，若分數等同“輕微受損程度”一級，仍屬正常。

注意：並非所有因腦部受損而導致的認知缺陷都可用 NCSE 測試出來，故此，表示正常的分數不足以證明腦部沒有問題；同樣，表示輕微、中度或嚴重受損的分數也不一定反映出腦部出現機能障礙。（ 參照 NCSE 手冊中的“闡明須知” ）

神經行爲認知狀況測試（簡稱 NCSE）

清楚正確地記錄病人的回應

....

一、意識程度

清醒____　　呆滯____　　不穩定 ______

描述病人的情況：

二、定向能力（分數爲 2、1 或 0）

		回應	分數
（一）人物	1. 姓名（0 分）	______	______
	2. 年齡（2 分）	______	______
（二）地點	1. 現時位置（2 分）	______	______
	2. 城市名稱（2 分）	______	______
（三）時間	1. 日期：月（1 分）	______	______
	日（1 分）	______	______
	年（2 分）	______	______
	2. 星 期（1 分）	______	______
	3. 一小時內的當時時間（1 分）	______	______

總分 □

三、專注能力

（一）數字復述

1. 篩查試： 8-3-5-2-9-1　　　　合格____ 不合格 _______

2. 分級測試：數位分組復述（分數爲 1 或 0；若在復述一組數位時出現兩次錯誤，則停止此項測試）

3-7-2____　　5-1-4-9____　　8-3-5-2-9____　　2-8-5-1-6-4

4-9-5____　　9-2-7-4____　　6-1-7-3-8____　　9-1-7-5-8-2

總分 □

（二）四詞記憶測試

從第六節中選出四個不相關的詞語：燕子、蘿蔔、鋼琴、綠色。

（其他選擇：桌子、獅子、蘋果、手套）

病人必須正確地把這四個詞語復述兩次（參閱手冊）

並把病人所須的練習次數記錄下來：

四、語言能力-

（一）看圖描述

釣魚圖畫（清楚正確地記錄病人的回應）

（二）理解能力（進行此項測試時，必須最少把三件其他物件同時放于病人的面前）假如（I）、（Ⅱ）、（Ⅲ）能順利完成，此項測試的反應被認爲是正常。

1. 篩查試：三步指令：“把紙翻過來，把圓珠筆遞給我，然後指著你自己的鼻子。”

合格____ 不合格

2. 分級測試：（分數爲 1 或 0）如果不正確，請描述病人的表現。

	反 應	分 數
（Ⅰ）拾起圓珠筆		
（Ⅱ）指向地板		
（Ⅲ）把鑰匙交給我		
（Ⅳ）指著圓珠筆然後拾起鑰匙		
（Ⅴ）把紙遞給我然後指著硬幣		
（Ⅵ）指著鑰匙，把圓珠筆遞給我，然後拾起硬幣		

總分 □

（三）復述能力

1. 篩查試：第一個動作顯示了作曲家的意圖

合格____ 不合格 ____

2. 分級測試：（第一次答對得 2 分，第二次答對得 1 分，答錯則 0 分）

	回 應	分 數
（Ⅰ）在窗外面		
（Ⅱ）他遊過那個湖		
（Ⅲ）那條彎路是通往那個村莊		
（Ⅳ）他讓門半掩著		
（Ⅴ）那個山洞擠滿了喜歡旅遊的人		

（Ⅵ）不是如果、和或但是 ____________ ____________

總分 □

（四）命名能力

1. 篩查試：（Ⅰ）圓珠筆　（Ⅱ）筆帽 / 筆蓋
（Ⅲ）筆夾　（Ⅳ）筆尖 / 筆嘴

合格____ 不合格

2. 分級測試（分數爲 1 或 0）：

	回 應	分 數		回 應	分 數
（Ⅰ）鞋	_____	____	（Ⅴ）鐵錘	________	_______
（Ⅱ）巴士	_____	____	（Ⅵ）錨	________	_______
（Ⅲ）梯子	_____	____	（Ⅶ）章魚	________	_______
（Ⅳ）風箏	_____	____	（Ⅷ）鋼琴	________	_______

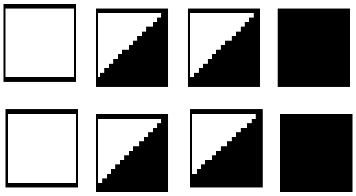
總分 □

五、結構組織能力

（一）篩查試：視覺記憶測試（讓病人觀察測試用的圖案板，限時 10 秒，然後要求病人憑記憶畫出板上的圖案，所畫的圖案必須與板上的完全相同才算合格，如病人不能畫出相同的圖案，檢查者可要求病人依板上的圖案模仿出來）

合格____ 不合格 ____

（二）分級測試：組合圖案（能夠在 0-30 秒內正確地完成得 2 分，31- 60 秒內才完成得 1 分，超過 60 秒才完成或仍然不正確則得 0 分）

請把方塊如下圖所示放于病人的面前	把不正確的圖案記錄在下面的方格中	時間	分數
	1. 圖案一 田	________	________
	2. 圖案二 田	________	________
	3. 圖案三 田	________	________

總分 □

六、記憶能力（如不需要提示下記起得 3 分，如需要類別提示才記起得 2 分，從目錄中選出正確答案得 1 分，選擇錯誤得 0 分）核對是否正確。

詞語	核對	類別提示	核對病人的答案
燕子	_____	雀鳥	______________________________
蘿蔔	_____	蔬菜	______________________________
鋼琴	_____	樂器	______________________________
綠色	_____	顏色	______________________________

目錄（圈出來）	分數
麻雀、燕子、白鴿	______
蘿蔔、紅薯、洋蔥	______
小提琴、吉他、鋼琴	______
紅色、綠色、黃色	______

總分 □

七、計算能力

（一）篩查試： 5×13(病人必須在 20 秒內答對)　答案：______ 時間： ______

合格 ______ 不合格:______

（二）分級測試：（20 秒內答對得 1 分）可重複問題，但不能停止記時。

		答案	時間	分數
1. 5 + 3	等於多少	_____	_____	_____
2. 15 + 7	等於多少	_____	_____	_____
3. 31－8	等於多少	_____	_____	_____
4. 39÷3	等於多少	_____	_____	_____

總分 □

八、推理能力

（一） **類似性** (解釋: “帽子和外套相似的原因是它們都屬於衣服這個類別。”假如病人不回答，必須鼓勵病人回答；如果病人所答的原因與標準答案不符合，則爲 0 分)

1. 篩查試：一幅畫、音樂（原因必須是抽象的；答案只可以提“藝術”、“藝術性”或“藝術的一種”）

____

合格____ 不合格 ______

2. 分級測試：（抽象的答案得 2 分; 答案若是部分正確的得 1 分; 答錯則 0 分）例子可參閱手冊，核對答案是否正確。

	核對	抽象概念	其他答案	分數
(I) 玫瑰、劍蘭	_____	花	_____	______

(II)	計程車、火車 _____	交通工具	______	_______
(III)	手錶、尺子 ______	量度工具	______	_______
(IV)	罐頭刀、錘子 ______	工具	______	_______

總分 □

（二）判斷能力

1. 篩查試：假如你流落在廣州白雲機場，但是口袋裏只有一元錢，你會怎樣做？

____

____

____

____

合格____ 不合格 ___

2 .分級測試：（答對得 2 分； 部分答對得 1 分； 答錯 0 分）

(1) 本來今天早上 8 點鐘你有重要的事情約好了要到市區一個朋友家裏，但你一醒來還差一分鐘就到 8 點鐘了，這種情況下你會怎樣做？

____

____

____

分數 ____________

(2)假如你在湖邊散步, 看見一個 2 歲的小孩獨自在碼頭的盡頭玩耍,你會怎樣做？

____

____

分數 ____________

(3)假如當你回家的時候，發現一條水管爆裂，廚房被水浸，你會怎樣做？

分數 ___________

總分 □

九、服用藥物

列舉所有目前服用的藥物和劑量

1. ______________ 2. ______________ 3. ______________ 4. ______________
5. ______________ 6. ______________ 7. ______________ 8. ______________

十、概念意見

記下任何已知或觀察得知的那些可以影響此項測試的缺陷，不論在肢體運動、感官或知覺各方面（例如：視覺或聽覺受損、顫抖、活動能力失控、發音困難等）

____

____

記下“測試過程的特點”如注意力不集中、不耐煩、疲勞和合作程度等，同時必須記下病人對自己表現的印象

____

____

……………………………………………………………………

視覺記憶測試用的空位（根據圖案版，晝出圖案）

RBMT

Thames Valley
Test Company

The Rivermead behavioural memory test

Procedural guide and scoring sheet

- This scoring sheet provides a summary procedure to ensure that the test is consistently carried-out in the correct order.
- Please follow the instructions in the Manual for detailed procedural and scoring guidance.

Subject and test details

Name

Date of birth

Date of test

Assessment 1 2 3 4

Version A (Red) B (Blue) C (Green) D (Brown)

• 1 and 2 First and Second Name

Action
Present the portrait for 'Remembering a name'
A Catherine Taylor
B Henry Fisher
C Pauline Roberts
D Philip Goodwin

• 3 Belonging

Action
Hide a belonging for 'Remembering a hidden belonging'.
A Desk drawer
B Cupboard
C Filing cabinet
D Brief case or bag

• 4 Appointment

Action
Set the timer for 'Remembering an appointment'
A 'When do I have to see you again?'
B 'When does this session end?'
C 'When will I know the results of the test?'
D 'What time do we finish today?'

• 5 Pictures

Action
Present the ten presentation cards for 'Picture recognition'.

• 6a Story (immediate)

Action
Read the prose passage from the separate Story Sheet. Then ask the subject to recall the prose passage.
Response
Adopt your own technique (e.g. underlining and encircling) for recording each of the 21 'ideas' correctly recalled or partially recalled against the appropriate passage on the Story Sheet.
Scoring
Scoring is based on points awarded for the number of 'ideas' correctly recalled. You should therefore count and calculate *after* the test has been completed.

