A REVIEW OF THE LITERATURE ON
THE ROLE OF COMPUTERS FOR PEOPLE WITH BRAIN INJURY

Beginnings
The emergence of personal computers in the late 1970s and early 1980s also marks the beginning of a period of experimentation with computers to assist people with cognitive disabilities. As has been the case in many other professional areas, the arrival of computers among those involved in cognitive rehabilitation has produced diverging responses.

One of the pioneers was William Lynch in the USA in the late 1970s. Such was the early enthusiasm that in 1983 the UK Government distributed Acorn BBC computers to 43 occupational therapy centres throughout the UK. This platform came to dominate the field in the UK, whereas in the USA the Apple II computer was more prominent. Initially the response was generally enthusiastic and positive:

While there are many therapeutic modalities that will serve to reorganize and enhance the (function of damaged) cognitive processes... none compare to the potential offered by the computer. The computer may be the most powerful tool in the area of cognitive rehabilitation.

Purdy was able to comment in 1989 that “the personal computer has greatly contributed to the area of cognitive rehabilitation”. The benefits noted were:

- To supplement a formal therapy program;
- To be used to improve or maintain the current level of cognitive functioning once formal treatment has been discontinued;
- To provide the injured individual with something productive to do in his or her spare time; and

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2 Bracy O.L., “Computer Based Cognitive Rehabilitation” Cognitive Rehabilitation 1(1) 7 1983
• To develop skills that could be used outside the therapeutic environment such as at school or work.”

Early Studies
Some early studies were promising, thus endorsing the initial positive reaction to computers. Skinner (1985) successfully used PC Coloring Book software to work on attention span, visual scanning, colour discrimination, sequencing, eye-hand coordination and motor planning with patients with brain injury. One patient increased her attention span from 5-7 mins to 15-20 mins. These gains were apparently carried over to over activities.

Kerner’s study (1985) also achieved positive results: “This study has demonstrated enhancement of memory skills in head injured individuals using memory retraining software on a Apple II+ computer”. Motivational benefits were noted, and generalization of skills, but the participants lost ground in many areas after 15 days.

Malachowski (1986) believed that writing is important for head trauma victims, as it assists in learning, and involves the objectification of language. It also assists with eye-hand-brain coordination. Computers were seen to expand these benefits, and were described as “invaluable composing aids for head trauma victims”. In one case the computer helped the patient with neatness, visual reinforcement and the ability to self correct. “The microcomputer has given her a new sense of freedom and flexibility” and she was now writing to her family and friends.

Abbot (1989) also saw benefits in word processing for a patient with brain injury:

4 ibid p. 37
8 ibid p. 13
The more Max used the word processor, the more we saw this treatment approach was beneficial to him in his daily life. We noted that it helped him compensate in many aspects of daily living, assisted him in his vocational planning and served as a compensatory device for his memory deficits...It provided him cognitively with structure, organization and served as a compensatory strategy for his memory and planning skills.9

**Reaction**

Around the end of the 1980s several influential articles cast doubts on the efficacy of computer assisted cognitive rehabilitation (CACR10). Batchelor et al. conducted a study with 34 patients, with one group using computer-assisted cognitive treatment and the other using standard non-computer treatment.11 They concluded:

The results of the present study failed to support the hypothesis that computer-assisted cognitive therapy, at least in the form employed in the current research, is any more effective in remediating disorders of memory, attention, information processing, and higher cognitive functioning in severely head-injured patients than are noncomputerized techniques.12

While conceding that the computer may offer “clinical advantages”, and that the results “may reflect the inadequacy of the software that was employed”, they nevertheless questioned the allocation of resources to computer-assisted cognitive retraining.13

Another critique was offered by Robertson (1990), who noted the poor quality of many of the published studies. Many were seen as anecdotal, with poor controls and deficient analysis of results.

No computer cognitive rehabilitative procedures have been shown to generalise to real life and there is no existing empirical basis for the sale

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10 This term is generally used in reference to computer-based programs aimed at the restoration of cognitive function.


12 ibid 83.

