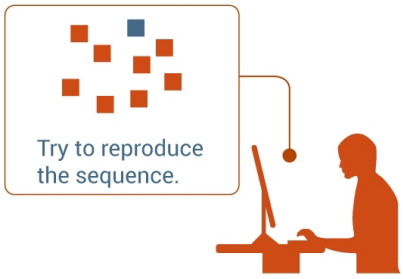
COGNITIVE TESTS REPORT

WORKING MEMORY TEST

The 'Corsi Block Tapping' test (CBT) is a measure of visuospatial working memory. In contrast to long-term memory, working memory refers to the capacity to hold information active in your mind. Working memory has primarily been associated with the prefrontal cortex and impaired performance on the CBT test has been demonstrated in patients with prefrontal brain damage or dysfunction, such as in patients with frontal lesions[1], and patients suffering from psychotic disorders[2] or depression[3]. However, CBT test performance not only relies on the integrity of the prefrontal cortex, but also on the integrity of the parietal cortex[1] and the hippocampus[1,4], which are important for visuo-spatial and memory processes, respectively.

In the CBT test, 9 squares are presented on the screen. One by one, squares can change color for about 1 second before changing back to its original color. When such a sequence is completed, the subject is asked to reproduce the sequence by selecting the squares in the correct order. At first, the sequences are short and easily reproducible by the subject. However as the sequences become longer the task of reproducing the sequences becomes harder. The maximum number of blocks in a sequence that can succesfully be reproduced in 2 out of 3 trials is called the 'Corsi Span'.



WORKING MEMORY TEST PERFORMANCE

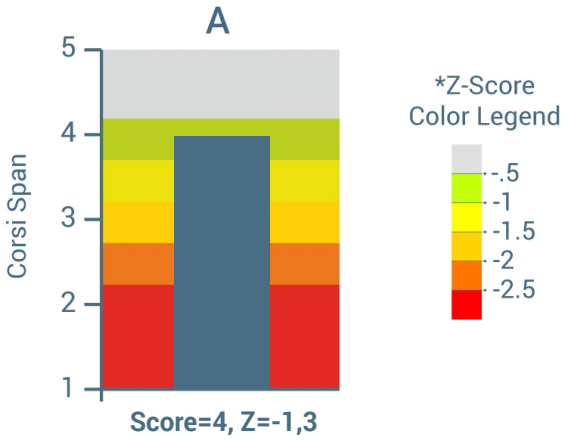


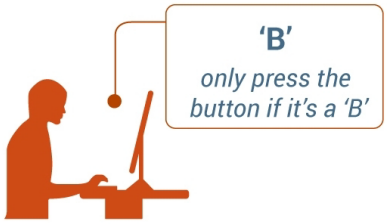
Figure A (left) shows the Corsi Span of the subject. The Corsi Span is depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graph.

[1] *Van Asselen, M., et al. (2006). Brain areas involved in spatial working memory. Neuropsychologia, 44: 1185-1194.*
[2] *Siddi, S., et al. (2020). Comparison of the touch-screen and traditional versions of the Corsi blocktapping test in patients with psychosis and healthy controls. BMC Psychiatry, 20:329.*
[3] *Galkin, S.A., et al. (2020). Impairments to the functions of spatial working memory in mild depression and their neurophysiological correlates. Neuroscience and Behavioral Physiology, 50(7): 825-829.*
[4] *Toeper, M., et al. (2010). Hippocampal involvement in working memory encoding of changing locations: An fMRI study. Brain Research, 1354: 91-99.*