Raw Score
Each 'idea' recalled word perfect
or using a close synonym = 1
Each 'idea' partially recalled,
or recalled with approximate
synonym = ½
(Maximum = 21)

☐ *Standardised Profile Score*

Raw Score	≤3.5	4–5.5	≥6
Standardised Profile Score	0	1	2

Screening Score
Score later

• 5 Pictures

Action
Present the 20 recognition cards for 'Picture recognition'
Response
Tick each picture identified correctly. (Those pictures which were previously presented are indicated by superior figures on the reverse of the picture cards.)

1 2 3 4 5 6 7 8 9 10

Total

Record the number of false positives ☐

Scoring

Raw Score
Subtract the number of false positives from the total number of pictures correctly identified
(Maximum = 10)

☐ *Standardised Profile Score*

Raw Score	≤8	9	10
Standardised Profile Score	0	1	2

Screening Score
All ten pictures identified correctly with no false positives = 1
(Otherwise = 0)

• 7 Faces

Action

Present the five presentation cards for 'Face recognition'.

• 8a Route (Immediate)

Action

Demonstrate the route for 'Remembering a short route' (immediate). (Leave the 'Message' envelope for 'Remembering to deliver a message' at the location marked by an asterisk below.) Then ask the subject to reproduce the route. Record each of the stages reproduced correctly below. The subject's response to 'Remembering to deliver a message' should be recorded in the next section.

Response

Tick each stage of the route correctly recalled.

A Chair	door	window	table*	chair
B Door	window*	table	chair	door
C Window	table	chair*	door	window
D Table	chair	door*	window	table

Scoring

Raw Score
Total number of stages recalled correctly
(Maximum = 5)

☐

Standardised Profile Score

Raw Score	≤4	4	5
Standardised Profile Score	0	1	2

Screening Score
All five stages of the route recalled in the correct order = 1
(Otherwise = 0)

• 9a Message (immediate)

Action

When demonstrating the route, leave the 'Message' envelope for 'Remembering to deliver a message' (immediate) at the location marked by an asterisk above.

Response

Tick as appropriate:
'Message' envelope picked-up spontaneously

picked-up after prompt

left at correct location

Scoring

Raw Score
'Message' picked-up spontaneously = 2
picked-up after prompt = 1
left at correct location = another 1
(Maximum = 3)

Standardised Profile Score
Score later

Screening Score
Score later

• 7 Faces

Action

Present the ten recognition cards for 'Face recognition'.

Response

Tick each face identified correctly. (Those faces which were previously presented are indicated by superior figures on the reverse of the face cards.)

1 2 3 4 5

Total

Record the number of false positives

Scoring

Raw Score
Subtract the number of false positives from the total number of faces correctly identified
(Maximum = 5)

☐

Standardised Profile Score

Raw Score	≤3	4	5
Standardised Profile Score	0	1	2

Screening Score
All five faces identified correctly with no false positives = 1
(Otherwise = 0)

• 10 and 11 Orientation and Date

Action

Ask the ten questions for 'Orientation' and 'Date' in the order given below

Response

Record the subject's responses in the spaces provided:

1 Year	2 Month	3 Day of week
4 Date	5 Place	6 City or town
7 Age	8 Year born	9 Prime Minister
10 President		

Scoring

Raw Score
Score one point for each correct response.
- Total number of correct responses to Orientation questions **i.e. excluding Date**

(Maximum = 9)
- Correct Date

(Maximum = 1)

Standardised Profile Score

☐

- Orientation questions

Raw Score	≤7	8	9
Standardised Profile Score	0	1	2

☐

- Date

Raw Score	≥ Two days out	One day out	Correct
Standardised Profile Score	0	1	2

Screening Score

- Orientation questions

All nine Orientation questions answered correctly = 1
(Otherwise = 0)

- Date

Correct Date given = 1
(Otherwise = 0)

• 4 Appointment

Action

Engage the subject in conversation until the timer sounds for 'Remembering an appointment'. Prompt if necessary.

A 'When do I have to see you again?'
B 'When does this session end?'
C 'When will I know the results of the test?'
D 'What time do we finish today?'

Response

Tick as appropriate:

Subject asked appropriate question spontaneously

after prompt

Subject remembered that something had to be asked but could not remember what it was

Scoring

Raw Score

Subject asked appropriate question
spontaneously = 2
after prompt = 1
Subject remembered that something had to be asked but could not remember what it was = 1
(Maximum = 2)

☐

Standardised Profile Score

Raw Score	0	1	2
Standardised Profile Score	0	1	2

Screening Score

Appropriate question asked without prompt when timer sounded = 1
(Otherwise = 0)

• 6b Story (delayed)

Action

Ask the subject to recall the prose passage for 'Delayed prose recall'. Give opening prompt if necessary.

Response

Record each of the 'ideas' correctly recalled or partially recalled against the appropriate passage on the Story sheet.

Scoring

Score exactly as for 'Immediate prose recall' *but deduct one point if the subject needed an opening prompt*

Raw Score

Each 'idea' recalled word perfect or using a close synonym = 1
Each 'idea' partially recalled, or recalled with approximate synonym = ½
(Maximum = 21)

☐

Standardised Profile Score

Raw Score	≤1.5	2–3.5	≥4
Standardised Profile Score	0	1	2

Screening Score

If the subject recalled at least six 'ideas' on 'Story (immediate)' and at least four 'ideas' on 'Story (delayed)' = 1
(Otherwise = 0)

• 8b Route (delayed)

Action

Ask the subject to reproduce the route for 'Remembering a short route' (delayed). Record each of the stages reproduced correctly below. The subject's response to 'Remembering to deliver a message' (delayed) should be recorded in the next section

Response

Tick each stage of the route correctly recalled:

A	Chair	door	window	table*	chair
B	Door	window*	table	chair	door
C	Window	table	chair*	door	window
D	Table	chair	door*	window	table

Scoring

Raw Score

Total number of stages recalled correctly
(Maximum = 5)

☐

Standardised Profile Score

Raw Score	≤3	4	5
Standardised Profile Score	0	1	2

Screening Score

All five stages of the route recalled in the correct order = 1
(Otherwise = 0)

• 9b Message (delayed)

Action

Remind the subject, if necessary, about the 'Message' envelope for 'Remembering to deliver a message' (delayed). The location is marked by an asterisk above

Response

Tick as appropriate

'Message' envelope picked-up spontaneously

picked-up after prompt

left at correct location

Scoring

Raw Score

'Message' picked up spontaneously = 2
picked-up after prompt = 1
left at correct location = another 1
(Maximum = 3)

☐ *Standardised Profile Score*
The Standardised Profile Score for 'Remembering to deliver a message' is based on the sum of the Raw Scores obtained for the **immediate and delayed** recalls (therefore maximum Raw Score = 6).

Sum of Raw Scores	≤4	5	6
Standardised Profile Score	0	1	2

Screening Score
If the subject spontaneously picked-up the 'Message' envelope and left it at the correct location in the **immediate and delayed** recalls = 1
(Otherwise = 0)

• 1 and 2 First and Second Name

Action
Re-present the portrait for 'Remembering a name'.
Give first letter prompt if necessary.
A Catherine Taylor
B Henry Fisher
C Pauline Roberts
D Philip Goodwin

Response
Tick as appropriate
First Name recalled without prompt

recalled with prompt

Second Name recalled without prompt

recalled with prompt

Scoring

Raw Score
- First Name recalled without prompt = 2
  recalled with prompt = 1

(Maximum = 2)
- Second Name recalled without prompt = 2
  recalled with prompt = 1

(Maximum = 2)

☐ *Standardised Profile Score*
The Standardised Profile Score for 'Remembering a name' is based on the sum of the Raw Scores obtained for the recall of the **First and Second Names** (therefore maximum Raw Score = 4).

Raw Score	≤2	3	4
Standardised Profile Score	0	1	2

Screening Score
- If the subject recalled the First Name without prompt = 1

(Otherwise = 0)
- If the subject recalled the Second Name without prompt = 1

(Otherwise = 0)

• 3 Belonging

Action
Inform the subject that 'We have finished this test'.
Wait for recall of 'Remembering a hidden belonging'.
Prompt if necessary
A Desk drawer
B Cupboard
C Filing cabinet
D Brief case or bag

Response
Tick as appropriate.
Place recalled without prompt

recalled with prompt

Item recalled without prompt

recalled with prompt

Scoring

Raw Score
Place recalled without prompt = 2
recalled with prompt = 1
Item recalled without prompt = 2
recalled with prompt = 1
(Maximum = 4)

☐ *Standardised Profile Score*

Raw Score	≤1	3	4
Standardised Profile Score	0	1	2

Screening Score
If the subject spontaneously recalled the item and the place where it was hidden = 1
(Otherwise = 0)

Score summary

	Standardised Profile Score (2,1 or 0)	Screening Score (1 or 0)
1 First Name	☐	
2 Second Name		
3 Belonging	☐	
4 Appointment	☐	
5 Pictures	☐	
6a Story immediate	☐	
6b delayed		
7 Faces	☐	
8a Route immediate	☐	
8b delayed	☐	
9 Message (immediate & delayed)	☐	
10 Orientation (not including date)	☐	
11 Date	☐	
Total	☐	○
	maximum = 24	maximum = 12

Rivermead 行爲記憶能力測驗

姓名
年齡
測試日期

測試*　1　2　3　4

版本*　甲　乙　丙　丁

*請圈上

分數摘要及解釋

	標準分數 （2、1、0 分）	篩選分數 （1、0 分）
一．姓	□	○
二．名		○
三．物件	□	○
四．約會	□	○
五．圖片	□	○
六甲．故事（即時憶述）	□	○
六乙．故事（延遲憶述）	□	
七．相貌	□	○
八甲．路線（即時處理）	□	○
八乙．路線（延遲處理）	□	○
九．『信息』信封	□	○
十．時空的定向	□	○
十一．日期	□	○
總分	□	○
	最高 24 分	最高 21 分