13 ibid. A commentary by Claude Munday appended to the article points out that the study applied to patients in the acute recovery phase, leaving open the possible benefits of computers in later phases.
Lynch also criticised the early studies, with their small groups, lack of controls and limited software. He noted that these studies make it difficult to tell whether the results are due to the software itself or the frequency, pattern and duration of delivery. The issue of input devices had been completely overlooked. The whole process has, he argues, been so boring that “Should we be surprised that so many of our patients fail to generalise the gains they demonstrate in the clinic?”

While aspects of these critiques are valid, some also indicate a misunderstanding of case study methodology. They attempt to apply verification criteria that are not appropriate to this form of research.

Perhaps more indicative of the mood of the time was the reaction to an article by Ross (1992). This study “may have reduced the overall use of computers within occupational therapy departments” according to Stern. Yet a closer look at the study, which failed to find any cognitive gain through the use of computerised visual scanning training, makes it surprising that it can be called upon to support any conclusions about the role of computers in cognitive rehabilitation. It is part of a Master’s thesis, and involved three participants. The article itself acknowledges that its results are not statistically significant, and that it is not possible to distinguish the outcomes from intervention from those arising from practice effects and spontaneous recovery. Serious methodological problems are also acknowledged by Ross, such as the failure to establish a stable response pattern by subjects during the baseline phase. Ross concludes:

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15 Lynch W., “Ecological validity of cognitive rehabilitation software”, op. cit p. 41
16 Yin R.K., Case Study Research: Design and Methods, Sage: CA (1994)
One cannot make highly accurate predictions from these data...This study neither supports nor refutes the validity of computer-based remediation in the achievement of performance-based occupational therapy goals.\textsuperscript{19}

Other articles around this time indicate a change in the mood, especially by therapists, regarding the use of computers for people with brain injury. This could be regarded as defensiveness on the part of therapists who, as with many other occupations and professions, saw computer technology as a threat. Several articles retreated from the contention that computers may help restore cognitive functioning, and instead confined them to the role of providing tools for therapists. This was the approach of McGuire (1990)\textsuperscript{20}:

They are capable of highly controlled presentation of stimuli in a standardised format and can record data more accurately, consistently and objectively than can a therapist or observer. They can then analyse and record these data in a permanent record which is easily accessed. The stimuli presented can be attractive, bright and colourful, helping to engage and focus the patient's attention...the computer is infinitely patient...is able to present a variety of tasks according to the patient's needs and abilities, at a level which will challenge but not frustrate the patient. Feedback can be provided immediately in a clear, consistent and non-judgemental fashion. The patient is able to work at his or her own pace in a non-threatening environment, and can make mistakes without feeling any of the humiliation which may occur in interpersonal situations. (303-304)

But he notes that computers offer no substitute for the personal relationship the patient can develop with patient.\textsuperscript{21} The role of the therapist was thus preserved.

\textbf{Re-assessment}

The period from the early 1990s has provided an opportunity for a more sober assessment of the aims and issues involved in the use of computers for people with brain injury. A fairer evaluation of the role of computers was able to take place at this time.

\textsuperscript{19} Ross F., \textit{op. cit} p. 320
\textsuperscript{21} \textit{ibid}
Several critical factors have provided a backdrop to this period of re-assessment. The first was the recognition that it is virtually impossible to distinguish any gains in cognitive function derived from CACR from natural recovery. “The most fundamental obstacle arises from individual differences in spontaneous recovery from head injury”.22 Natural recovery occurs at different rates for different patients, and this makes research in this area very difficult.23

A second factor in the re-assessment of the role of computers has been brought about by changes in the world of computers. There has been a growing sense of inevitability that computers have a role of the rehabilitation of people with brain injury, as they have established a role in almost every other sphere of work.24 But also the types of changes in computer capabilities and features have been seen as favourable for their use in cognitive rehabilitation.25

A final and possibly most significant element in this re-assessment in the 1990s has been a more careful definition of aims. Are we really seeking to use computers to restore cognitive function, or are we using them to help people adapt to their new circumstances? Subsequent studies have followed one or other of these two streams.

Computers and the Restoration of Cognitive Function

There are those who remained committed to the task of using computers to achieve demonstrable restoration of cognitive functioning among patients with brain injury. They believed that we need to be more specific in targeting areas of cognitive deficit, and be more careful in the selection of suitable patients, in order to achieve positive results.

