The Effects of Cognitive Rehabilitation Therapy Techniques for Enhancing the Cognitive/ Intellectual Functioning of Seventh and Eighth Grade Children

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Both computer-assisted classroom education and computer-assisted cognitive rehabilitation are established in learning and rehabilitation methods. The use of rehabilitation techniques for the development of foundational cognitive skills in the general population of school children has gone untested. This experiment demonstrates the utility of computer-assisted cognitive skills training for improving the intellectual functioning of 12 to 14 year-old children, Eighty middle school students participated in a 9-week study. The students were enrolled in either a computer-assisted cognitive skills training group (which utilized computerized exercises modified from brain injury rehabilitation applications) or a study hall control group. A significant increase in intellectual functioning ($p< .01$) was found only in the experimental group for Full Scale and Performance 10 scores as measured by Jackson's Multidimensional Aptitude Battery.This is an indication of the possible benefits of a computerized cognitive skills training program focused on training attentional, executive, visuospatial and problem solving skills. Replication of this study could hold far-reaching implications for future educational curricula.

Enhancing cognitive/intellectual abilities of human learning has been a topic of great interest and considerable research in both education and rehabilitation, in education, computers have seen increased use in the classroom for the instruction of advanced skills such as math and language. In the field of brain injury rehabilitation, clinicians have sought to utilize the computer as a high tech tool in the retraining of impaired cognitive skills (Bracy, Lynch, Sbordone, & Berrol, 1985). The success of this Computer Assisted Cognitive Rehabilitation (CACR) has raised the question of whether these same techniques could be utilized to enhance the intellectual function, and thus hopefully the academic performance, of non-impaired individuals.

Computers in classrooms

When computers first started to be used as an instructional tool, educators believed there would be a great improvement in student learning. "It was thought that every student could have at his/her disposal a tutor who was nonjudgmental, patient and continuously reinforcing. The potential seemed limitless." (Niemiec & Walherg, 1987). This enthusiasm generated a proliferation of Computer Assisted Instruction (CAT) studies in the education arena over the course of the last thirty years.

A number of these CAT studies report some cognitive benefit with student populations. One such study by Messerly (1986) reported improvement in SAT math scores in two groups of hearing impaired students who were given computer-assisted training. in a review of 16 articles, Niemiec and Walberg (1987) concluded that the use of CAT resulted in an increase in academic performance. MacGregor (1988) demonstrated that CAl was related to greater vocabulary knowledge in language learning among third grade students. Erland (1992) reported gains of nearly 30% on standardized tests of achievement among reading and learning disabled students after a semester of a media based "cognitive skills training" program. in a study of sixth through eighth grade students, it was found that significant increases in understanding were tied to the method of presentation (i.e., animated instruction) (Hays, 1996).

In a 1995 meta-analysis Fletcher-Flinn and Gravatt concluded that the use of CAl results in an educational benefit; however, they suggest that what likely accounts for increased learning with CAT is the improved materials. Thus while the work that has already been done seems to support the thesis that CAT can be beneficial, the active elements have yet to be identified. Rocheleau (1995) has suggested that some part of the epi-phenomena of improved performance (significantly higher grades in both English and Math) noted in many studies can be traced to more fundamental issues, i.e., socioeconomic status, home availability of computers, and quality of training materials. Other researchers, such as Mevarech and Ben-Artzi (1987) found no treatment effect for CAT in regards to achievement.

Computer Assisted Cognitive Rehabilitation (CACR)

Cognitive rehabilitation has been defined as the " reattainment of mental abilities. . following insult to and compromise of the brain (Bracy, 1986a). A number of cognitive rehabilitation methods have been utilized, many of which use specially designed computer software, and are called computer assisted cognitive rehabilitation.