COGNITIVE TESTS REPORT

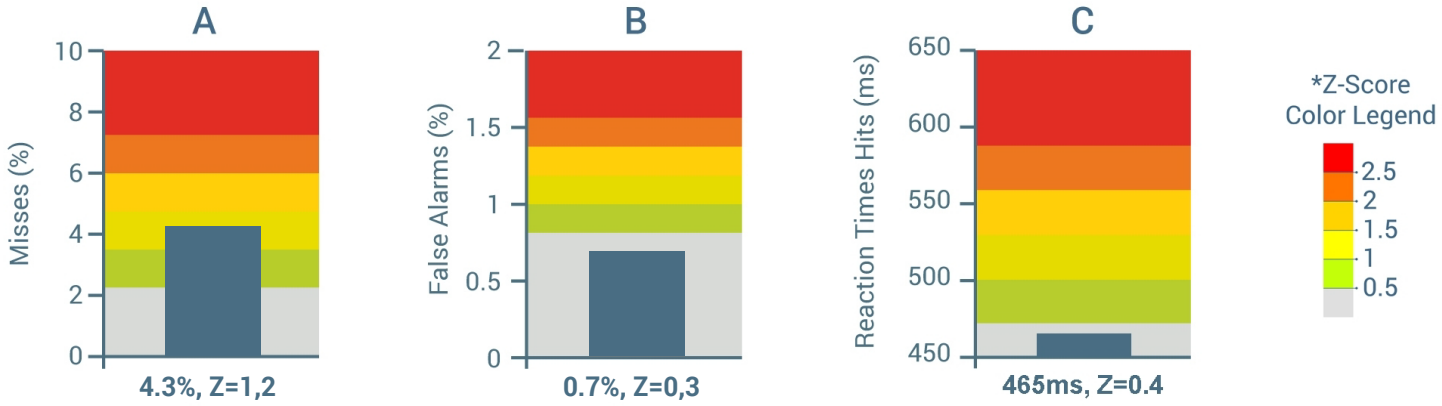
CONTINUOUS PERFORMANCE TEST

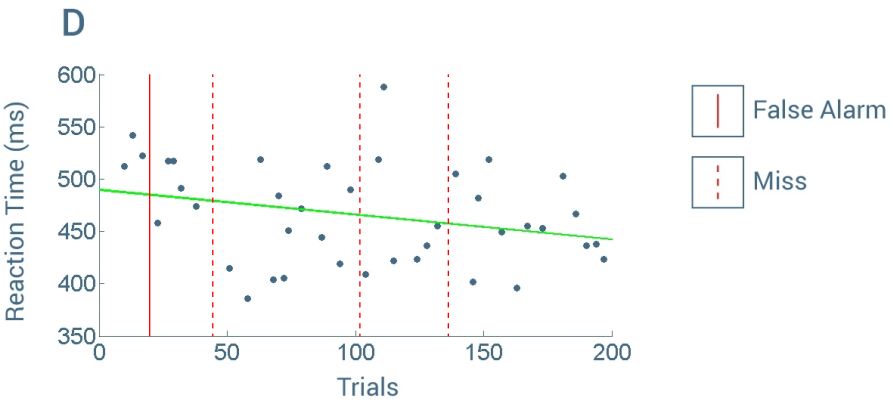
Sustained attention can reliably be measured with the Continuous Performance Test ('CPT'). The CPT that is implemented here is based on the original CPT developed by Rosvold et al.[1] Letters are sequentially presented on a screen and the subject is instructed to respond with a button press only when the letter 'B' is presented. In a CPT, subjects need to maintain a tonic level of alertness for an extended period in order to respond to the target letter amidst non-target letters. Research has shown that a broad range of (neuro)psychological disorders is associated with impaired performance on a CPT, especially in patients with ADHD[2], but also in patients with TBI[3], Alzheimer's[4], schizophrenia[5] and bipolar disorder[6].



Figures A-D (below) show the performance of the subject. Figure A-C show the percentage of misses (A: target present but no response), the percentage of false alarms (B: responses to non-targets) and the average reaction times for hits (C: target present and button pressed). The performance data for figure A-C are depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graphs. Figure D shows the distribution of the reaction times and errors across trials and Figure E shows the confusion matrix.