24 See for example Stern op. cit., 1999 (549), McBain & Renton op. cit., p. 203
25 McBain & Renton op. cit., p. 203
Bergman (1991), for example, argued that we must look at pertinent neuropsychological weaknesses (such as inattention, visual neglect) and use this information in the design of a computer prosthesis:

Although a neuropsychologically unguided design process may serendipitously create some helpful features, the potential is great that it will become a scattered, inefficient and trial-and-error exercise…will place undue stress on the brain-injured user. 26

Lynch (1992) proposed that a battery of psychological tests (especially targeting reaction times and memory) should be used to determine the suitability of patients for CACR and to pinpoint the goals of a program.27

Mazaux (1998) saw developments in brain imaging as offering prospects for more precise rehabilitation after traumatic brain injury, and sees computers as able to complement face-to-face therapy.28

Several studies have achieved positive outcomes. In one study by Ruff (1994) software called THINKable was used by 15 patients with severe traumatic brain injury. The attention and memory remediation modules of the program were used by each patient for up to 20 hours. The study concluded:

“Significant results were documented on the computerized tasks, psychometric measures and on patient and observer ratings of everyday behaviours of attention and memory”.29

A study by Gauggel and Niemann found some improvements among four patients in training tasks, tests of attention and a visual memory test, when using a computer-assisted training program, but no improvements in verbal

26 Bergman M., “The necessity of a clinical perspective in the design of computer prostheses” Journal of Head Trauma Rehabilitation 1991 6(2) p. 103
29 Ruff R. et al., “Efficacy study of THINKable in the attention and memory retraining of traumatically head-injured patients”, Brain Injury 8(1) 1994, p. 3
memory tests or in a general intelligence test. However it was not possible to isolate the gains from spontaneous recovery.  

Another successful study was that conducted by Thomas-Stonell using remediation software:

Significant group differences were found on several of the standardised assessment battery test scores suggesting that the remediation modules are an effective enhancement to traditional rehabilitation and education programs. Skill improvements were not instrument specific... but generalised to noncomputer-based activities as measured by the standardised assessment battery... anecdotal reports suggest that skill improvements from the remediation program generalized to classroom activities.  

Chen (1997) summarised a number of studies that used the Psychological Software Services Package to achieve specific gains. Gains were made in 9 studies, but no gains in 4 studies. Chen noted that the successful studies had longer treatment duration (3-6 months) and posed the possibility that "variations in the duration and intensity of therapy may have accounted for differences between these outcome studies".  

Recent work at the Hong Kong Polytechnic University, using more modern technology such as virtual reality, has found that computer-assisted cognitive rehabilitation "had significant improvement in memory, problem-solving and functional skills like writing, reading, following treatment".  

Gianutsos (1992) took a slightly different approach, by arguing that computers "permit the establishment of home-based computer-augmented rehabilitation programs, which allow aggressive pursuit of restoration of function in through exercise and practice". While also acknowledging the compensatory role of

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32 Chen op. cit p. 198  
34 Gianutsos R., “The computer in cognitive rehabilitation: It’s not just a tool anymore Journal of Head Trauma Rehabilitation 7/3 1992, 26-35 p. 26
computers (such as using word processing to compensate for a poor memory), she sees benefit in seeking restoration first:

A good argument can be made for beginning therapy with restoration as a goal, even when the goal might be remote. There is value in having pursued restoration, even when it does not occur … computer technology facilitates the pursuit of restoration of cognitive functions. Whatever the outcome, if the individual has been given an option and decides how far to pursue it, the result should be positive psychologically. 35

Such an approach sees value in the pursuit of restoration, regardless of the outcome.

The results from the restoration approach have been mixed. Yet such an outcome should not be unexpected from its very methodology — positive results will only come if specific areas of cognitive functioning are targeted, patients are carefully chosen, appropriate software used and for a long enough period.