記憶功能水準	範圍（標準）	範圍（篩選）
正常	22-24	10-12
輕度損害	17-21	7-9
中度損害	10-16	3-6
重度損害	0-9	0-2

測試步驟

一及二姓名

甲.李彩霞	乙.黃觀南
丙.陳盛才	丁.張偉雄

三.物件

甲.抽屜裏	乙.櫃裏
丙.枕頭下	丁.書包裏

四.約會

甲.什麼時候見你	乙.什麼時候做完測驗
丙.什麼時候有測驗成績	丁.什麼時候可以走

五.圖片

六甲.故事（即時憶述）

五.圖片

七.相貌

八甲.路線（即時處理）

九甲．『資訊』信封（即時處理）

甲．由椅，去門，去窗，去台，返回椅。
乙．由門，去窗，去台，去椅，返回門。
丙．由窗，去台，去椅，去門，返回窗。
丁．由台，去椅，去門，去窗，返回台。

七．相貌

十及十一．時空的定向及日期

四・約會

六乙・故事（延時憶起）

八乙・路線（延遲處理）

九乙・『資訊』信封（延時處理）

一及二姓名

三・物件

評分

六甲. 故事（即時憶述）

□

初步積分

每說出一個正確的意思，可得 1 分。

說出部分正確的意思，可得 1/2 分。

（最高可得 21 分）

□

標準分數

初步積分	≤3.5	4-5.5	≥6
標準分數	0	1	2

五・圖片

在被正確認出圖片的號碼上加上√

1	2	3	4	5	6	7	8	9	10

□

初步積分

正確答案的數目減去錯答案的數目

（最高可得 10 分）

□

標準分數

初步積分	≤8	9	10
標準分數	0	1	2

八・路線（即時處理）

□

初步積分

正確路線段的總分

（最高可得 5 分）

□

標準分數

初步積分	≤3	4	5
標準分數	0	1	2

九甲・『資訊』信封（即時處理）

□

初步積分

能自覺的拾起信封，可得 2 分。

經提示拾起信封，可得 1 分。

信封放置於正確地點，可得另外 1 分（最高可得 3 分）

標準分數及稍後得分

七・相貌

在被正確認出圖片的號碼上加上√

1	2	3	4	5

□

初步積分

正確答案的數目減去錯答案的數目。

（最高可得 5 分）

□

標準分數

初步積分	≤3	4	5
標準分數	0	1	2

十及十一・時空定向及日期

將被測試者的反應填在空格內

1・現在是二零零幾年？ □

2・現在是幾月份？ □

3・現在是星期幾？ □

4・現在是幾號？ □

5・你現在在那裏？ □

6・這裏是什麼區？ □

7・您今年多少歲？ □

8・您是哪一年出生的？ □

9・廣東省省長是誰？ □

10・中國的總理是誰？ □

□

初步積分

所有“時空定向”的問題（“日期”除外），每一個正確答案得 1 分。

（最高可得 9 分）

□

正確日期

（最高可得 3 分）

標準分數

□

時空定向的問題

初步積分	≤7	8	9
標準分數	0	1	2

□

日期

初步積分	≤2 日	1 日	正確
標準分數	0	1	2

四・約會

□ *初步積分*

能自覺得問指定的問題，可得 2 分。

經提示後問指定的問題，可得 1 分。

被測試者記起應問問題，但未能記起問題是什麼，可得 1 分。

（最高可得 2 分）

□ *標準分數*

初步積分	0	1	2
標準分數	0	1	2

六乙・故事（延時憶起）

□ *初步積分*

每說出一個正確的意念，可得 1 分。

說出部分正確的意思，可得 1/2 分。

（最高可得 21 分）

□ *標準分數*

初步積分	≤1.5	2-3.5	≥4
標準分數	0	1	2

八・路線（延遲處理）

□ *初步積分*

正確路線段的總分

（最高可得 5 分）

□ *標準分數*

初步積分	≤3	4	5
標準分數	0	1	2

九乙・『資訊』信封（延遲處理）

□ *初步積分*

能自覺的拾起信封，可得 2 分。

經提示拾起信封，可得 1 分。

信封放置於正確地點，可得另外 1 分

（最高可得 3 分）

□ *標準分數*

根據『資訊』（即時處理）及（延遲處理）的初部積分之總和計算。（所以最高分數爲 6 分）

初部積分總和	≤4	5	6
標準分數	0	1	2

一及二・姓名

□ *初步積分*

能自覺地說出姓氏，可得 2 分。

經提示後說出姓氏，可得 1 分。

（最高可得 2 分）

能自覺地說出姓氏，可得 2 分。

經提示後說出姓氏，可得 1 分。

（最高可得 2 分）

□ *標準分數*

根據姓氏及名字的初步積分之總和計算

（所以最高分數爲 4 分）

初步積分	≤2	3	4
標準分數	0	1	2

三・物件

□ *初步積分*

物件

能自覺的記起物件，可得 2 分。

經提示後記起物件，可得 1 分。

地點

能自覺的記起地點，可得 2 分。

經提示後記起地點，可得 1 分。

（總共最高可得 4 分）

□ *標準分數*

初步積分	≤2	3	4
標準分數	0	1	2

故事憶述

請依照個人的方法去記錄被測試者在故事即時及延遲憶述的反應。

甲. 一名保安員／彭／嘉禮，／星期一／在天河城廣場／一宗銀行劫案中／被槍擊斃。／四名匪徒／都有蒙面；／其中一名手持／改裝過的／手槍。／警方／昨晚／詳細查問／目擊證人的證詞，／一名警方發言人說：／死者很勇敢，/竟然撲向／持槍匪徒，／糾纏了一會。

（字數：89　資料：21）

乙. 昨天／消防員／和一群群眾／全天／撲救／在廣州／白雲山／以南／六公里／的一場火。／由於消防車／不能夠直達火場，／全部消防設備／都要由手推車運送。／附近的／大生農場／被白色／濃煙／遮蓋，／所有家畜／都要疏散。

（字數：82　資料：21）

丙. 今早／有二百名工人／在黃埔／貨櫃碼頭／罷工，／這次行動／是爲了支持／五十個／下崗的員工。／吊車控制員／林／連成／對記者說：／簡直是荒謬，／在未來的兩年，／公司有足夠訂單，／沒理由還要讓職工下崗。／而公司發言人說：／我們希望明天／在總公司／召開／會議討論。

（字數：92　資料：21）

丁. 昨晚／一艘大連／運油船／在虎門／對外十裏的／海面沉沒。／所有的船員／都被水警／救起。／海面上出現／一大片油漬，／環保人士／擔心／會影響／生態環境；／部分熱心分子／準備開展行動／去拯救／在海灘／被油漬困住的／雀鳥。

（字數：79 資料：21）

Hong Kong List Learning Test (HKLLT)
香港文字記憶學習測試

Agnes S. Chan, Ph.D., & Isaac C. Kwok, B.S.Sc
陳瑞燕博士及郭澤恩先生

Record Form 記錄表

Form 1 (Random Condition) 表一 (隨意詞句)

(Trial 1)(第一回)

我會讀一些詞語給你聽，請你儘量記住它們。當我讀完之後，請你告訴我你記得的詞語，次序不要緊，你記得多少便多少。你有沒有問題呢？沒有便開始。

(Trial 2 & 3)(第二及第三回)

我會將那些詞語再讀多一次給你聽，請你儘量記住它們。我讀完之後，請你告訴我所有你記得的詞語，連同你剛說給我聽的那些都請再說一次，次序不要緊，預備好便開始。

	Trial 1 **第一回**	**Trial 2** **第二回**	**Trial 3** **第三回**
祖母 △			
書櫃 ○			
印度 ◆			
鏡子 ○			
瑞士 ◆			
嬸母 △			
茄子 ▼			
姪女 △			
泰國 ◆			
黃瓜 ▼			
智利 ◆			
表弟 △			
電燈 ○			
芥菜 ▼			
衣櫃 ○			
洋葱 ▼			

你用什麼方法幫助你記憶以上的詞語？

____

____

(Trial 4, 10-minute delay recall) (第四回，十分鐘後口述)

「我剛才讀過一些詞語給你記，讀過三次，請你現在告訴我那些詞語是什麼，次序不要緊，預備好便開始。

	Trial 4 第四回
祖母 △	
書櫃 ○	
印度 ◆	
鏡子 ○	
瑞士 ◆	
嬸母 △	
茄子 ▼	
姪女 △	
泰國 ◆	
黃瓜 ▼	
智利 ◆	
表弟 △	
電燈 ○	
芥菜 ▼	
衣櫃 ○	
洋蔥 ▼	

(Trial 5, 30-minute delay recall) (第五回，三十分鐘後口述)

「我剛才讀過一些詞語給你記，讀過三次，請你現在告訴我那些詞語是什麼，次序不要緊，預備好便開始。」

(Recognition)(辨認)

「現在我讀一些詞語給你聽，當中有部份你剛才已聽過，有部份則是未聽過的。如果你曾聽過，你就說舊的。如果是新詞語，你就說新的。」

	Trial 5 第五回	Recognition 辨認					
祖母 △		電燈	O		油菜	NSR	
書櫃 ○		茄子	O		印度	O	
印度 ◆		地氈	NR		表哥	NSR	
鏡子 ○		衣架	NSR		游水	N	
瑞士 ◆		姪女	O		鏡子	O	
嬸母 △		狐狸	N		跑步	N	
茄子 ▼		姑丈	NR		嬸母	O	
姪女 △		書櫃	O		瑞士	O	
泰國 ◆		泰國	O		火車	N	
黃瓜 ▼		秋天	N		豌豆	NR	
智利 ◆		荷蘭	NR		衣櫃	O	
表弟 △		祖母	O		芥菜	O	
電燈 ○		印尼	NSR		暴風	N	
芥菜 ▼		表弟	O		洋蔥	O	
衣櫃 ○		輪船	N		黃瓜	O	
洋蔥 ▼		智利	O		獅子	N	

Form 2 (Blocked Condition) 表二 (組織詞句)

(Trial 1) (第一回)

「我又會讀另外四個組別十六個詞語給你聽，它們分別是服飾、音樂、花朵和職業。我首先讀四個和服飾有關的詞語，之後是四種音樂、四種花朵和四種職業，請你儘量記住它們。當我讀完之後，請你告訴我你記得的詞語，次序不要緊，你有沒有問題呢？沒有便開始。」

(Trial 2 & 3) (第二及第三回)

「我會將那些詞語再讀多一次給你聽，請你儘量記住它們。我讀完之後，請你告訴我所有你記得的詞語，連同你剛說給我聽的那些都請再說一次，次序不要緊，預備好便開始。」

(Trial 4, cued recall 1) (第四回，提示回憶一)