CONTINUOUS PERFORMANCE TEST PERFORMANCE





E

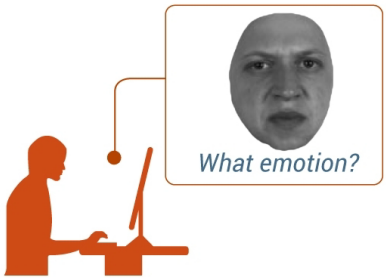
Response \ Target present	Yes	No
Yes	HIT 96%	FALSE ALARM 4%
No	MISS 1%	CORRECT REJECTION 99%

[1]Rosvold, H., Mirsky, A., Sarason, I., Bransome Jr., E.D , & Beck, L.H. (1956). A continuous performance test of brain damage. Journal of Consulting Psychology, 20, 343–350.
[2]Huang-Pollock, C.L., Karalunas, S.L., Tam, H., & Moore, A.N. (2012). Evaluating vigilance deficits in ADHD: A meta-analysis of CPT performance. Journal of Abnormal Psychology, 121(2), 360–371.
[3]Riccio, C.A., Reynolds, C.R., Lowe, P., & Moore, J.J. (2002). The continuous performance test: A window on the neural substrates for attention? Archives of Clinical Neuropsychology, 17, 235–272.
[4]Perry, R.J., & Hodges, J.R. (1999). Attention and executive deficits in Alzheimer's disease: A critical review. Brain, 122, 383–404.
[5]Nieuwenstein, M.R., Aleman, A., & de Haan, E.H.F. (2001). Relationship between symptom dimensions and neurocognitive functioning in schizophrenia: A meta-analysis of WCST and CPT studies. Journal of Psychiatric Research, 35, 119–125.
[6]Robinson, L.J., et al. (2006). A meta-analysis of cognitive deficits in euthymic patients with bipolar disorder. Journal of Affective Disorders, 93, 105–115.