Generalisation of skills, however, will always be an issue with the restoration approach, where the software used tends to focus on drill and practice rather than real life situations. As Rizzo notes, restorative approaches involve “overemphasis on the brittle performance of overly learned functional behaviours, with a neglect of the underlying cognitive abilities required for the flexible problem solving needed to handle normally occurring variations in real-world circumstances”.36

**Computers as a Compensatory Strategy**

The other approach since the 1990s has been to use computers to help people learn skills they can use in everyday situations. In these studies there is no attempt, nor any need to attempt, to demonstrate improvements in cognitive

35 ibid 29-30
functioning. It is a case of helping people with brain injury to better use the capabilities they have.\textsuperscript{37}

One of the earliest proponents of this strategy was Glisky (1992).\textsuperscript{38} She describes the compensatory or alleviation approach as “training patients to perform specific functions in everyday life that they would otherwise be unable to perform because of the memory problems”.\textsuperscript{39} She notes the promising role of a computer in this role for the patient at home:

Various kinds of information relevant to everyday activities – listings of addresses and phone numbers, scheduled daily activities, information about home finances or budget, instructions for carrying out household chores, medication regimes, special dates, and so forth -- can be stored in a computer database and retrieved when necessary. Used in this way, a computer essentially functions as a memory prosthesis, providing a reservoir of facts that might otherwise be unavailable to patients with memory deficits.\textsuperscript{40}

However the main focus of Glisky’s own research was on the teaching of domain-specific knowledge, which she regards as an alternative compensatory strategy:

The studies reported in this article had demonstrated that TB I patients with memory and learning deficits are capable of acquiring considerable amounts of complex knowledge and skills relevant to important domains of everyday life. Although their learning is slow compared to normal, patients are nevertheless able to acquire complex computer tasks such as data entry, database management, and word processing, and to use them to enhance independent functioning both at home and in the workplace. In the reported studies, the microcomputer played a major role.\textsuperscript{41}

Many other studies have followed Glisky’s approach, seeking ways in which computers may help people learn skills necessary for coping with everyday life. This has had the effect of broadening the debate about computers and

\textsuperscript{37} See Pepin \textit{op. cit.}, (1995) who postulates that “everyone is able to learn in varying degrees” and that this “does not require any specific inferences from the underlying neurological mechanisms” (8)


\textsuperscript{39} ibid p. 2

\textsuperscript{40} ibid pp. 6-7

\textsuperscript{41} Glisky \textit{op. cit} p. 10
their role in assisting people with brain injury. Lynch coined the term ecological validity to describe “the extent to which performance on a training activity predicts performance on a target task that is considered relevant to the patient’s adaptive functioning”.42 He saw this as an alternative to using computers for restoration of function. They can be used “purely as prosthetic devices allowing the patient to accomplish a specific treatment or vocational objectives”.43

Reid (1995) argued that assistive technology is not just about the enhancement of specific functional capacities. Rather, it has “a more general and much more powerful goal: social inclusion”.44 Social inclusion is taken to mean full and meaningful inclusion in all relevant contexts. Assistive technology, including computers:

permits children with disabilities following traumatic brain injury to function in many different environments, achieve greater academic success, and participate within the community rather than growing up in social isolation.45

This study fits in well with the compensation approach.

A study by Birnboim (1995) used a computer to help patients understand their own thinking processes.46 A program was used to teach and train patients how to analyse their strategies and then apply them in real life situations. “Patients come to realise that problem solving, which was an automatic skill before their brain damage, now requires constant monitoring efforts”.47 Perhaps McGuire’s conclusion is salutary: that computers “appear most competent in aiding the learning of particular skills or information sets than regenerating complete areas of cognitive functioning”.48

42 Lynch W. op. cit. (1992) p. 36
43 ibid p. 44
44 Reid S. et al., “Computers, assistive devices, and augmentative communication aids: Technology for social inclusion” Journal of Head Trauma Rehabilitation 10(5) 1995 p.81
45 ibid p. 89
47 ibid p. 63
48 McGuire B., op. cit, p. 306
On the whole, the use of computers as a compensatory strategy for people with brain injury has been a liberating one. It has opened up creative pathways for the use of computers. No longer has the role of computers been sidelined by the elusive requirement that restoration of cognitive function be demonstrated.

**New Frontiers**
The distinction between restorative and compensatory approaches to the use of computers for patients with traumatic brain injury does not exhaust the important developments of the 1990s and beyond. Several other themes have emerged.

