Analysis of a continuous recognition test using photographs:

Test-retest reliability and variability, inter-test consistency, and signal-detection theory parameters

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ABSTRACT

Background: Measuring memory, particularly that aspect described as declarative, episodic, or retentive, which is that type most associated with dementia and Alzheimer's disease, has presented a significant logistical problem. The currently available memory tests are mostly based on the Auditory Verbal Learning Test, originally published in 1907 by Édouard Claparède. These tests are time-consuming and generally must be administered by a psychometrician in a one-to-one interaction with a participant in a confidential and quiet environment. Such tests must combine long duration and participant burden with poor accuracy and a low ceiling effect making assessment of normal individuals problematic. There is a need for simple, accurate memory tests that can be administered quickly and that are feasible for testing older individuals.

Methods: The MEMTRAX Memory Game is a continuous recognition paradigm that was adapted to an on-line slide show format. The format is a 50-slide test, that has 25 unique pictures, 15 repeated once, and 10 of those repeated a second time. The pictures are presented on a computer screen, for 3 seconds or until the subject presses the space-bar. The instruction is that the space-bar be pressed immediately if the subject perceives that a picture is a repeat of one shown before in the sequence. In this study, subjects took a series of tests each day of the week for 2 weeks. The MemTrax game was provided in 11 different forms that were given twice each session. Two tests were each offered during a specific day of the week, both weeks. In some cases, if a subject needed to take an additional test, test #11 was provided. Analyses were made of percent correct (hits) and percent correct rejections, as well as signal detection parameters d' and beta and reaction time to hits.

Results: In this study, 12 subjects, employees of the Kronos Science Laboratory, with no known medical problems, volunteered to participate. Subjects were allowed to miss 2 days of testing, and subjects took between 15 and 20 MemTrax tests each. Subjects' ages varied from 32 to 68 years. Performance levels varied across subjects to an expected degree, with minor outliers in different measures, but generally all subjects performed in what can be considered a normal range. Only one subject had several reaction times above 900 msecs. There were no significant performance differences across the 11 tests and no significant relationships between performance and age, specific tests, test order, or repetition of tests.

Conclusions: The MemTrax test versions provided in this study showed substantial equivalence in performance across tests as well as stability across a 2 week period of testing. Individuals did vary significantly between each other, with each subject's performance consistently characteristic of the individual and showing less variability than was present in the population. Age has been shown to disrupt episodic/declarative memory in other tests, but no significant age effect was seen in this population in the age range of 32 to 68 years of age. Versions of the test, test order, and test-repetition did not affect performance. MemTrax has the potential to provide highly accurate and cost-effective evaluation of memory function and screening for memory problems.

BACKGROUND

Memory is the most fundamental function of the cerebrum. Memory is complex and spans numerous functions. However, the aspect of memory involving the retention of new information, often called episodic or declarative, is related to the function of the structures of the medial temporal lobe, and the neural substrates of this type of memory are particularly vulnerable to a variety of disorders, including traumatic brain injury, vitamin deficiency, chemical toxicity, and neurodegenerative conditions including Alzheimer's disease. Generally, this type of memory is assessed with auditory verbal learning tests (e.g., the REY AVLT, the California AVLT, the Hopkins AVLT, the Buschke SRT) or picture recall tests (REY-Ostereith, Benton VRT). These tests must be administered by raters and have inherent problems of dynamic range and precision, along with being unpleasant tests. There is a major need for simple memory tests that can be administered by computer and that are adequately enjoyable that individuals will willingly retake the tests, like computer games.

Further, by focusing on memory function, a screening test can address the issue most important for recognizing the earliest indications of Alzheimer's disease, new-learning memory difficulties. Visual information provides an essentially unlimited challenge to the brain's memory storage mechanisms. Performance information can be used to determine when further testing is appropriate. The purpose of this presentation is to report on the experience with a computerized memory test system that was adapted to Internet presentation.

METHODS

CONCEPT

The principle psycho-pathological factor in Alzheimer's disease is the attack on the formation of new memory traces that can be retrieved after distraction. For example, recall of learned words after an interval is the earliest problem seen in Alzheimer patients. This process is commonly tested using several different memory challenges. However, providing complex stimuli that are easy for a normal person to remember would provide the most effective test for the Alzheimer process.

TESTING

MemTrax was developed based on the concept of providing a large volume of easily remembered information to a subject, then testing recollection. The format used is a "long-N-back" paradigm, with multiple complex visual stimuli, a continuous recognition paradigm. Generally the images are of discrete objects, though some objects are similar and some are difficult to name, to avoid strict reliance on verbal cues and to provide a challenge and maintain the interest of the subjects.

The paradigm uses a computerized administration, web-based format. The MemTrax game runs automatically with 3 second presentations for each stimulus or until the space-bar is pressed. 25 discrete objects are shown, with 15 of them repeated, 10 repeated a second time, making a total of 50 objects, requiring less than 150 seconds to display. Data, response time for each stimulus, is stored on a server.

Twelve subjects participated in this study. All were employees of the Kronos Science Laboratory in Phoenix, AZ. Each subject was asked to take a series of tests each day of the week. Testing was conducted on the Blueberry Study web site and was entirely anonymous. Only age was available, but no one analyzing the data knew any subjects (age range: 32-68).