COGNITIVE TESTS REPORT

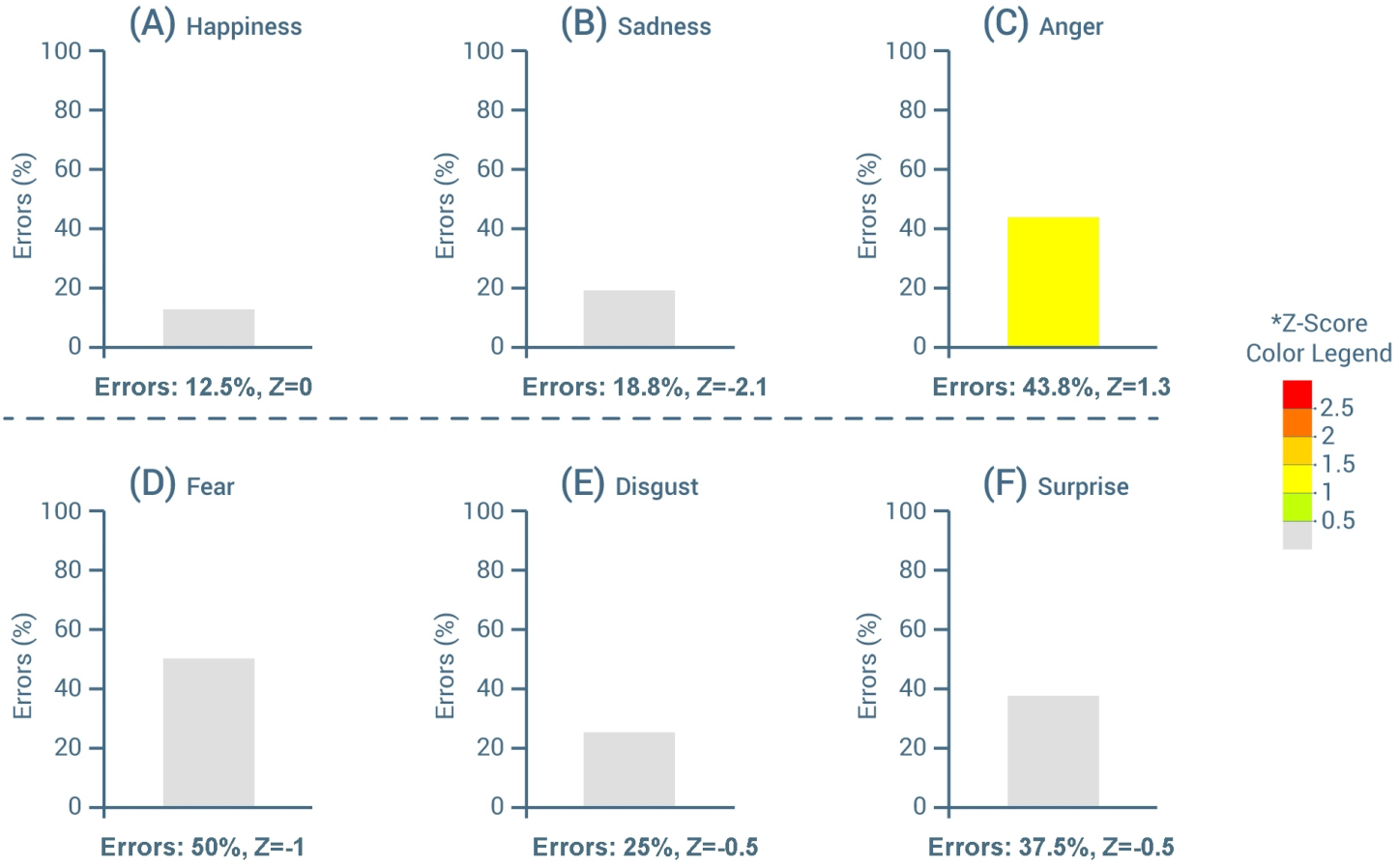
EMOTION RECOGNITION TEST

The Emotion Recognition Test (ERT) measures the ability to recognize emotional expressions. The ERT that is implemented here was developed by Montagne et al.[1] In the ERT, subject are presented with short movie clips of neutral faces that evolve into one of six emotional expressions (happiness, sadness, anger, fear, disgust and surprise). When the movie clip is finished, subjects need to choose which of six possible emotional expressions was presented. While it is relatively easy to identify the emotional expressions when the movie clip is shown in full, it becomes significantly more difficult in trials where the movie clip is cut short and and only the first part of the transition from a neutral expression to an emotional expression is shown. Research has shown that performance on the ERT is impaired in patients with autism spectrum disorder[2] and ventro-medial frontal lobe lesions[3]. Patients suffering from a post-traumatic stress disorder[4], bipolar disorder[5] or psychotic disorder[5] have also shown to have altered recognition performance on (specific subsets of) facial expressions.



Figures A-F (below) show the performance of the subject on the ERT, for each facial expression seperately. The performance data are depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graphs.

EMOTION RECOGNITION TEST PERFORMANCE



[1]*Montagne, B., Kessels, R.P.C., De Haan, E.H.F., & Perret, D.I. (2007). The emotion recognition task: A paradigm to measure the perception of facial emotional expressions at different intensities. Perceptual and Motor Skills, 104, 589-598.*

[2]*Keating, C.T., & Cook, J.L. (2020). Facial expression production and recognition in autism spectrum disorders: A shifting landscape. Child and Adolescent Psychiatric Clinics of North America, 29(3), 557-571.*

[3]*Yu, L.Q., Kan, I.P, & Kable, J.W. (2020). Beyond a rod through the skull: A systematic review of lesion studies of the human ventromedial frontal lobe. Cognitive Neuropsychology, 37, 97-141.*

[4]*Passardi, S., Peyk, P., Rufer, M., Wingenbach, T.S.H., & Pfaltz, M.C. (2019). Facial mimicry, facial emotion recognition and alexithymia in post-traumatic stress disorder. Behaviour Research and Therapy, 122.*

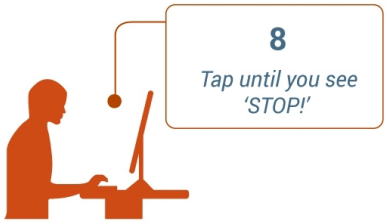
[5]*Daros, A.R., Ruocco, A.C., Reilly, J.L., Harris, M.S.H., & Sweeney, J.A. (2014). Facial emotion recognition in first-episode schizophrenia and bipolar disorder with psychosis. Schizophrenia Research, 153, 32-37.*