The first is the recognition that software used in cognitive rehabilitation must be *user friendly* and *age appropriate*. Jarvis (1990) noted the drastic consequences that can flow from ‘unfriendly’ software:

> Patients will probably react in whatever maladaptive way is most characteristic for them. Some may experience increased feelings of inadequacy and depression, some may increase demands for dependency on the therapist, and others may ‘project’ the blame onto the computer. In any case the ‘unfriendliness’ of the software is likely to reinforce the patient’s maladaptive responses. 49

As previously mentioned, Lynch was critical of the boring nature of much of the software used in CACR.50

The problem of age appropriateness of software is well known among therapists. McBain (1997) noted the growth in special needs software, but identifies “problems in using this software with adults. Often patients with head injury find that educational computer programs are not age-appropriate and, therefore, not fully motivating”.51 Software that is age appropriate for

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51 McBain & Renton *op. cit.*, p. 203
adults is often too fast and too cognitively demanding for those with brain injury.

The matter of *computer access* has also been given some prominence in the 1990s.52 Lynch identified neglect of this issue as one of the problems of earlier studies of CACR software.53 O’Leary (1991) observed that “For the person with traumatic brain injury, access to a personal computer may be improved through the use of positioning, adaptive aids, adaptive hardware, and adaptive software”.54 She mentions a range of adaptations, most of which are still relevant:

- Adjustments may be required to monitor height or keyboard position.
- Mobile arm supports, slings or splints may help.
- Trackballs may be useful.
- Software such as Sticky keys and word prediction can assist.
- Mouthsticks, headpointers, infrared controllers and on-screen keyboards may all be useful where control by head movement is required.
- Screen enlargement or large monitors may assist.
- Auditory and visual cues can be modified to increase attention and sensory input. 55

A case study by Gutman also highlighted a range of adaptations that facilitated computer access for the client. These included adjustments to the key-repeat feature, auditory feedback for key presses, simplification of the main desktop interface, reduced toolbar options, increased font size, prompts to attend to the computer after gaps of more than 5 minutes, automatic saving

54 O’Leary S., *op. cit.*, p. 91
55 ibid
of open documents every 2 minutes and offsetting the screen image to the right by an inch.56

Other developments since these studies have also proven useful. These include high quality speech output, multimedia technology, large animated cursors and a host of alternative mouse devices (including joysticks and control systems based on head or mouth movement).

However Scherer offers some cautionary advice:

As the number of assistive technology options increase, individualized interventions for individuals with cognitive disabilities will be easier to accomplish. The key to successful and optimal use of these products will be an appropriate and comprehensive assessment of consumer needs and preferences and the identification of additional accommodations and supports.57

The need for careful matching of clients’ needs and preferences with available technology is probably more crucial in the case of those with cognitive disabilities than those with physical disabilities. Otherwise the danger of technology abandonment will arise.

A third important development since the 1990s has been the use of virtual reality in cognitive rehabilitation. Put simply: “... information gained from experience in a VE [virtual environment] can transfer to the real world... in a simulated world disabled people can enjoy experiences that would otherwise be denied them”.58 From a therapist’s perspective virtual reality enables one to “assess a patient’s ability to perform everyday functions...without endangering the patient and without sacrificing strict control over the test situation”.59 One recent review concludes: “the use of VR in brain damage

56 Gutman S., “Using a computer an an environmental facilitator to promote post-head injury social role resumption: A case report”, Occupational Therapy in Mental Health 15/2, 2000, 71-90.
59 Ibid p. 217
rehabilitation is expanding dramatically and will become an integral part of cognitive assessment and rehabilitation in the future”.

Virtual reality also offers the possibility of overcoming the distinction between restorative and compensatory techniques. As Rizzo explains:

“It may be possible for a VR application to provide systematic restorative training within the context of functionally relevant, ecologically valid simulated environments that optimise the degree of transfer of training or generalisation of learning to the person’s real world environment.”

Several studies have reported on the successful use of portable computer devices as memory aids for patients with brain injury. Ten out of 12 participants in one study found these memory aids “very useful”. A more recent study of 80 people with moderate to severe TBI, median 3.7 years post injury, concluded that “portable electronic devices are acceptable or desirable by consumers with moderate to severe TBI for use as compensatory aids”.