The empirical evidence for CACR seems to indicate a potential for improving cognitive function. Berrol (1990) argued that there is substantial evidence supporting the effectiveness of cognitive retraining for those suffering traumatic brain injury, and Skilbeck (1991) strongly suggested that "micro-based rehabilitation" elicited improvements in the areas of "attention/information processing" and "memory dysfunction". Finlayson, Aifano and Sullivan (1987) documented improvements in "new learning and problem solving skills" following computer rehabilitation training. Beck, Heacock, Mercer, Thatcher, and Sparkman (1988) found that a group of ten Alzheimer patients, who used computerized cognitive skills training, had significant gains in remembering lists of numbers compared to a control group. Techniques researched by Ethier, Braun, and Baribeau (1989) yielded performance improvements in the areas of auditory memory, attention, visuospatial and problem-solving exercises for people with closed head injuries.

In another study dealing with patients with traumatic brain injury (Ruff, Baser, Johnston, Marshall, Kiauher, Klauber, & Minteer, 1989), patients who received computer based training in spatial, attention, memory and problem solving skills showed gains in memory tasks and a reduced error rate for visual selective attention over controls who were provided with an equivalent amount of traditional supportive therapy. Tn 1994, Burda, Starkey, Dominguez, and Vera conducted a study with cognitively impaired psychiatric inpatients. Their CACR training targeted attention, memory, visuospatial skills, visuomotor skills, and conceptualization. Significant improvements were noted on the Wechsler Memory Scale, the Trail Making Test, and on self-report measures of functioning. In a study of drug treatment patients suffering from neurological impairments (Fals-Stewart & Lucente, 1994), those receiving computerized cognitive rehabilitation demonstrated a faster rate of neuropsychological recovery than did those in the comparison groups (i.e., progressive relaxation, computer typing, and normal inpatient care).

A more recent study (Chen, Thomas, Glueckauf, & Bracy, 1997) examined the efficacy of computer-assisted cognitive rehabilitation in persons with traumatic brain injury (TBI). Twenty persons with TBI who received CACR were compared to a group of 20 persons with TBT who received traditional therapies matched for age, education, days in coma and time between testing. The difference between preand post-treatment neuropsychological test scores were used to measure improvements in the domains of attention, visual spatial ability, memory and problem solving. The traditional therapy group showed significant improvement on seven of the neuropsychological measures while the CACR groups showed significant gains on 15 of the measures. In a pilot study (Beattie & Owen, 1985) conducted within the education arena, three with learning disabilities (LD), using the same software cited in the previous study improved their scaled scores on the Kaufman Spatial Memory task.

While the educational literature is somewhat equivocal the CACR literature seems to demonstrate the usefulness of these techniques. The positive results with CACR have led the authors to hypothesize about its potential use in the traditional classroom environment. Supporting a foundational skills model (Bracy, 1986h) over more traditional classroom skills training, this study seeks to determine if a modified version of a CACR software protocol can he used to successfully improve students' cognitive/intellectual abilities as measured by standard IQ tests.

Method

Participants

The experimental and control groups were composed of 80 students between 12 and 14 years of age attending Yorktown Middle School, Yorktown, Indiana. The experimental group was comprised of 31 students who volunteered for a new elective class entitled, "Challenge of the Minds" while the control group consisted of 49 students in a study hall. Though the selection of the experimental group was not random, the two groups were equivalent as measured at baseline on the Multidimensional Aptitude Battery (Jackson, 1985). No significant group differences were found on the Verbal IQ (t = .365, *df* 78, NS), the Performance IQ (t = .72, *df* 78, NS), or the Full Scale IQ (t = .22, *df 78,* NS).

Materials

Aptitude test. The Multidimensional Aptitude Battery-Form L (MAB) is a group administered multiple choice test calibrated to match the Wechsler Adult Intelligence Scale-Revised (WAIS-R). The MAB is presented in two booklets. The first contains five verbal subtests (i.e., information, Comprehension, Arithmetic, Similarities, and Vocabulary), and the second booklet contains five non-verbal suhtests (i.e., Digit Symbol, Picture Completion, Spatial, Picture Arrangement, and Object Assembly). Every subtest has a seven-minute time limit. The MAB reports its test/retest reliabilities at .95, and its concurrent validity to the WAIS-R at .85 Verbal, .84 Performance, and .91 Full Scale.