COGNITIVE TESTS REPORT

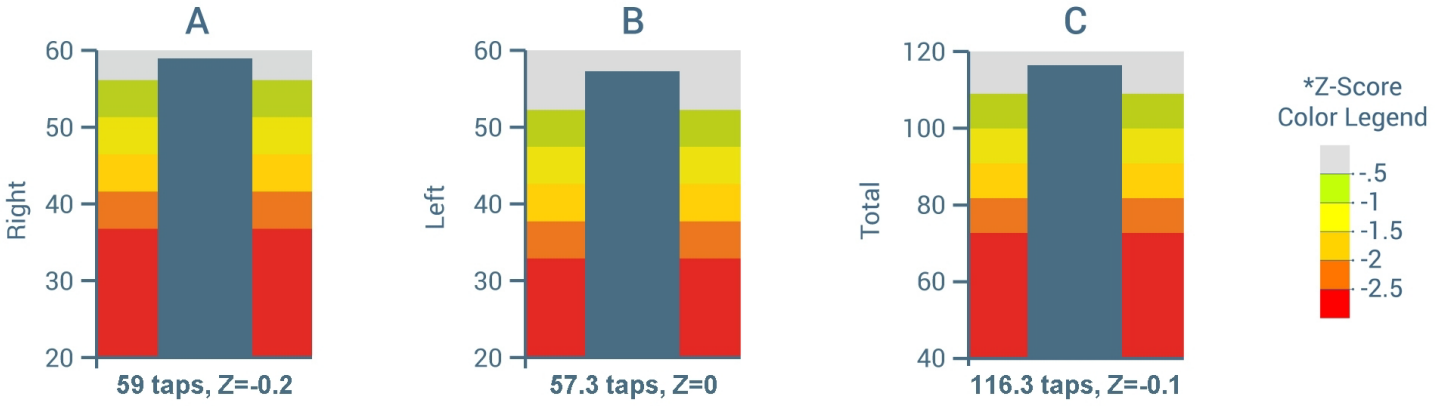
FINGER TAPPING TEST

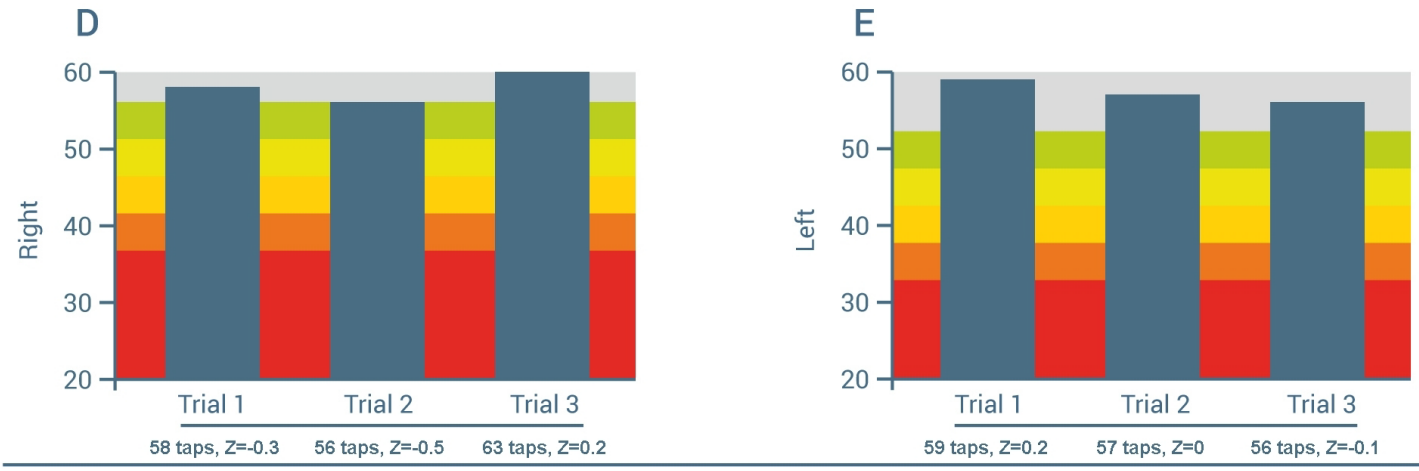
The 'Finger Tapping Test' (FTT) measures how fast a subject can tap a button within a certain amount of time. FTT performance is impaired in patients suffering from motor dysfunctions as a result of, for example, TBI[1,2], Parkinson's disease[3,4] or stroke[5]. The FTT that is implemented here consists of 7 trials. The first trial is a practice trial in which subjects are instructed to tap the space bar with their right hand as many times as they can until time runs out. A countdown of 10 seconds is presented during each trial, after which a stop signal ('STOP!') is presented, indicating that the trial is over and the subject needs to stop tapping. Trials 2-4 are identical to the practice trial and in trials 5-7, subjects are instructed to use their left hand.