「請告訴我那幾個和服飾有關的詞語。請告訴我那幾個和音樂有關的詞語。
請告訴我那幾個和花朵有關的詞語。請告訴我那幾個和職業有關的詞語。」

	Trial 1 第一回	Trial 2 第二回	Trial 3 第三回		Trial 4 第四回
長褲 △				服飾	
耳環 △					
大衣 △					
手套 △					
民謠 ◆				音樂	
歌劇 ◆					
獨奏 ◆					
聖樂 ◆					
牡丹 ○				花朵	
海棠 ○					
劍蘭 ○					
蓮花 ○					
校長 ▼				職業	
律師 ▼					
工人 ▼					
主任 ▼					

AppendixA9a: The Hong Kong List Learning Test

(Trial 5, 10-minute delay recall) (第五回，十分鐘後口述)

「剛才我讀過十六個詞語給你聽，現在請你告訴我那些詞語是什麼？」

(Trial 6, cued recall 2) (第六回，提示口述二)

「請告訴我那幾個和服飾有關的詞語。請告訴我那幾個和音樂有關的詞語。
請告訴我那幾個和花朵有關的詞語。請告訴我那幾個和職業有關的詞語。」

	Trial 5 第五回		Trial 6 第六回
長褲 △		服飾	
耳環 △			
大衣 △			
手套 △			
民謠 ◆		音樂	
歌劇 ◆			
獨奏 ◆			
聖樂 ◆			
牡丹 ○		花朵	
海棠 ○			
劍蘭 ○			
蓮花 ○			
校長 ▼		職業	
律師 ▼			
工人 ▼			
主任 ▼			

(Trial 7, 30-minute delay recall) (第七回，三十分鐘後口述)

剛才我讀過十六個詞語給你聽，現在請你告訴我那些詞語是什麼？

(Trial 8, cued recall 3) (第八回，提示口述三)

「請告訴我那幾個和服飾有關的詞語。請告訴我那幾個和音樂有關的詞語。
請告訴我那幾個和花朵有關的詞語。請告訴我那幾個和職業有關的詞語。」

(Recognition)(別認)

「現在我讀一些詞語給你聽，當中有部份你剛才已聽過，有部份則是未聽過的。如果你曾聽過，你就說舊的。
如果是新詞語，你就說新的。」

	Trial 7 第七回		Trial 8 第八回	Recognition 別認					
長褲 △		服飾		子彈	N		劍蘭	O	
耳環 △				長褲	O		櫻花	NSR	
大衣 △				獨奏	O		聖樂	O	
手套 △				公屋	N		海棠	O	
民謠 ◆		音樂		手套	O		英尺	N	
歌劇 ◆				歌劇	O		管樂	NR	
獨奏 ◆				翻版	N		合唱	NR	
聖樂 ◆				爵士	NR		牡丹	O	
牡丹 ○		花朵		西裝	NR		律師	O	
海棠 ○				工人	O		鑽石	N	
劍蘭 ○				火箭	N		蓮花	O	
蓮花 ○				校長	O		民謠	O	
校長 ▼		職業		短褲	NSR		主任	O	
律師 ▼				大衣	O		毛筆	N	
工人 ▼				弦樂	NSR		耳環	O	
主任 ▼				珍珠	N		商人	NSR	

Hong Kong List Learning Test (HKLLT)
香港文字記憶學習測試

Agnes S. Chan, Ph.D., & Isaac C. Kwok, B.S.Sc
陳瑞燕博士及郭澤恩先生

Scoring Form

Subject ID : ......

	Random Condition (Form 1)	Blocked Condition (Form 2)	Difference
Trial 1			
Trial 2			
Trial 3			
Trial 4 (Form 1) / Trial 5 (Form 2)			
Trial 5 (Form 1) / Trial 7 (Form 2)			
Trial 4 (Form 2) Cued recall (1)	▨		▨
Trial 6 (Form 2) Cued recall (2)	▨		▨
Trial 8 (Form 2) Cued recall (3)	▨		▨
Trial 1 - 3 Subjective Organization			
Learning Slope			
Trial 3: Intrusion Errors			
Perseveration Errors			
Semantic Clustering *			
Primacy Effect			
Recency Effect			
Concrete Concepts *			
Abstract Concepts *			
Recognition (Correct hits: O = O)			
False Alarm (N = O)			
Errors a) category related (NR)			
b) sound related (NSR)			
c) unrelated (N)			

*Write down the sequence of recalled items (Trial 3):

e.g.

嬸母	書檯		
表弟	鏡子	8	
電燈	電燈	3, 9	
瑞士	衣櫃		1/3
印度	茄子		
智利	黃瓜		
祖母	芥菜	11	
鏡子	洋蔥		0/3
電燈	祖母	7	
帽子	嬸母	1	
芥菜	姪女		
	表弟	2	1/3
	印度	5	
	瑞士	4	
	泰國		
	智利	6	2/3

Form 1:

具體	書檯		
	鏡子		
	電燈		
	衣櫃		/3
具體	茄子		
	黃瓜		
	芥菜		
	洋蔥		/3
抽象	祖母		
	嬸母		
	姪女		
	表弟		/3
抽象	印度		
	瑞士		
	泰國		
	智利		/3

Form 2:

具體	長褲		
	耳環		
	大衣		
	手套		/3
具體	牡丹		
	海棠		
	劍蘭		
	蓮花		/3
抽象	民謠		
	歌劇		
	獨奏		
	聖樂		/3
抽象	校長		
	律師		
	工人		
	主任		/3

香港文字記憶學習測試
記錄表

表一 隨意詞語

第一次

我會讀一些詞語給你聽，請你儘量記住它們。當我讀完之後，請你告訴我你記得的詞語，次序不要緊，你記得多少是多少。你有沒有問題呢？沒有便開始。

第二及第三次

我現在把這些詞語再讀一遍，請你注意聽並儘量記住它們。我讀完之後，請你告訴我你記得的所有詞語，連同你剛說過的那些詞語都請再說一次，次序不要緊，準備好便開始。

	第一次	第二次	第三次
祖母△			
書櫃○			
印度◆			
鏡子○			
瑞士◆			
嫲嫲△			
茄子▼			
侄女△			
泰國◆			
黃瓜▼			
智利◆			
表弟△			
電燈○			
芥菜▼			
衣櫃○			
洋蔥▼			

你用什麼方法幫助你記憶以上的詞語？

____

____

____

____

第四次 （延遲 10 分鐘回憶）

我剛才讀過一些詞語給你聽並要求儘量記住它們，讀過三次，請你現在告訴我那些詞語是什麼，次序不要緊，預備好便開始。

	第四次
祖母△	
書櫃○	
印度◆	
鏡子○	
瑞士◆	
嫲嫲△	
茄子▼	
侄女△	
泰國◆	
黃瓜▼	
智利◆	
表弟△	
電燈○	
芥菜▼	
衣櫃○	
洋蔥▼	

第五次 （30 分鐘後口述）

我剛才讀過一些詞語給你聽，讀過三次，請你現在告訴我那些詞語是什麼，次序不要緊，預備好便開始。

再認

現在我再讀一些詞語給你聽，其中有一部分你剛才已聽過，有一部分則是未聽過的。如果你曾聽過，你就說聽過。如果是新詞語，你就說是新的。

	第五次	再　認					
祖母△		電燈	O		油菜	NSR	
書櫃○		茄子	O		印度	O	
印度◆		地毯	NR		表哥	NSR	
鏡子○		衣架	NSR		游水	N	
瑞士◆		侄女	O		鏡子	O	
嫲嫲△		狐狸	N		跑步	N	
茄子▼		姑丈	NR		嫲嫲	O	
侄女△		書櫃	O		瑞士	O	
泰國◆		泰國	O		火車	N	
黃瓜▼		秋天	N		豌豆	NR	
智利◆		荷蘭	NR		衣櫃	O	
表弟△		祖母	O		芥菜	O	
電燈○		印尼	NSR		暴風	N	
芥菜▼		表弟	O		洋蔥	O	
衣櫃○		輪船	N		黃瓜	O	
洋蔥▼		智利	O		獅子	N	

A9b： 香港文字記憶學習測試記錄表

表二 成組詞語

第一次

我會再讀另外四個組別 16 個詞語給你聽，它們分別和服飾、音樂、花朵和職業有關。我首先讀四個和服飾有關的詞語，之後是四種和音樂、四種和花朵、四種和職業有關的詞語，請你儘量記住它們。當我讀完之後，請你大聲說你記得的詞語，次序不要緊，你有沒有問題呢？沒有便開始。

第二次及第三次

我會將剛才讀過的那些詞語再讀一次，請你注意聽並儘量記住它們。當我讀完之後，請你告訴我你能記住的所有詞語，連同你剛才說給我聽的那些詞語都要再說一遍，次序不要緊，預備好便開始。

第四次 (第一次有提示的口述）

請告訴我和服飾有關的詞語。請告訴我和音樂有關的詞語。

請告訴我和花朵有關的詞語。請告訴我和職業有關的詞語。

	第一次	第二次	第三次		第四次
長褲△				服飾	
耳環△					
大衣△					
手套△					
民謠◆				音樂	
歌劇◆					
獨奏◆					
聖樂◆					
牡丹○				花朵	
海棠○					
劍蘭○					
蓮花○					
校長▼				職業	
律師▼					
工人▼					
主任▼					

A9b：香港文字記憶學習測試記錄表

第五次 （10 分鐘後口述）

剛才我讀過十六個詞語給你聽，現在請你告訴我那些詞語是什麼？

第六次 （第二次有提示的口述）

請告訴我和服飾相關的詞。請告訴我和音樂相關的詞。

請告訴我和花朵相關的詞。請告訴我和職業相關的

	第五次		第六次
長褲△		服飾	
耳環△			
大衣△			
手套△			
民謠◆		音樂	
歌劇◆			
獨奏◆			
聖樂◆			
牡丹○		花朵	
海棠○			
劍蘭○			
蓮花○			
校長▼		職業	
律師▼			
工人▼			
主任▼			