However some problems have been identified with this platform, including the need for the patient to locate and interpret information on the device, the danger of accidental erasure of data and the possibility of damage (as the device must be held in the hand when used). One device that overcomes some of these problems is the ISAAC, a “small, individualized, wearable cognitive prosthetic assistive technology system”. User access is via a touch screen, while content is developed on a PC using authoring software. Data is

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66 Gorman P. et al., “Effectiveness of the ISAAC cognitive prosthetic system for improving rehabilitation outcomes with neurofunctional impairment”, NeuroRehabilitation 2003, 18, 60.
also logged, giving information on user interactions and responses over a period. Gorman’s study, involving two patients, illustrates the potential of such a system.\(^67\) Other studies have found some success with portable *voice organisers*.\(^68\)

New developments in *telecommunication* have also had an impact, particularly the advent of email. This has been the focus of detailed research funded by the National Institute on Disability and Rehabilitation Research in the US. One of their prime findings has been: “Our longitudinal data clearly documented improvements in self esteem and feelings of social connectedness associated with long term emailing”.\(^69\) The research has resulted in the development of a commercial product called *Coglink*.

High speed internet connections have also spawned the development of interactive rehabilitation strategies for people with cognitive impairments. One is called *telerehabilitation*, analogous to *telemedicine*. Ziegmann et al. report on the successful use of computer-based videoconferencing to link the therapist and patient. Both can control the patient’s computer, where the activity materials are housed. Patients are assisted in areas such as letter writing, daily scheduling, organising sequences and money management. Remote prompting, by sending messages to a mobile phone or pager, is also involved.\(^70\)

Interesting research in this direction is being undertaken regarding the MAPS (Memory Aiding Prompting System). It “provides support for a wireless safety net that affords error detection and correction by dynamically pushing corrective prompts and/or summoning appropriate levels of external assistance”.\(^71\) A support person provides real-time support through a PC to the client’s PDA. The display is clear and uncluttered, incorporates dynamic

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\(^{67}\) *ibid* 57-67.

\(^{68}\) See Hart T, Hawkey K & Whyte J., “Use of a portable voice organizer to remember therapy goals in traumatic brain injury rehabilitation: A within-subjects trial” *Journal Of Head Trauma Rehabilitation* 2002, 17(6), 556-570.

\(^{69}\) See [www.think-and-link.org](http://www.think-and-link.org); also Todis B. et al., “making electronic mail accessible: Perspectives of people with acquired cognitive impairments, caregivers and professionals”, *Brain Injury* 2005, 19/6, 389-401.


\(^{71}\) Carmien S., “MAPS: Creating socio-technical environments in support of distributed cognition for people with cognitive impairments and their caregivers” *CHI* 2004, 24-29 April, 1051.
error detection and correction, has restarting options and also has a “panic” button.

Similar is tele-cognitive rehabilitation, defined as using “customized online computer software as a treatment mode… Through implementing the tele-cognitive rehabilitation activities, therapists can help clients to practise and thus improve their cognitive skills…” Tam’s study had mixed results. The benefits were obvious – it provides a home-based service, thus avoiding the stress of travel. It offers a flexible, interactive service, easily adapted to the client’s performance and learning styles. But it depends heavily on the quality of network performance, the computer knowledge of the patient and factors (such as noise) in the patient’s home, over which the clinician may have no control.

These emerging themes have their own importance and relevance, whether one favours the restorative or compensatory approaches to CACR. They will become increasingly important as technological change continues to accelerate.

The Computer as a Motivator

When one reads the literature on the use of computers in cognitive rehabilitation, and the major themes that have unfolded over the past 25 years, one can’t help but notice a most persistent sub-theme. Studies frequently suggest that computers give people with brain injury greater confidence and self esteem, and that they provide positive motivation. This conclusion has emerged, even in studies that showed that no cognitive improvement arose from the use of computers.

One study described the methods used to enable a 54 year old stroke victim to use a computer. After eight months it was noted that he was “brighter and
he appeared more tolerant of his disability”. He was able to write letters and stories, and this improved his self esteem. Further, “the patient believed that working on the computer improved his memory and quickened his mind. It also enabled him to pursue his leisure activities for hours at a time without losing his concentration”.  