Computer-assisted cognitive skills training software. The software used in this experiment was an adapted version of the cognitive rehabilitation software, PSSCogRehab 95. While the software exercises were initially developed to assist in the rehabilitation of people with a variety of brain injuries, they have since been utilized for the rehabilitation of other neurologically based problems including attention deficit disorder (ADD) and learning disabilities (LD). A number of the PSSCogRehab therapy exercises have also proven useful as an assessment instrument for detecting malingering (Ray, Engum, Lambert, Bane, Nash & Bracy, 1997).

A brief description of the computerized exercises used in this study is available in Appendix A. For the purpose of this experiment the therapy program was designed as a regular school course and entitled "Challenge of the Minds". The therapy protocol progresses through specific skill building tasks, beginning with the basic skills of attention and advancing systematically to complex problem-solving tasks. The theory behind the development of the programs is more thoroughly presented in Bracy (1986b, 1994).

Procedure

Students were allowed to voluntarily register to take the "Challenge of the Minds" course. Parental consent forms for enrollees were obtained. Two teachers, the fourth and fifth authors of this article, were trained in the use of the software and testing materials at a two-day seminar conducted by principal investigators. One of these teachers, a middle school science teacher, administered the pre and post course testing and served as the classroom teacher for the "Challenge of the Minds" course. Thirty five daily lesson plans that detailed the daily activities for the students covering all the exercises in order of administration, including each program's description, hardware requirements, set up, instructions to students, response inputs, data produced and criterion scores was written.

The first day of class included administration of the performance section of the MAB to both the experimental and control groups. Then the experimental group was given a brief overview of the experiment, a brief demonstration of how the software worked, and clear indication that participation was voluntary. Participants were informed that they could quit at any time without any adverse effects (only two participants withdrew over the course of the study). On the second day the MAB verbal section was administered to both groups.

On the third day the participants in the control group attended study hall while the experimental group began the first of the 35 lessons to be administered over nine weeks. At the beginning of each class, the participants were given a packet containing the daily lesson plan. They were instructed in how to fill out their daily performance results on these sheets. Each lesson was designed to be completed in a class period (approximately 45 minutes). A lesson might consist of one or more programs. included with each lesson was a target goal score for each program. Unlike cognitive rehabilitation with brain injured patients, the students were moved on to the next lesson each day regardless of mastery of goals on the lesson. However, high scores obtained by individual students were posted during classes where participants could see them as a challenge to other students. After the completion of the 35-lesson program, the last two sessions were devoted to the readministration of the MAB to both groups.

Results

Mean scores for the MAB Full (FSIQ), Verbal (VIQ), and Performance (PIQ) Scales were compared within the experimental and control groups. The scores for each group were corrected for practice effects. This was accomplished by subtracting the control group's mean change from pretest to post test from both the control and experimental groups' scores. The pre versus post test scores were analyzed for both groups using the student's t-test. A significant difference was found for the experimental group's FSIQ (t=5.18, p<.01) and PIQ (t=5.02, p<.01) scales.

The three subscales with significant improvement accounting for this overall improvement were the Digit Symbol, Picture Completion, and Picture Arrangement. No significant difference was found for any control group scale.

Table 1 Mean IQ Scores

	Experimental Group	Control Group
Pre VIQ	96.9	95.84
PIQ	96.52	98.14
FSIQ	96.1	96.27
Post VIQ	98.51	95.84
PIQ	104.7	98.17
FSIQ	101.4	96.29

The amount of change in each group's performance was calculated by subtracting the pretest scores from the post test scores. These results, called gain scores, were analyzed using t-tests. The experimental group had significantly higher gain scores than the control group for both the PIQ (t=3.58, p<.01) and FSIQ (t=3.62, p<.01) scales.