第七次 （30 分鐘後口述）

剛才我讀過十六個詞語給你聽，現在請你告訴我那些詞語是什麼？

第八次 （第三次有提示的口述）

請告訴我和服飾相關的詞。請告訴我和音樂相關的詞。

請告訴我和花朵相關的詞。請告訴我和職業相關的詞。

再 認

現在我讀一些詞語給你聽，其中有部分你剛才已聽過，有部分則是未聽過的。如果你聽過，你就說聽過。如果是新詞語，你就說是新的。

	第七次		第八次	再認					
長褲△		服飾		子彈	N		劍蘭	O	
耳環△				長褲	O		梅花	NSR	
大衣△				獨奏	O		聖樂	O	
手套△				鳌米	N		海棠	O	
民謠◆		音樂		手套	O		英尺	N	
歌劇◆				歌劇	O		杜鵑	NR	
獨奏◆				蜘蛛	N		合唱	NR	
聖樂◆				護士	NR		牡丹	O	
牡丹○		花朵		西裝	NR		律師	O	
海棠○				工人	O		鑽石	N	
劍蘭○				火箭	N		蓮花	O	
蓮花○				校長	O		民謠	O	
校長▼		職業		短褲	NSR		主任	O	
律師▼				大衣	O		毛蟲	N	
工人▼				弦樂	NSR		耳環	O	
主任▼				珍珠	N		軍人	NSR	

A9b： 香港文字記憶學習測試記錄表

香港文字記憶學習測試
評分表

姓名　　　　　　編號

	隨機狀況（表１）	分組狀況（表２）	差異
第一次			
第二次			
第三次			
第四次（表１）/第五次（表２）			
第五次（表１）/第七次（表２）			
第四次（表２）提示回憶（１）	▨		▨
第六次（表２）提示回憶（２）	▨		▨
第八次（表２）提示回憶（３）	▨		▨
第 1-3 次 主觀組織			
學習斜率			
第三次　插入錯誤			
重複錯誤			
語意串聯			
初次記憶			
新近記憶			
具體記憶			
抽象記憶			
再認　正確再認（0=0）			
錯誤再認（N=0）			
錯誤　a）同類錯誤（NR）			
b）音近錯誤（NSR）			
c）無關的錯誤（N）			

寫下第三次回憶專案的順序：

例如
嬸嬸
表弟
電燈
瑞士
印度
智利
祖母
鏡子
電燈
櫃子
芥菜

書櫃	
鏡子	8
電燈	3，9
衣櫃	
茄子	
黃瓜	
芥菜	11
洋蔥	
祖母	7
嬸嬸	1
侄女	
表弟	2
印度	
瑞士	
泰國	
智利	

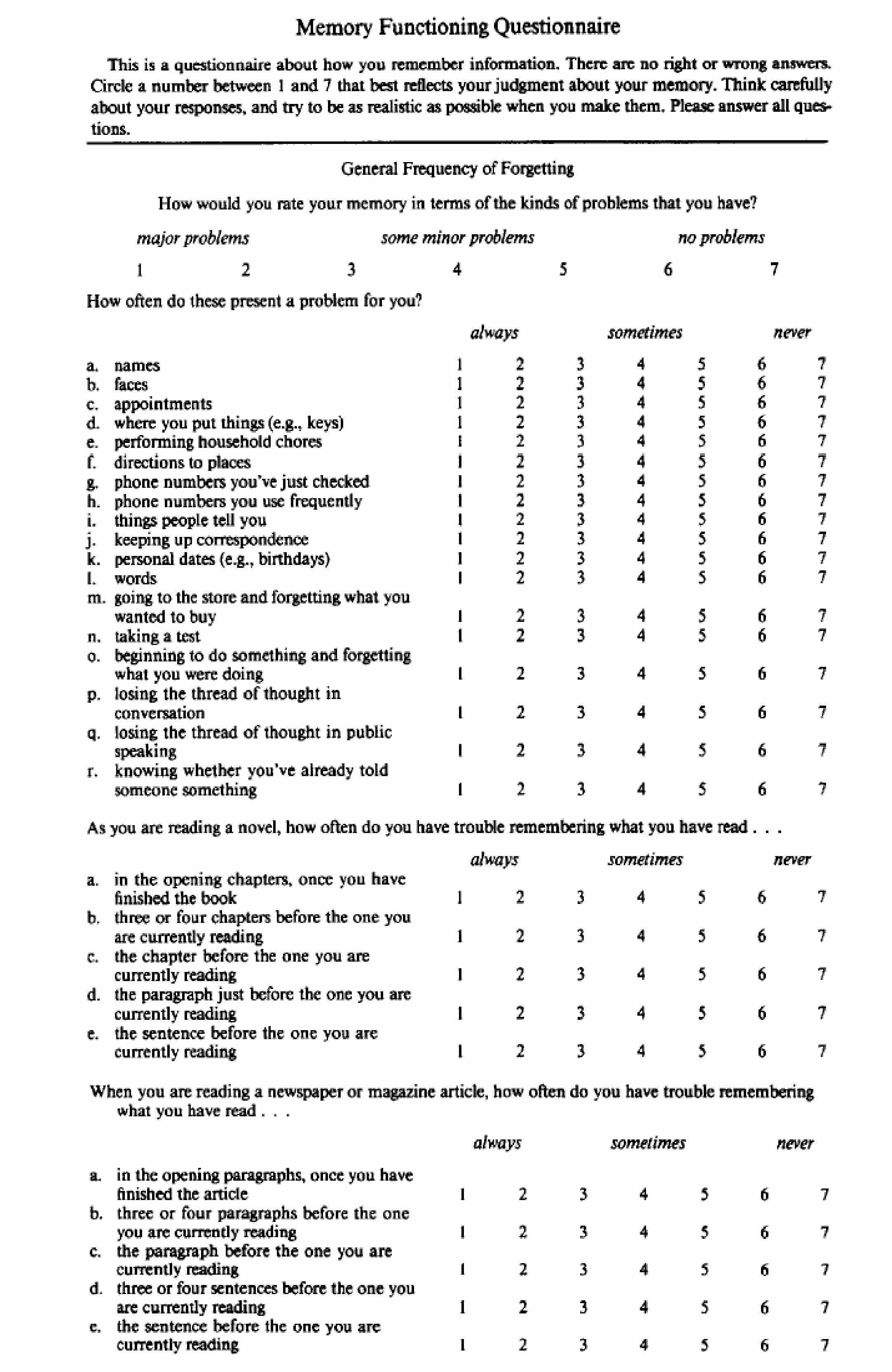
表 1

書櫃	
鏡子	
電燈	
衣櫃	
茄子	
黃瓜	
芥菜	
洋蔥	
祖母	
嬸嬸	
侄女	
表弟	
印度	
瑞士	
泰國	
智利	

表 2

長褲	
耳環	
大衣	
手套	
牡丹	
海棠	
劍蘭	
蓮花	
民謠	
歌劇	
獨奏	
聖樂	
校長	
律師	
工人	
主任	

Appendix A10a: The Memory Functioning Questionnaire



Memory Functioning Questionnaire

This is a questionnaire about how you remember information. There are no right or wrong answers. Circle a number between 1 and 7 that best reflects your judgment about your memory. Think carefully about your responses, and try to be as realistic as possible when you make them. Please answer all questions.

General Frequency of Forgetting

How would you rate your memory in terms of the kinds of problems that you have?

major problems			*some minor problems*			*no problems*
1	2	3	4	5	6	7

How often do these present a problem for you?

	always			*sometimes*			*never*
a. names	1	2	3	4	5	6	7
b. faces	1	2	3	4	5	6	7
c. appointments	1	2	3	4	5	6	7
d. where you put things (e.g., keys)	1	2	3	4	5	6	7
e. performing household chores	1	2	3	4	5	6	7
f. directions to places	1	2	3	4	5	6	7
g. phone numbers you've just checked	1	2	3	4	5	6	7
h. phone numbers you use frequently	1	2	3	4	5	6	7
i. things people tell you	1	2	3	4	5	6	7
j. keeping up correspondence	1	2	3	4	5	6	7
k. personal dates (e.g., birthdays)	1	2	3	4	5	6	7
l. words	1	2	3	4	5	6	7
m. going to the store and forgetting what you wanted to buy	1	2	3	4	5	6	7
n. taking a test	1	2	3	4	5	6	7
o. beginning to do something and forgetting what you were doing	1	2	3	4	5	6	7
p. losing the thread of thought in conversation	1	2	3	4	5	6	7
q. losing the thread of thought in public speaking	1	2	3	4	5	6	7
r. knowing whether you've already told someone something	1	2	3	4	5	6	7

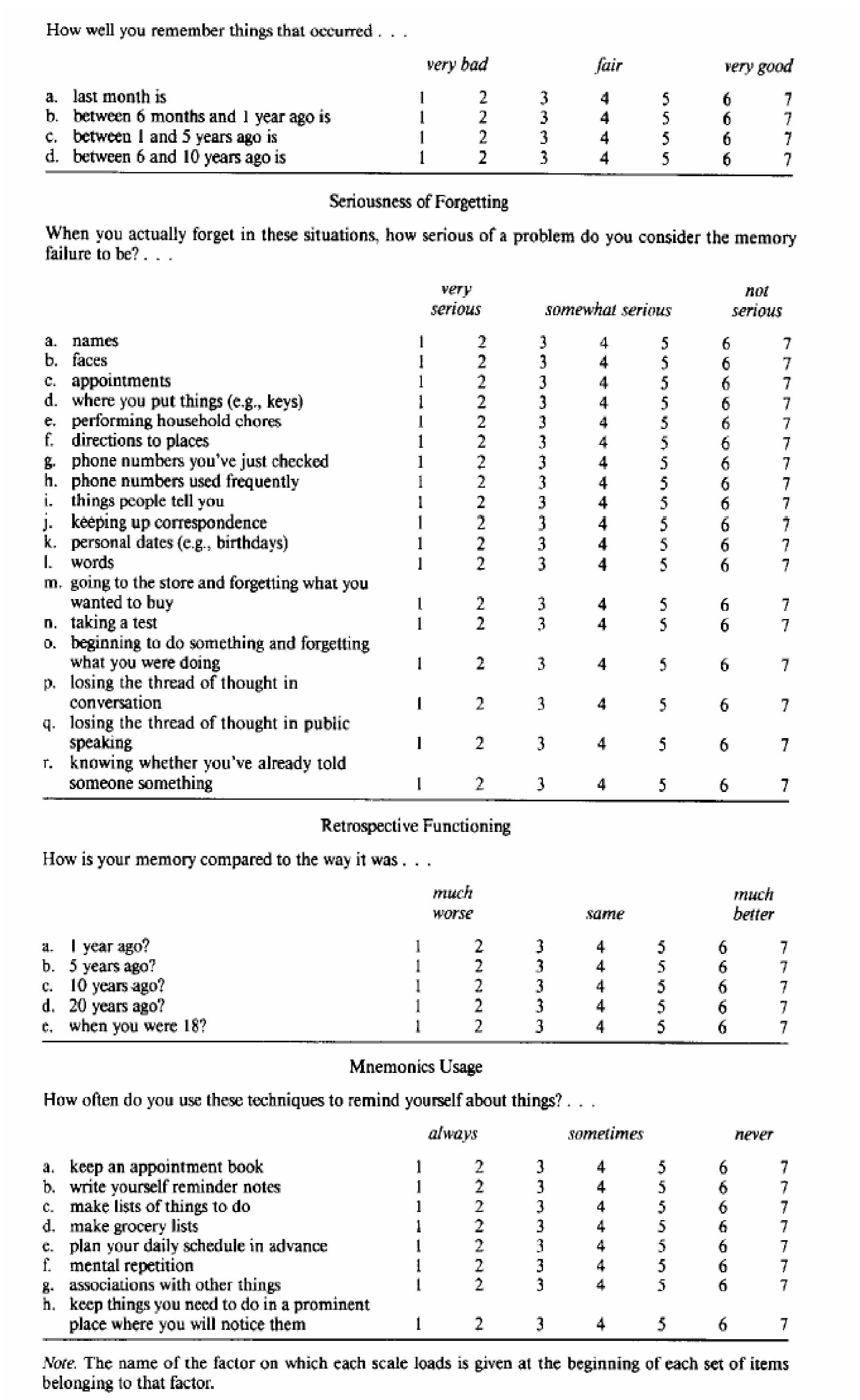
As you are reading a novel, how often do you have trouble remembering what you have read . . .