Sietsma (1993) studied 20 people with TBI who had mild to moderate spasticity in the upper extremity. The results from a rote arm-reach exercise were compared with those from using a computer-controlled game. “Results indicated that the use of the game elicited significantly more range of motion than the rote exercise”. Further, “The flashing lenses and sounds of the Simon game provided motivating feedback to enhance performance, and the game promoted more enthusiasm and increased attention span…many subjects continued playing Simon after they had completed 10 repetitions”. Malec’s study (1984) showed no improvement in performance on measures of sustained attention for patients using a games machine, compared with those not receiving treatment. However:

Subjects in the study appeared to enjoy and to be engaged by the video games. The subjects actively participated in video game sessions even though many were highly uncooperative and distractible in other rehabilitation activities.

Stern (1999) commented: “Although not clinically researched, it appears that many patients regain some self-esteem through using the computers”. Kirsch (1991) noted that computers “can increase a patient’s self-esteem and life-satisfaction”. Johnson’s study (1994) using TEACHware software observed “Both the subjects and the normal students reported that the

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76 Sietsma op. cit. p. 19
77 ibid. p. 23
78 Malec op. cit. p. 22
79 Stern op. cit. p. 552
TEACHware program was motivating and fun to use”.81 The full results of the study made a similar affirmation: “Computers provide... a motivating, interactive learning environment.” 82

Purdy’s study (1988) concluded that patients “showed an increase in attention and motivation as well as improvement in skills specifically addressed by the program”.83 Skinner (1985) found that “we have noted with all patients the increase in motivation was greater with this program than with more conventional treatment modalities”.84 McGuire (1990) noted that “This feeling of control of the situation by the patient can lead to increased motivation and feelings of self-worth”. 85 Bergman (1991) observed “Computer-enhanced self-sufficiency in the performance of routine activities improves self-esteem and emotional adjustment”. Further, “Successful implementation of a cognitive prosthesis... can lead to task mastery, enhanced self-esteem, and better overall use of resources”.86

The remarkable consistency of these comments across a wide variety of studies suggests that the motivational capabilities of computer technology for people with TBI should be taken seriously. The importance of a technique that elevates a patient’s motivation and self esteem is significant, given the acknowledged negative impact of deficits in attention for people with brain injury. Gray, for example, notes how attention deficits “can compromise rehabilitation in other spheres”. 87 Malec had earlier noted the importance of attention in rehabilitation:

Because of the close association between learning and the ability to sustain attention to the learning task, improving sustained attention following craniocerebral trauma may be critical to enhance other types of learning in other rehabilitation therapies.88

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82 Thomas-Stonell op. cit., p. 26
83 Purdy & Neri op. cit, p.34
84 Skinner A., op. cit p. 472
85 McGuire op. cit p. 304
86 Bergman op. cit p. 103
88 Malec op. cit, p. 18
So what appears to be a side-issue to the main debates of the period may be more important than at first realised. Motivation, confidence and self-esteem can be precious commodities for a person with brain injury. Gains in these areas may improve the person’s prospects for cognitive rehabilitation in general.

Computers and Employment

In spite of the fertile discussion on the role of computer technology in the rehabilitation of people with brain injury, as outlined above, there appear to be little more than anecdotal attempts to link this to employment issues. While the “increasing importance of assistive technology” is freely acknowledged, this has not been matched by studies that verify the benefits of such technology in the employment of people with brain injury. Yet the possibility is tantalisingly real:

ATC [assistive technology for cognition] interventions represent entirely new methods of treatment that can reinforce a person’s residual intrinsic abilities, provide alternative means by which activities can be completed or provide extrinsic supports so that functional activities can be performed that might otherwise not be possible.

Similarly, Gartland argues that an individual’s potential to live independently and be engaged in a vocational activity may depend on technology:

The use of technology can influence this potential through enabling a person to adapt or compensate for long-term cognitive deficits and thereby reduce the functional consequences of those deficits. Rehabilitation of such individuals therefore needs to address the use of

technology to enable the individual to perform at optimum functional ability.  