Discussion

The capability to enhance the cognitive/intellectual functioning of children and thus potentially enhance their academic performance would have profound impact on education. In addition, improved academic performance stemming from an enhanced skill base (e.g., improved attentional skills, improved deductive and inductive reasoning, ability to manipulate numbers and concepts, etc.) rather than from just educational based interventions (e.g., memorizing math tables, using rote recall exercises, memorizing steps, etc.) would appear a more desirable avenue as the child would actually "own" the skills to acquire knowledge. Our clinical work with those with impaired cognitive skills, from neurological anomalies, attention deficit or learning disability has demonstrated the effectiveness of a comprehensive Computer Assisted Rehabilitation Program of therapy. The results of this study show that a similar program may have the capability of enhancing cognitive/intellectual skills in the general population of seventh and eighth grade children. Further study of additional academic performance measures collected from the same subjects will be the focus of research reports to follow.

Table 2 Mean Gain Scores

	Experimental Group	Control Group
VIQ	1.605	0
PIQ	8.185	0.08673
FSIQ	4.977	0.02286

The significant changes reported above all involved skills that would be classified as visuospatial in nature. Significant differences were not present for measures that were more verbally based. This is not surprising since our therapy tasks were almost totally visuospatial in nature and were, in fact, presented in the format of video games.

Our future research in this area will include more comprehensive measures of cognitive skills to include more verbal based functioning, memory, and problem solving functioning. In addition, we plan to further study and refine the training program in order to broaden the skill areas addressed and affected by the intervention. It is our premise that as much effort should be applied to the acquisition of the basic skills required for educational pursuits as is applied to the presentation of educational material. The end result may be children better enabled to utilize what they are learning and better equipped to learn.