The MemTrax test was given in 11 forms (11 image sets), two each day, repeated the second week, with testing provided 5 days per week for 2 weeks, a specific pair for each day of the week. Subjects took between 15 and 20 tests, mean 17.1, for a total of 205 times.

DATA PROCESSING

Results calculated included percent correct (hits, first column), percent correct rejections (false-alarms, second column), signal detection characteristics (d', third column, and beta, fourth column), and reaction time to hits (fifth column). Data analyses were computed from an EXCEL spreadsheet, which was used to produce graphs. Graphs were examined for each unique test (first row), for age (second row), for test order (third row, all subjects took at least 15 tests, with one subjects taking 20 tests), and first versus second administrations of the same tests (fourth row). Trend lines were added for d', beta, and reaction time for age, test order, and retests.

MemTrax Memory Test (Example of an image set)

RESULTS

Mean,

Standard Deviation

Age	Pct Hits	Pct CR	d'	Beta	RT Mean	RT Median
49.3	95.8	91.4	3.2	0.4	689.7	666.0
11.7	5.9	9.8	0.6	0.8	95.0	154.4

The graphs show that most subjects performed better than 80% correct on hits and correct rejections, above 2.5 d' standard deviations on most tests, and between 600 and 900 msecs on reaction times (with a rare exception and except for one subject), though outliers were not far from the average. There was minor but significant variability between individuals in their levels of performance, but not comparable variation between tests on any of the measures. Further, there were no significant or relevant effects of age, test order, or test repetition.

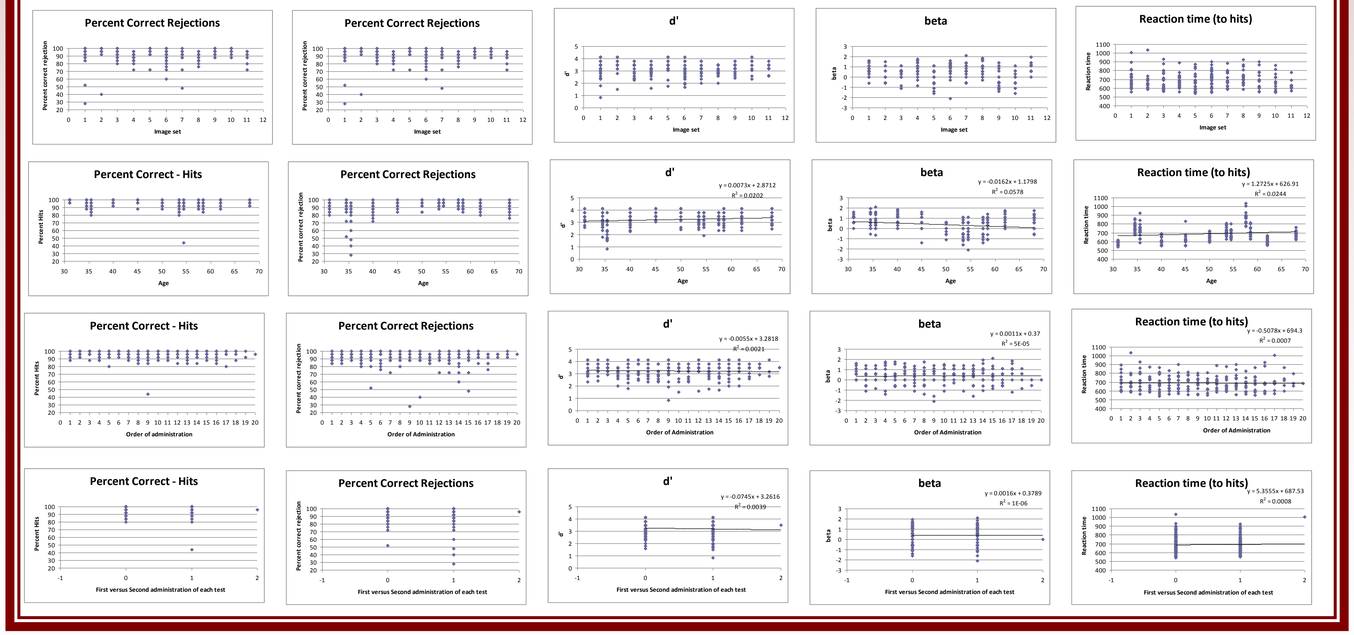
SUMMARY

Conclusions:

- **MemTrax tests showed minimal differences between tests, either related to set of images, order of the test, or repetition of the same test.**
- **There was variation between individuals that was consistent across tests. Variation between individuals was consistent for specific measures, but different individuals showed different patterns of performance across the various measures that were consistent for that individual. Age was not a significant factor in this set of subjects with a low average age relative to those at risk for dementia.**

IMPLICATIONS

- **MemTrax is a brief, convenient, fun test of the type of complex memory affected by Alzheimer pathology.**
- **MemTrax can be used for studying episodic/declarative memory in a large population.**
- **MemTrax needs to be studied further to establish its relationship with other memory measures, brain function parameters and for estimating its utility for screening for many levels of memory impairment, as well as accuracy, validity, and reliability.**



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