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ABSTRACT

BACKGROUND: To determine which measurements provide highest reliability per minute of measurement, the MemTrax, Kronos (H-Scan) and Blueberry Study (BBS) groups compared results obtained by the same participant cohort over two-weeks (10 measurement days).

METHODS: Methods and measurement sites are available at Memtrax.com and Blueberrystudy.com. These sites link to Android, iPhone, and Kindle book reader versions, which are under development to provide inexpensive screening alternatives.

RESULTS: For offline (H-Scan) highest audible pitch (HAP) and online HAP, MemTrax photo recognition, BBS word recall and face recognition (FR), test-retest and split half reliability (correlation: r) ranged from poor (r<0.7) to high (MemTrax reaction time: r=0.87; BBS word recall: r=0.96; offline H-Scan HAP: r=0.98) depending on number of repeated measurements averaged before reliability calculation. Correlations with age were HAP offline: r=-0.61; HAP online: r=-0.79; MemTrax (beta): r=0.61. MemTrax and FR correlated more closely with HAP than chronological age (e.g., MemTrax(beta)-age: r=0.61; MemTrax (beta)-HAP: r=0.77) suggesting that HAP may reflect biological rather than chronological age. Correlations between online MemTrax and FR response times were: r=0.75; between offline and online HAP: r=0.93. Within-person standard deviations for vertical finger movement times were approximately half as large as horizontal movement times, resulting in large statistical power increases. Memtrax discriminability (d') values from this investigation matched those obtained previously in a study of audience performance (Ashford et al. J.Alzheimers Dis.2011;27(4):885-95).

CONCLUSIONS: MemTrax photo recognition reaction time, BBS word recall, and H-Scan HAP had highest test-retest reliability values (0.87-0.98) indicating that relatively precise measurements can be obtained online for either screening or long-term performance monitoring. MemTrax, taking less than 2 minutes, provided the most information about memory function per unit time.

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, and 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 tests.

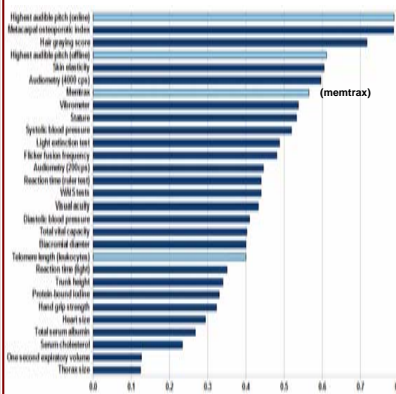
DATA PROCESSING

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 and Highest Audible Pitch (HAP) Correlated with Age Compared to Telomeres and Comfot's Test Battery

From Alex Comfot, The Biology of Senescence, Elsevier, NY, Third Edition, 1979

Correlation with Age (r)



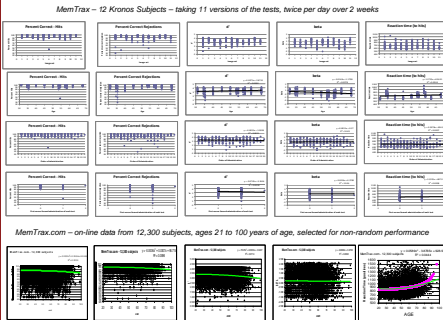
RESULTS

MemTrax Memory Test (Example of an image set)

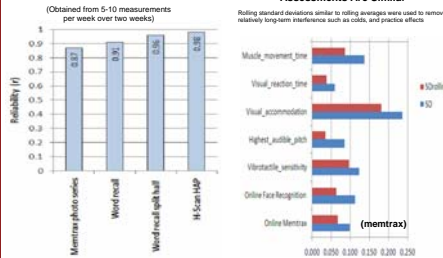


Mean Age	STD	Pct Hits	Pct CR	d'	Beta	RT Mean	RT Median
49.3	95.8	95.8	91.4	3.2	0.4	689.7	666.0
11.7	5.9	9.8	0.6	0.8	95.0	154.4	

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 msec 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.



MemTrax, Word, and H-Scan HAP Test-Retest Reliability Values



CONCLUSIONS

- MemTrax, H-Scan HAP, and other on-line (computer or internet) performance measurements can provide similar precision to other tests if motivated individuals "self screen" and take the testing approach seriously and without distraction.

- Such tests can be used to monitor large populations of individuals for progression toward or protection from Alzheimer's and other chronic age-associated illnesses.

- In previous large data sets, various tests corresponded differently with age and age-related deterioration, with highest-audible pitch (presumably related to noise-exposure over life-time) and retentive (episodic) memory (presumably related to dementia-related brain changes) showing the most robust relationships with age.

- MemTrax tests (measuring retentive/episodic memory) showed minimal performance differences between tests, either related to set of images, order of tests, or repetition of the same test.

- MemTrax showed substantial 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 the Kronos set of high-functioning subjects with low-average age relative to older subjects at risk higher risk for dementia. However, using MemTrax, large samples including elderly subjects (on-line and audience data - Ashford et al., 2011) show increasing decline in signal detection and reaction-time characteristics over 50 years of age.

IMPLICATIONS

- On-line testing is a powerful methodology for studying cognitive function in both individuals and populations, for both studies of age and positive and negative effects of environmental agents and clinical interventions.

- MemTrax is a brief, convenient, fun test of the type of complex memory affected by Alzheimer pathology.

- MemTrax can be used for studying retentive/episodic/declarative memory in large populations.

- 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.

REFERENCE

Ashford, JW, Gere E, Bayley PJ. Measuring Memory in Large Group Settings Using a Continuous Recognition Test. J Alzheimers Dis. 2011 Sep 9. 27(4):885-95, 2011.

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Some images by Henry Bowles, Bowles-Langley Technology: www.bowles-langley.com; Some images courtesy of Geoffrey Beane Foundation

BACKGROUND

A fundamental problem in measurement of psychological function is the requirement for a test, and traditionally tests of cognitive function have been administered by a rater sitting face-to-face with a subject administering a "paper-and-pencil" test. Particular problems are the time consumed by such testing and the large number of subjects that must be tested to validate a test or determine the effect of an experimental intervention.

A potential modern solution to the testing resource dilemma is the application of computerized testing, which can be done in an office or even with an internet application. To test the utility of several computerized tests and determine which measurements provide the highest reliability per minute of measurement, three groups, the developers of MemTrax (a computer-based memory test using a continuous recognition paradigm), Kronos (H-Scan, for testing several aspects of cognition), and the Blueberry Study Group (BBS, coordinating studies of Blueberries), implemented a study of 12 subjects, each participating for two weeks (10 days).

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 particularly vulnerable to a variety of disorders, including traumatic brain injury, vitamin deficiency, chemical toxicity, and neurodegenerative conditions including Alzheimer's disease, as well as aging. 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-Osterith, 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 re-take the tests, like computer games. MemTrax was specifically designed to provide a rapid, precise, and fun to take test with numerous versions.

The H-Scan provides several measures of function which have been related to the aging process. In the Blueberry Study, test-retest reliability values obtained online are as high as 0.97, and statistical power derived in major part from large numbers of repeated measurements is sufficient to enable individual participants to measure year to year changes in their performance as small as 1 percent. Each participant can therefore measure whether use of medications, nutrient supplements and healthful diets are associated with more or less rapid age-associated memory decline.

The purpose of this presentation is to report on the experience with a computerized test system using both MemTrax and H-Scan that was adapted to Internet presentation.