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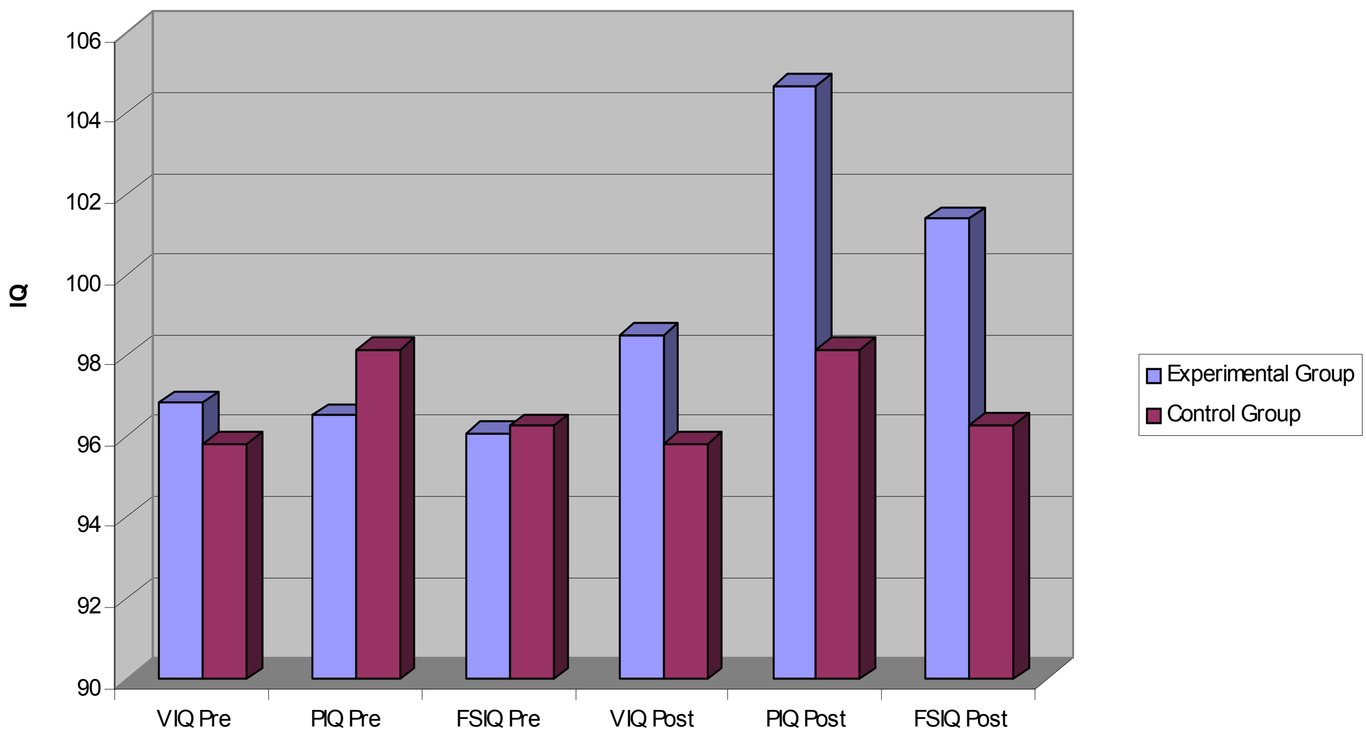
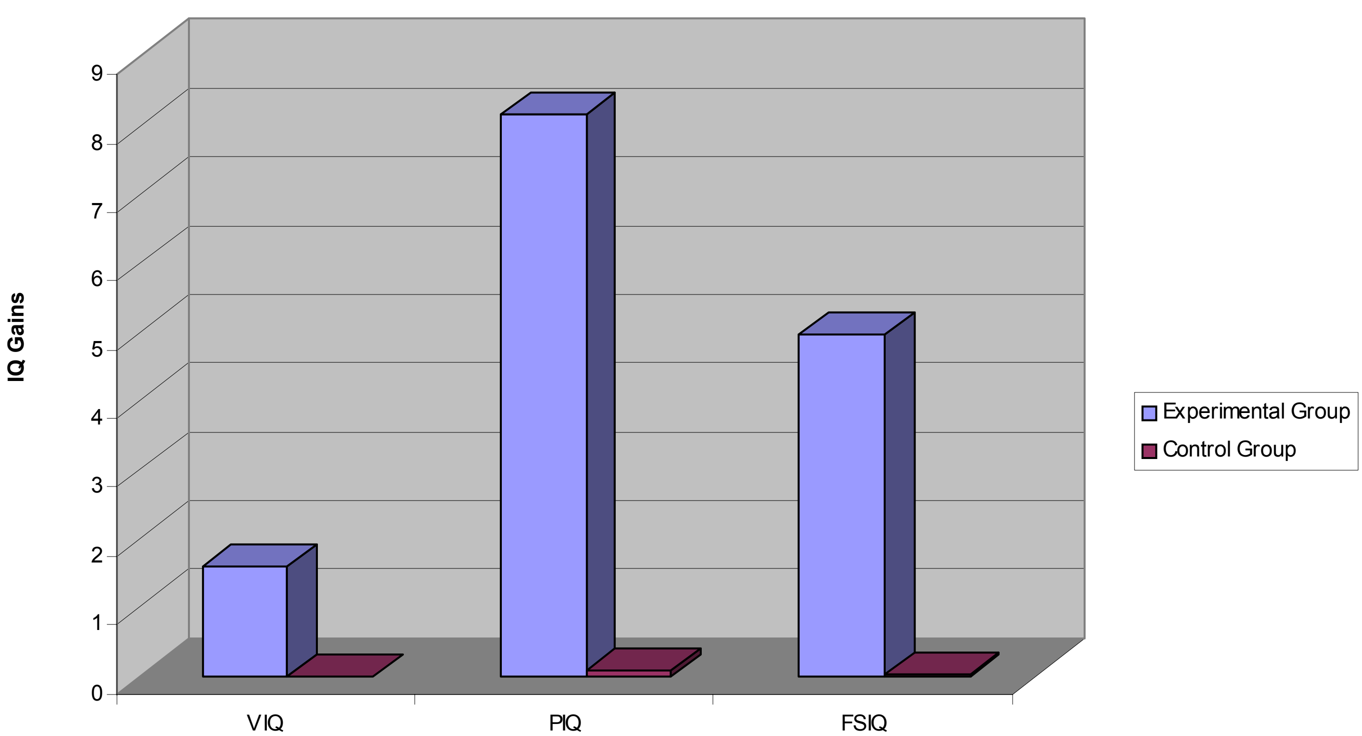
Graph 1 Mean IQ Scores