	always			*sometimes*			*never*
a. in the opening chapters, once you have finished the book	1	2	3	4	5	6	7
b. three or four chapters before the one you are currently reading	1	2	3	4	5	6	7
c. the chapter before the one you are currently reading	1	2	3	4	5	6	7
d. the paragraph just before the one you are currently reading	1	2	3	4	5	6	7
e. the sentence before the one you are currently reading	1	2	3	4	5	6	7

When you are reading a newspaper or magazine article, how often do you have trouble remembering what you have read . . .

	always			*sometimes*			*never*
a. in the opening paragraphs, once you have finished the article	1	2	3	4	5	6	7
b. three or four paragraphs before the one you are currently reading	1	2	3	4	5	6	7
c. the paragraph before the one you are currently reading	1	2	3	4	5	6	7
d. three or four sentences before the one you are currently reading	1	2	3	4	5	6	7
e. the sentence before the one you are currently reading	1	2	3	4	5	6	7

A10a： The Memory Functioning Questionnaire



How well you remember things that occurred . . .

	very bad			*fair*			*very good*
a. last month is	1	2	3	4	5	6	7
b. between 6 months and 1 year ago is	1	2	3	4	5	6	7
c. between 1 and 5 years ago is	1	2	3	4	5	6	7
d. between 6 and 10 years ago is	1	2	3	4	5	6	7

Seriousness of Forgetting

When you actually forget in these situations, how serious of a problem do you consider the memory failure to be? . . .

	very serious			*somewhat serious*			*not serious*
a. names	1	2	3	4	5	6	7
b. faces	1	2	3	4	5	6	7
c. appointments	1	2	3	4	5	6	7
d. where you put things (e.g., keys)	1	2	3	4	5	6	7
e. performing household chores	1	2	3	4	5	6	7
f. directions to places	1	2	3	4	5	6	7
g. phone numbers you've just checked	1	2	3	4	5	6	7
h. phone numbers used frequently	1	2	3	4	5	6	7
i. things people tell you	1	2	3	4	5	6	7
j. keeping up correspondence	1	2	3	4	5	6	7
k. personal dates (e.g., birthdays)	1	2	3	4	5	6	7
l. words	1	2	3	4	5	6	7
m. going to the store and forgetting what you wanted to buy	1	2	3	4	5	6	7
n. taking a test	1	2	3	4	5	6	7
o. beginning to do something and forgetting what you were doing	1	2	3	4	5	6	7
p. losing the thread of thought in conversation	1	2	3	4	5	6	7
q. losing the thread of thought in public speaking	1	2	3	4	5	6	7
r. knowing whether you've already told someone something	1	2	3	4	5	6	7

Retrospective Functioning

How is your memory compared to the way it was . . .

	much worse			*same*			*much better*
a. 1 year ago?	1	2	3	4	5	6	7
b. 5 years ago?	1	2	3	4	5	6	7
c. 10 years ago?	1	2	3	4	5	6	7
d. 20 years ago?	1	2	3	4	5	6	7
e. when you were 18?	1	2	3	4	5	6	7

Mnemonics Usage

How often do you use these techniques to remind yourself about things? . . .

	always			*sometimes*			*never*
a. keep an appointment book	1	2	3	4	5	6	7
b. write yourself reminder notes	1	2	3	4	5	6	7
c. make lists of things to do	1	2	3	4	5	6	7
d. make grocery lists	1	2	3	4	5	6	7
e. plan your daily schedule in advance	1	2	3	4	5	6	7
f. mental repetition	1	2	3	4	5	6	7
g. associations with other things	1	2	3	4	5	6	7
h. keep things you need to do in a prominent place where you will notice them	1	2	3	4	5	6	7

Note. The name of the factor on which each scale loads is given at the beginning of each set of items belonging to that factor.

記憶功能問卷

這是一份關於你如何記憶資訊的問卷，沒有標準答案。根據你的記憶判斷在 1—7 上畫圈，仔細思考一下你的答案，使它能最真實反映你的想法。請回答所有問題。

遺忘頻率

你如何評價你的記憶問題？

	經常遺忘		有時遺忘			從不遺忘	
	1	2	3	4	5	6	7

對你來說，這些問題遺忘的頻率有多少？

	經常遺忘		有時遺忘			從不遺忘	
a.姓名	1	2	3	4	5	6	7
b.面孔	1	2	3	4	5	6	7
c.約會	1	2	3	4	5	6	7
d.東西放置處（如鑰匙）	1	2	3	4	5	6	7
e.做家務瑣事	1	2	3	4	5	6	7
f.去某地的方向	1	2	3	4	5	6	7
g.剛查過的電話號碼	1	2	3	4	5	6	7
h.常用的電話號碼	1	2	3	4	5	6	7
i.別人告訴的事	1	2	3	4	5	6	7
j.保持的信件	1	2	3	4	5	6	7
k.個人的重要日期（如生日）	1	2	3	4	5	6	7
l..詞語	1	2	3	4	5	6	7
m.去了商店但忘記要買的東西	1	2	3	4	5	6	7
n.考試	1	2	3	4	5	6	7
o.開始做某事時忘記剛才正做的事情	1	2	3	4	5	6	7
p.在談話中思路中斷	1	2	3	4	5	6	7
q.在公開場合講話時思路中斷	1	2	3	4	5	6	7
r. 知道是否已把某事告訴某人	1	2	3	4	5	6	7

當你閱讀一本小說時，對於你讀過的內容，發生的遺忘情況如何？

	經常遺忘		有時遺忘			從不遺忘	
a.整本書剛讀完，開頭幾章	1	2	3	4	5	6	7
b.正在閱讀處之前的 3-4 章	1	2	3	4	5	6	7
c 正在閱讀處之前的一章	1	2	3	4	5	6	7
d.正在閱讀處之前的一段	1	2	3	4	5	6	7
e.正在閱讀處之前的句子	1	2	3	4	5	6	7

當你閱讀一份報紙或雜誌文章時，對於你讀過的內容，發生的遺忘情況如何？

	經常遺忘		有時遺忘			從不遺忘	

Appendix A10b：記憶功能問卷

a.讀完整篇文章後，開頭內容	1	2	3	4	5	6	7
b.正在閱讀處之前的 3-4 段	1	2	3	4	5	6	7
c.正在閱讀處之前的一段	1	2	3	4	5	6	7
d 正在閱讀處之前的 3-4 句	1	2	3	4	5	6	7
e.正在閱讀處之前的一個句子	1	2	3	4	5	6	7

對於發生過的事情，你的記憶狀況是………

	很壞		一般			很好	
a.上個月發生的事	1	2	3	4	5	6	7
b.六個月至一年前發生事	1	2	3	4	5	6	7
c.一至五年前發生的事	1	2	3	4	5	6	7
d.六至十年前發生的事	1	2	3	4	5	6	7

遺忘的程度

在下列情況發生遺忘時，你認爲遺忘的程度是多少

	非常嚴重		有點嚴重			不嚴重	
a.姓名	1	2	3	4	5	6	7
b.面孔	1	2	3	4	5	6	7
c.約會	1	2	3	4	5	6	7
d.東西放置處（如鑰匙）	1	2	3	4	5	6	7
e.做家務瑣事	1	2	3	4	5	6	7
f.去某地的方向	1	2	3	4	5	6	7
g.剛查過的電話號碼	1	2	3	4	5	6	7
h 常用的電話號碼	1	2	3	4	5	6	7
i.別人告訴的事	1	2	3	4	5	6	7
j.保持的信件	1	2	3	4	5	6	7
k.個人的重要日期（如生日）	1	2	3	4	5	6	7
l..詞語	1	2	3	4	5	6	7
m.去了商店但忘記要買的東西	1	2	3	4	5	6	7
n.考試	1	2	3	4	5	6	7
o.開始做某事時忘記剛才正做的事情	1	2	3	4	5	6	7
p.在談話中思路中斷	1	2	3	4	5	6	7
q.在公開場合講話時思路中斷	1	2	3	4	5	6	7
r. 知道是否已把某事告訴某人	1	2	3	4	5	6	7

記憶能力的回顧性比較

與下列時間相比較，你的記憶能力如何？

	很糟		一般			很好	
a.1 年前？	1	2	3	4	5	6	7
b.5 年前？	1	2	3	4	5	6	7
c.10 年前？	1	2	3	4	5	6	7
d.20 年前？	1	2	3	4	5	6	7
e.18 歲時？	1	2	3	4	5	6	7