Gutman’s case study also points to employment potential for the client, who was enabled to write again through use of a computer. However this potential does not materialise into actual employment during the study. There seems little reason why the benefits of computer assistive technology would not be applicable to the workplace. Falconer observes:

> While traditional theory recommends utilizing ‘transferable skills’, clients may have no transferable skills or utilization of pre-injury skills is compromised by lack of insight, difficulty upgrading skills in selected areas, and/or perceptual deficits. A total vocational shift may be necessary to fully utilize remaining assets and minimize the effect of deficits on vocational performance. When such a shift is made, the client may have no preconceptions about abilities and may be more open to learning new skills. The ‘mystique’ of computers frequently facilitates transitioning to such employment... Although the learning process may be extremely slow, some clients can acquire sufficient skills to be competitively employable at entry level.

Importantly she notes: “Even if vocational placement does not require use of computers, clients may benefit from using one of the pocket-type computers to store information such as names, phone numbers, and basic job instructions. Some of these devices can be programmed to signal the individual to attend to time-relevant information (appointments, medication schedules, etc).”

Research into the MAPS system (mentioned earlier) has been directed towards the workplace context, but this is still in the development stage. As the authors point out:

91 Gartland D., “Considerations in the selection and use of technology with people who have cognitive deficits following acquired brain injury”; Neuropsychological Rehabilitation 2004, 14/1-2, 61.
92 Gutman S, op cit., 80-81.
94 ibid
95 Carmien S. et al., ‘Increasing workplace independence for people with cognitive disabilities by leveraging distributed cognition among caregivers and clients”; http://l3d.cs.colorado.edu/clever/assets/pdf/group03.pdf (downloaded 20/12/05).
Often the limitation for people with cognitive disabilities is not an inability to complete a task, per se, but rather an inability to manage the cognitive load of remembering the sequence of steps required to complete a task or how to problem solve when an error occurs.96

The hope is to produce a cost-effective interactive system that provides tailored prompts, as an alternative to costly caregivers and job coaches.

Why this lack of attention to the application of computer technology for people with cognitive disabilities in their work? Clearly the technology is available to benefit people with traumatic brain injury; the key issue is one of application. Some possible explanations are discussed below:

- **Narrow job expectations**: Perhaps people with traumatic brain injury and job placement agencies that support them have become locked into narrow job expectations. Jobs involving IT may not be considered as often as they could and this is reflected in academic research priorities.

- **Ignorance regarding assistive technology for people with cognitive impairments**: The application of assistive technology to those with cognitive disabilities is less well known than for those with physical disabilities, and this ignorance may be reflected in academic research interests.

- **Assistive technology not considered in non-IT jobs**: The literature makes clear that assistive devices (such as PDAs) can benefit people with cognitive impairments in a range of occupations, not just those directly involving IT. This fact may not be well-known in job placement agencies and this is reflected in academic research preferences.

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96 ibid p. 100
Conclusion

Some general observations are possible from this survey of the literature in this relatively new field. Computer technology has had an impact here, as in just about all other fields.

We have seen how earlier enthusiasm gave way to suspicion and defensiveness. It was not until the 1990s that a re-assessment of the proper role of computers in cognitive rehabilitation took place. Some have pursued the restorative approach, seeking to use computer technology to achieve measurable gains in cognitive functioning. Greater rigour in the selection of software and participants has been called for. One suspects the problem of individual differences in spontaneous recovery, as well as the problem of generalising gains to real-life situations, will continue to thwart the persuasiveness of these types of studies.

The majority of studies have looked at the alternative, a compensatory strategy. Here there has been more success. Computers have an established role in assisting people with TBI to cope with real-life situations. Recent technologies such as virtual reality, multimedia, portable digital assistants (PDAs) and the internet may strengthen this role.

Other issues have been mentioned. Computers offer benefits as a therapist’s tool. They allow patients to pursue remediation of function for as long as they desire. Computer access issues for people with brain injury have been given some attention, as has the importance of user-friendly, age-appropriate software.

We have noted consistent mention of the computer as a device that increases motivation, self esteem and confidence of people with brain injury. This surely invites further research as a topic on its own right.

Finally, we have noted that there has been very little mention in the literature of the application of assistive technology to benefit people with cognitive disabilities in their work. Ignorance may be a factor in this, but one would
expect that soon to be superseded by the momentum of new technology, which carries such clear benefits to this group.

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