Graph 2 Mean Gain Scores



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Appendix A

Computer Program Descriptions

Simple Visual Reaction (I and II) – the participant responds as quickly as possible to a yellow square which appears randomly on the screen.

Visual Reaction Stimulus Discrimination (I and II) – either a blue or yellow square appears randomly on the screen, and the participant must react as quickly as possible to the yellow square while inhibiting any response to the blue square.

Visual Reaction Differential Response – a black square appears on the screen randomly and the participant reacts by indicating which half of the screen the square appeared on.

Visual Reaction Auditory Prestimulus – the participant must respond quickly to a randomly occurring square while inhibiting any response to the auditory stimulus that precedes the visual stimulus.

Visual Discrimination Differential Response I – the participant must respond to either a blue or red square randomly appearing with the designated hand (e.g., left hand for red square, right hand for blue square).

Visual Discrimination Differential Response II – three large squares are presented at one time and the participant responds whenever either of the outside squares matches the center square by pushing the right button if the square on the right matches the center, etc.

Visual Scanning/Tracking – a black line is plotted left to right down the screen, and the participant must react whenever a yellow block appears on the black line.

Simple Auditory Reaction – a tone is presented after random delays and the participant responds to the sound as quickly as possible.

Auditory Reaction Visual Prestimulus – a target tone is preceded by a yellow square and the participant must react to the tone while inhibiting a response to the visual stimulus.

Visual Reaction Multiple Stimuli – three colored blocks appear randomly on the screen and the participant must respond as quickly as possible if two or more of the blocks are yellow.

Multiple Attention/Multiple Response – the participant must keep the indicator needle from falling into the danger zone (too far left or right) on 1 to 5 dials simultaneously (depending on level of difficulty). This is done by indicating the dial he/she is reacting to with one key and the needle change of direction with another key.

Complex Attention I (Even/Odd) – three digits are displayed in the center of the screen and the participant presses "E" if the digits sum to an even number or "0" if the digits sum to an odd number.

Visual Scanning II – the participant is shown a target stimulus (punctuation mark) and then the 10 squares appear with various punctuation marks at the center of each surrounded by a number. The participant must indicate the correct square by pressing the key with the number that surrounds the correct punctuation mark.

Visual Scanning III – two columns of the same alphabet characters but in a different order are displayed on each side of the screen. The computer randomly selects a character in the first column and then the participant must move the highlighter to the same character in the second column. The computer then randomly highlights a character in the second column and the participant must identify the new character in the first column.

Maze (I and II) – the participant moves a small black square through a maze without touching the walls of the maze.

Cube in a Box (I and II) – the computer randomly moves a square around the screen and the participant tries to keep a smaller square inside the larger square.

Guess Which Shape – the computer fills in a shape dot by dot and the participant indicates the shape from a number of predetermined shapes (4, 8, or 16 shapes) as soon as he/she guesses which shape it is.

Designer Patterns – the computer randomly creates a pattern of blocks (difficulty can be set in pattern from 2 by 3 to 12 by 16), and the participant attempts to copy the pattern with provided blocks.

Spatial Perception I – the computer creates a 5 by 5 matrix in which one white block flashes randomly and the participant identifies which block was white by using coordinates 1-5 along top and side of matrix. With each correct response, the computer flashes speed up until a top speed is reached.

Verbal Memory (Sequenced Words) – the cornputer presents three 4-letter words which the participant studies and then recalls from a list of sixteen words. Following a correct response the computer adds a word to the next presentation.

Auditory Memory – the computer presents a series of either ascending or descending tones and the participant must indicate the tones in the order presented.