Appendix A10b：記憶功能問卷

記憶方法的應用

你經常用下列哪種方法提醒您去記憶？

	經常		有時			不會	
a.隨身帶記事本	1	2	3	4	5	6	7
b.寫下提醒便箋	1	2	3	4	5	6	7
c.把要做的事情列表	1	2	3	4	5	6	7
d.列購物清單	1	2	3	4	5	6	7
e.提前做日常計畫	1	2	3	4	5	6	7
f. 腦子裏不斷重複	1	2	3	4	5	6	7
g.與其他事情聯繫起來	1	2	3	4	5	6	7
h.把需要做的事情放在能注意到的顯要位置上	1	2	3	4	5	6	7

記憶康復訓練效果問卷

Checklist of Memory Training

序	號	問題		1	2	3	4	5	6	7	
1		我同意這項訓練對我的記憶能力有幫助	非常不同意	□	□	□	□	□	□	□	非常同意
2		在完成這幾節訓練後, 我更有信心面對日常生活中的困難	非常不同意	□	□	□	□	□	□	□	非常同意
3		訓練內容很適合我	非常不適合	□	□	□	□	□	□	□	非常適合
4		我同意這種康復方式對我特別有用	非常不同意	□	□	□	□	□	□	□	非常同意
5		我能夠把這些記憶技巧應用於我的日常生活學習中	非常不同意	□	□	□	□	□	□	□	非常同意
6		通過訓練後, 我克服了一些日常生活上遇到的記憶困難	非常不同意	□	□	□	□	□	□	□	非常同意
7		通過訓練後, 以下能力有改變		1	2	3	4	5	6	7	
	a	忘記常用物件的位置	比以前更差	□	□	□	□	□	□	□	有顯著改善
	b	忘記這幾天在身邊發生的事情的重要細節	比以前更差	□	□	□	□	□	□	□	有顯著改善
	c	遺忘身邊物品(鑰匙、錢包、眼鏡、手機等)	比以前更差	□	□	□	□	□	□	□	有顯著改善
	d	需要他人提示才能回憶最近發生或聽過的事情	比以前更差	□	□	□	□	□	□	□	有顯著改善
	e	話到嘴邊說不出來	比以前更差	□	□	□	□	□	□	□	有顯著改善
	f	出門迷失方向	比以前更差	□	□	□	□	□	□	□	有顯著改善
	g	思考問題能力	比以前更差	□	□	□	□	□	□	□	有顯著改善
	h	獨立能力	比以前更差	□	□	□	□	□	□	□	有顯著改善
	i	學習耐力及效率	比以前更差	□	□	□	□	□	□	□	有顯著改善
	j	語言溝通能力	比以前更差	□	□	□	□	□	□	□	有顯著改善
	k	辨認物件能力	比以前更差	□	□	□	□	□	□	□	有顯著改善
	l	專注能力	比以前更差	□	□	□	□	□	□	□	有顯著改善
	m	其他能力	比以前更差	□	□	□	□	□	□	□	有顯著改善

Appendix A11： 記憶訓練效果問卷

8	對這種電腦輔助/面對面認知記憶康復的意見是？	非常不滿意	1	2	3	4	5	6	7	非常滿意
a	你是否滿意這種記憶康復訓練方法 (satisfaction)		□	□	□	□	□	□	□	
b	這種訓練可否達到你對記憶康復的要求(effectively)	遠不能達到	□	□	□	□	□	□	□	完全達到
c	你認爲這種訓練是否有效率 (efficacy)	非常沒效率	□	□	□	□	□	□	□	有顯著效率
d	每次訓練過程是否順利 (Functionality)	非常不順利	□	□	□	□	□	□	□	非常順利
9	訓練是否需要改進，你認爲下列哪些方面需要改進 ？	不需要改進	1	2	3	4	5	6	7	需要改進
a	訓練方法		□	□	□	□	□	□	□	
b	時間長短		□	□	□	□	□	□	□	
c	訓練前預約		□	□	□	□	□	□	□	
d	治療師、家人、患者之間的交流		□	□	□	□	□	□	□	
e	電腦/圖片的操作		□	□	□	□	□	□	□	
f	聲音效果		□	□	□	□	□	□	□	
g	畫面清晰度		□	□	□	□	□	□	□	
10	電腦程式設計									
a	選圖是否合適	非常不合適	□	□	□	□	□	□	□	非常合適
b	文字是否合適	非常不合適	□	□	□	□	□	□	□	非常合適
c	難易程度	非常困難	□	□	□	□	□	□	□	非常容易

備註：你對這套訓練軟體哪些節印象深刻，請寫/說出來？

Appendix A12 NCSE –CV mean scores in post – pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			TAMG			CG		
	Pre	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**
Sub-test items	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
orientation	9.57±2.59	10.53±1.99	10.70±1.58	8.58±2.54	10.25±1.62	10.54±1.56	9.60±2.79	10.30±2.10	10.57±1.76
attention	7.63±1.07	7.80±0.76	7.97±0.18	7.63±1.14	7.92±0.41	7.83±0.82	7.87±0.51	8.00±0.00	8.00±0.00
comprehension	5.43±0.97	5.80±0.48	5.90±0.31	5.42±1.02	5.42±1.06	5.58±0.78	5.33±1.32	5.63±1.03	5.73±0.79
repetition	10.67±2.06	11.27±1.44	11.40±1.20	10.42±2.78	11.25±2.25	11.21±2.27	10.67±2.51	10.83±2.29	11.10±1.99
naming	7.30±1.34	7.80±0.55	7.83±0.46	7.54±0.98	7.75±0.68	7.87±0.45	7.60±1.22	7.70±1.15	7.80±0.66
construction	2.50±2.26	3.07±2.28	2.90±2.20	1.83±1.81	2.37±2.06	2.50±2.04	2.43±1.96	2.63±1.99	2.77±1.94
memory	6.40±2.92	8.57±2.71	8.33±2.75	4.29±3.54	7.04±3.29	6.75±3.21	5.87±2.78	6.67±2.60	6.53±2.50
calculation	3.27±1.31	3.53±1.14	3.67±0.92	2.92±1.28	3.37±1.01	3.46±1.06	3.30±1.34	3.33±1.27	3.40±1.19
similarities	5.00±1.95	5.47±1.55	5.63±1.33	4.63±1.86	4.96±1.30	5.17±1.09	4.47±1.91	4.73±1.76	4.93±1.60
judgment	4.73±0.87	5.00±0.46	5.07±0.25	4.58±1.18	5.04±0.20	5.04±0.20	4.50±1.28	4.70±1.06	4.87±0.94

Appendix A13 RBMT-CV mean scores in post- pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			**TAMG**			**CG**		
	Pre	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**
Sub-test item	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Name	0.53±0.86	0.87±0.97	0.80±0.93	0.17±0.57	0.38±0.77	0.33±0.70	0.43±0.82	0.30±0.65	0.23±0.57
Belonging	1.13±0.86	1.30±0.84	1.00±0.91	0.62±0.77	0.88±0.85	1.04±0.86	0.70±0.84	0.83±0.83	0.77±0.77
Appointment	0.60±0.77	0.97±0.93	0.90±0.80	0.38±0.58	0.50±0.59	0.63±0.58	0.43±0.63	0.33±0.55	0.33±0.61
Picture	1.27±0.91	1.63±0.72	1.53±0.78	0.75±0.94	1.25±0.85	1.17±0.87	0.90±0.92	1.07±0.91	1.03±0.89
Story(immediate)	0.40±0.62	1.10±0.80	1.07±0.79	0.33±0.64	0.96±0.86	0.88±0.85	0.27±0.52	0.43±0.63	0.57±0.68
Story(delay)	0.57±0.48	1.13±0.86	1.03±0.85	0.42±0.58	0.67±0.64	0.67±0.57	0.60±0.68	0.57±0.73	0.50±0.63
Face	0.73±0.79	1.40±0.86	1.37±0.77	0.42±0.78	0.75±0.90	0.75±0.85	0.90±0.92	0.97±0.93	0.87±0.94
Route(immediate)	1.57±0.77	1.83±0.46	1.93±0.25	1.62±0.71	1.83±0.48	1.83±0.48	1.57±0.77	1.73±0.58	1.77±0.91
Route(delay)	1.33±0.88	1.67±0.71	1.80±0.40	1.33±0.92	1.75±0.53	1.71±0.55	1.57±0.77	1.60±0.72	1.67±0.71
Message	0.93±0.91	1.43±0.82	1.53±0.82	0.75±0.85	1.54±0.83	1.42±0.78	1.17±0.91	1.23±0.90	1.30±0.83
Orientation	0.37±0.70	0.60±0.77	0.70±0.80	0.13±0.49	0.21±0.59	0.21±0.59	0.40±0.68	0.50±0.78	0.40±0.72
Date	0.83±0.91	1.17±0.99	0.87±0.97	0.58±0.88	0.63±0.92	0.88±0.0.99	0.53±0.90	0.67±0.99	0.67±0.96^{q}
Total	10.27±6.25	15.10±5.68	17.60±17.24	7.50±4.01	11.33±4.40	11.46±4.98	9.53±5.36	10.20±8.10	10.10±4.97

Appendix A14 HKLLT memory processes mean scores in post- pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			TAMG			CG		
	Pre	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**
Sub-test items	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Random encoding	5.17±1.95	6.59±2.71	7.62±3.08	4.59±1.81	5.40±1.60	6.28±1.80	4.69±1.87	4.88±1.77	5.70±1.75
Random storage	3.87±3.16	6.63±3.76	6.58±4.06	2.48±2.08	4.06±2.47	3.79±2.33	2.68±2.43	2.80±2.35	2.62±2.15
Random retrieval	0.58±0.25	0.79±0.20	0.77±0.21	0.49±0.22	0.73±0.23	0.71±0.22	0.52±0.25	0.58±0.25	0.60±0.22
Blocked encoding	5.01±2.80	7.62±3.57	7.25±3.48	4.56±1.96	6.06±2.88	5.88±2.92	4.06±1.62	4.41±0.51	4.62±1.49
Blocked storage	4.38±3.79	7.61±4.95	6.71±4.40	3.50±3.49	4.83±3.80	4.50±3.56	2.72±2.32	2.67±2.13	2.65±1.95
Blocked retrieval	0.54±0.27	0.81±0.21	0.78±0.21	0.44±0.23	0.73±0.20	0.74±0.19	0.46±0.29	0.57±0.24	0.59±0.23

Appendix A15 HKLLT random condition learning strategies mean scores in post- pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			TAMG			CG		
	Pre	Post	Follow up	Pre	Post	Follow up	Pre	Post	Follow up
Sub-test items	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Subjective organization	0.72±0.83	1.38±1.25	1.25±1.15	0.63±0.76	1.25±0.83	1.27±1.09	0.93±0.85	1.00±1.92	0.77±0.50
Semantic clustering	1.37±1.52	2.70±2.57	2.50±2.09	1.13±1.12	1.92±1.53	2.04±1.37	0.87±0.82	0.97±1.19	1.17±1.21
Primacy effect	1.47±1.22	1.93±1.14	2.20±0.99	1.21±0.93	1.54±1.10	1.50±1.06	1.37±1.32	1.20±1.09	1.17±1.09
Recency effect	2.03±1.27	2.50±1.08	2.33±1.16	2.00±1.29	2.00±0.89	2.21±1.02	1.87±1.23	2.03±0.85	2.20±0.71
Concrete concepts	3.23±1.50	4.37±1.54	4.13±1.89	2.88±1.62	3.37±1.01	3.42±1.41	3.07±1.29	3.17±1.26	3.00±1.23
Abstract concepts	2.90±1.49	3.80±2.07	4.03±1.75	2.50±1.64	3.38±1.41	2.96±1.49	2.40±1.49	2.47±1.23	2.77±1.41

Appendix A16 HKLLT Blocked condition learning strategies mean scores in post- pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			TAMG			CG		
	Pre	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**
Sub-test items	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Subjective organization	1.17±1.36	2.18±1.86	2.35±2.74	0.81±0.76	1.96±2.30	1.69±1.24	0.82±0.78	1.18±0.87	1.18±0.92
Semantic clustering	3.27±2.64	5.30±3.62	4.57±5.09	2.92±2.08	4.17±2.63	3.83±2.62	2.30±1.62	2.63±1.52	2.50±1.61
Primacy effect	1.83±1.68	2.57±1.33	2.63±1.49	1.71±1.46	2.25±1.36	2.33±1.13	1.47±1.43	1.60±1.30	1.80±1.09
Recency effect	2.47±1.25	3.00±1.08	3.07±0.91	2.25±1.51	2.79±1.14	2.79±1.02	2.07±1.34	2.30±0.99	2.20±0.88
Concrete concepts	2.87±2.21	4.50±2.30	3.93±1.96	2.83±1.86	3.75±1.98	3.79±1.64	2.27±1.70	2.73±1.57	3.03±1.47
Abstract concepts	3.10±1.85	4.50±2.06	4.30±1.86	4.54±8.14	3.46±1.82	3.25±1.51	2.33±1.39	2.87±1.19	2.63±0.93

Appendix A17 MFQ mean scores in post- pre training and follow up among CAMG, TAMG, CG groups（$\bar{x}$ ±s）

	CAMG			**TAMG**			**CG**		
	Pre	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**	**Pre**	**Post**	**Follow up**
Sub-test items	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Frequency of forgetting	98.63±34.86	116.83±35.14	113.50±36.00	72.83±23.53	84.75±23.79	83.62±24.17	94.30±41.45	92.60±40.46	93.70±38.69
Seriousness of forgetting	67.20±21.11	79.00±419.51	77.73±20.56	57.92±22.22	67.25±24.04	67.00±23.63	67.70±24.05	66.70±24.33	69.30±25.44
Retrospective functioning	15.97±5.71	18.80± 5.28	18.53± 5.37	13.67±7.31	14.04± 6.21	14.87± 6.13	15.23±7.02	15.83±7.55	15.87± 7.21
Mnemonics usages	45.63±12.96	40.07±11.89	40.13±11.42	54.83±3.63	46.67± 5.22	47.58± 5.37	50.60±8.02	51.40±7.04	51.30± 7.76

Appendix A18：　Across -subjects contrast results of NCSE-CV in post- pre training and follow up among CAMG 、TAMG、CG groups

Appendix A18 Across -subjects contrast results of NCSE-CV in post- pre training and follow up among CAMG, TAMG, CG groups (P value)

Sub-test items	**CAMG vs TAMG**			**CAMG vs CG**			**TAMG vs CG**			**F**	**P**
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**		
orientation	0.120	0.099	0.649	0.528	0.721	0.700	0.033	0.048	0.927	1.295	0.274
attention	0.587	0.563	0.043	0.878	0.328	0.150	0.491	0.729	0.496	1.248	0.293
comprehension	0.077	0.167	0.541	0.731	0.743	1.000	0.147	0.281	0.541	0.901	0.465
repetition	0.517	0.878	0.410	0.203	0.404	0.506	0.066	0.347	0.149	1.200	0.313
naming	0.212	0.419	0.428	0.071	0.155	0.540	0.642	0.590	0.829	0.975	0.423
construction	0.933	0.356	0.085	0.196	0.806	0.061	0.255	0.250	0.960	1.485	0.209
memory	0.255	0.295	0.850	0.006	0.009	0.731	0.000	0.001	0.607	3.814	0.005
calculation	0.360	0.528	0.744	0.238	0.158	0.644	0.044	0.051	0.913	1.216	0.306
similarities	0.657	0.775	0.822	0.480	0.582	0.849	0.824	0.815	0.964	0.134	0.970
judgment	0.405	0.650	0.560	0.758	0.898	0.355	0.263	0.740	0.148	1.056	0.380

Note: T1**:** *mean difference between post-pre training**;***

T2:** mean difference between follow up-pre training**;

***T3** ∶ mean difference between follow up-post training*

**= $P< 0.05$; **= $P < 0.01$*

Appendix A19： Across -subjects contrast results of RBMT-CV in post- pre training and follow up among CAMG 、TAMG、CG groups

Appendix A19 Across -subjects contrast results of RBMT-CV in post- pre training and follow up among CAMG, TAMG, CG groups (P value)

	CAMG vs TAMG			**CAMG vs CG**			**TAMG vs CG**			**F**	**P**
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**		
Name	0.555	0.595	0.831	0.021	0.010	1.000	0.109	0.054	0.831	1.842	0.123
Belonging	0.688	0.012	0.006	0.865	0.323	0.138	0.574	0.105	0.162	2.463	0.047
Appointment	0.203	0.799	0.168	0.010	0.033	0.609	0.236	0.078	0.367	2.171	0.075
Picture	0.486	0.433	0.902	0.268	0.460	0.600	0.084	0.141	0.711	0.819	0.515
Story(immediate)	0.691	0.501	0.685	0.003	0.039	0.154	0.017	0.195	0.081	2.681	0.034
Story(delay)	0.040	0.187	0.357	0.000	0.000	0.744	0.065	0.035	0.538	4.314	0.002
Face	0.079	0.120	0.806	0.001	0.000	0.602	0.158	0.058	0.461	3.452	0.010
Route(immediate)	0.763	0.387	0.294	0.583	0.334	0.457	0.829	0.964	0.726	0.516	0.724
Route(delay)	0.709	0.682	0.205	0.157	0.085	0.607	0.089	0.221	0.432	1.289	0.277
Message	0.273	0.805	0.189	0.086	0.069	0.836	0.007	0.051	0.263	2.178	0.074
Orientation	0.247	0.060	0.433	0.275	0.008	0.099	0.897	0.526	0.433	1.946	0.105
Date	0.119	0.257	0.006	0.256	0.641	0.105	0.622	0.486	0.202	2.110	0.082
Total	0.136	0.211	0.339	0.000	0.009	0.267	0.000	0.209	0.928	9.476	0.000

Note: T1: *mean difference between post-pre training;* ***T2****: mean difference between follow up-pre training;*

T3 *∶ mean difference between follow up-post training*

**= P< 0.05; **= P < 0.01*

Appendix A 20 Across -subjects contrast results of HKLLT memory process in post- pre training and follow up among CAMG, TAMG, CG groups (P value)

	CAMG vs TAMG			CAMG vs CG			TAMG vs CG			F	P
	T1	T2	T3	T1	T2	T3	T1	T2	T3		
Random encoding	0.005	0.010	0.491	0.000	0.000	0.331	0.005	0.025	0.818	8.193	0.000
Random storage	0.010	0.010	0.536	0.000	0.000	0.692	0.002	0.011	0.806	8.285	0.000
Random retrieval	0.501	0.344	0.741	0.002	0.020	0.157	0.000	0.002	0.313	3.752	0.006
Blocked encoding	0.007	0.030	0.522	0.000	0.000	0.037	0.005	0.076	0.180	7.386	0.000
Blocked storage	0.001	0.010	0.159	0.000	0.000	0.021	0.017	0.038	0.429	7.816	0.000
Blocked retrieval	0.574	0.299	0.300	0.001	0.036	0.054	0.000	0.003	0.424	4.472	0.002

***Note*: *T1*: mean difference between post-pre training;**

***T2:* mean difference between follow up-pre training;**

***T3*：mean difference between follow up-post training*

**= P< 0.05; **= P < 0.01*

Appendix A21 Across -subjects contrast results of MFQ scores in post- pre training and follow up among CAMG, TAMG, CG groups (P value)

Sub-test items	**CAMG vs TAMG**			**CAMG vs CG**			**TAMG vs CG**			**F**	**P**
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**		
Frequency of forgetting	0.065	0.336	0.446	0.000	0.000	0.107	0.000	0.008	0.442	8.395	0.000
Seriousness of forgetting	0.352	0.63	0.627	0.000	0.003	0.053	0.000	0.017	0.175	6.470	0.000
Retrospective functioning	0.04	0.328	0.106	0.048	0.141	0.637	0.849	0.678	0.238	2.112	0.082
Mnemonics usages	0.047	0.267	0.426	0.000	0.000	0.868	0.000	0.000	0.341	10.185	0.000

Note*: *T1:* *mean difference between post-pre training;

T2: *mean difference between follow up-pre training;*

T3: *mean difference between follow up-post training*

**= P< 0.05; **= P < 0.01*