Visual/Spatial Memory – shapes are placed at random locations in a grid on the monitor and the participant must recall the location in which the object was displayed. Following success the computer adds to the number of shapes presented.

Spatial Memory (Objects/Locations) – the computer shows an object in a location on the screen and the participant must then indicate the object/location from a screen full of 30 objects. The computer increases the number of objects shown with each passed trial.

Recognition Recall (I, II, and III) – the participant studies for 1 to 15 seconds a picture containing 19 items and then must select the items from a 90-word list. Feedback is provided and the participant may make three attempts.

Visual Memory (Sequenced/Spatial) – the participant must select the one square on a 3 by 4 matrix that turned black briefly. Following trials will increase the number of boxes that flash black and the participant must enter their response in the exact order the boxes flashed.

Number Manipulations I – the computer presents individual numbers for a serial addition task and the participant has to remember the previous number to add to the new number flashed on screen.

Number Manipulations II – the computer presents a string of number digits in mixed order and the participants must resequence the series from lowest to highest. The only way to resequence the series is by successive reversals of portions of the string of digits.

Checker Exchange – the participant alternates sides moving one checker from each side of the board one space in a traditional checkerboard set up.
No jumping is allowed and the goal is to totally exchange all the checkers from both sides/teams.

Deduction – the computer hides five markers on a 12 by 12 board and the participant has to determine were the five markers are by firing probes through the board along straight lines. The participant tries to determine the location of the markers while firing as few probes as possible. The probes can be fired from anywhere along the four sides of the board.

Number Manipulations III – the computer flashes numbers from one to five on the screen (up to 5 numbers total) one at a time and the participant must keep a running total. At level 2 and 3, the participant must keep a cumulative total of each column separately.

Color Match – there is an 8 by 8 grid with colors hidden behind each square. There is a match for every color, and the goal is for the participant to turn only one square at a time and remember the colors so that he/she can match all the 32 squares in as few moves as possible.

Corner's Game – a two by two grid is displayed which contains four random numbers. There is an adjustable period of time for a blank screen to appear followed by a request for the participant to supply the previous numbers.

Dot-to-Dot – the computer shows a line/dot diagram that the participant sequentially reproduces from memory on a 5 by 5 grid of large dots.

Shapes-in-a-Row – the computer presents geometric shapes in a row, and the participant has to recall the shapes in sequence. For each successful response the computer adds a shape to the sequence.

Sounds-in-a-Row – the computer generates tones in a sequence and then the participant has to recall the tones in sequence. For each successful response the computer adds a tone to the sequence.

Trail Trace – the computer generates a hidden path that the participant attempts to discover by trial and error. Any time the participant makes an error the pathway disappears leaving the participant to retrace from memory the previously discovered pathway before continuing.

Visispan – the computer flashes a sequence of lights on the screen on a 3 by 3 grid which the participant then reproduces on the keyboard.

Spots – the participant scans the screen to find T to 4 small blinking blocks, the location of which must be retained for later recall.

Number Comparison – the participant quickly scans for sets of numbers to determine which two sets match, then the participant must enter the digits from the matching pair.

Digit/Symbol Transfer – the computer displays a key of nine numbers paired with nine symbols at the top of the screen. The participant must rapidly supply the missing numbers that go to the symbols on the rest of the screen.

Visual Search – the computer hides three numbers within a screen filled with alphabet characters, and the participant attempts to locate, identify, and enter the three numbers as quickly as possible.

Sequential – the computer displays eight pictures on the screen that represent sequential stages of a complete image composed of colored lines and shapes. The participant indicates the proper sequence of pictures.

Guess Which Design – the computer places four graphic images one each in the four corners of the screen, and then begins to draw an image in the center of the screen piece by piece. The participant quickly indicates which of the four images the center drawing matches.

Deduce It – the computer randomly selects a 3-digit number and the participant attempts to determine the number by utilizing seven mathematical clues given by the computer.