Figures A-E (below) show the performance of the subject. Figure A shows the average number of space bar presses for trials 2-4 (right hand used), figure B shows the average number of space bar presses for trials 5-7 (left hand used) and figure C shows the sum of the average of trials 2-4 and the average of trials 5-7. Figure D and Figure E show the number of space bar presses for trials 5-7 seperately for each trial. The performance data for figure A-E are depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graphs.



FINGER TAPPING TEST PERFORMANCE





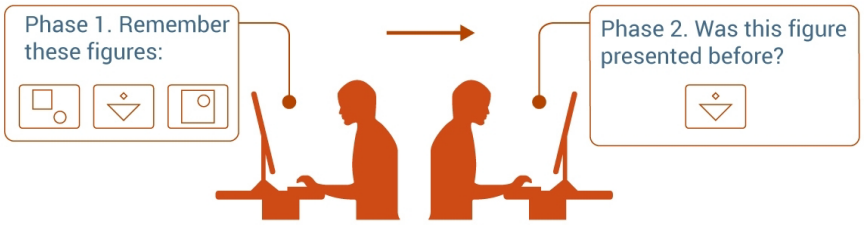
[1]Dikmen, S., Machamer, J., Winn, H. R., & Temkin, N. (1995). Neuropsychological outcome at 1-year post head injury. Neuropsychology, 9, 80–90.
[2]Prigatano, G. P., & Borgaro, S. R. (2003). Qualitative features of finger movement during the Halstead finger oscillation test following traumatic brain injury. Journal of the International Neuropsychological Society, 9, 128–133.
[3]Haaxma, C. A., Bloem, B. R., Overeem, S., Borm, G. F., & Horstink, M. W. (2010). Timed motor tests can detect subtle motor dysfunction in early Parkinson's disease. Movement Disorders, 25, 1150–1156.
[4]Jiménez-Jiménez, F. J., et al. (2010). Impairment of rapid repetitive finger movements and visual reaction time in patients with essential tremor. European Journal of Neurology, 17, 152–159.
[5]de Groot-Driessen, D., & van Heugten, C. (2006). Speed of finger tapping as a predictor of functional outcome after unilateral stroke. Archives of Physical Medicine and Rehabilitation, 87, 40–44.

COGNITIVE TESTS REPORT

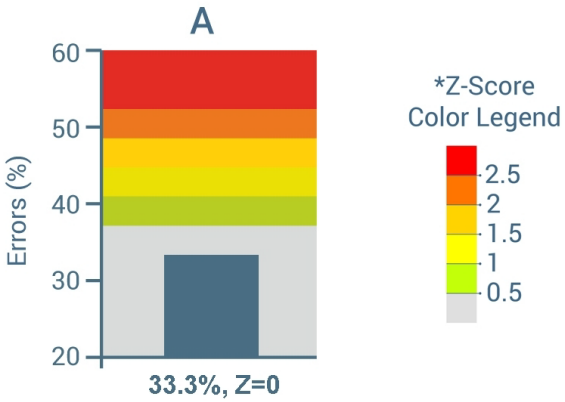
LONG-TERM MEMORY TEST

The long-term memory test is based on the Rey Visual Design Learning Test ('RVDLT'[1]). In the context of scientific work on memory, long-term memory is defined as the storage of information for later recall or recognition, as opposed to short-term memory or working memory, where information remains active in the mind. The currently used RVDLT version measures immediate visual memory span and recognition memory, which are known to be impaired in patients suffering from neurodegenerative diseases such as Alzheimer's disease[2]. Generally speaking, impaired memory is associated with temporal lobe and hippocampal lesions[3]. Finally, long-term use of substances such as MDMA[4] and Cannabis[5] can also lead to impaired memory performance.

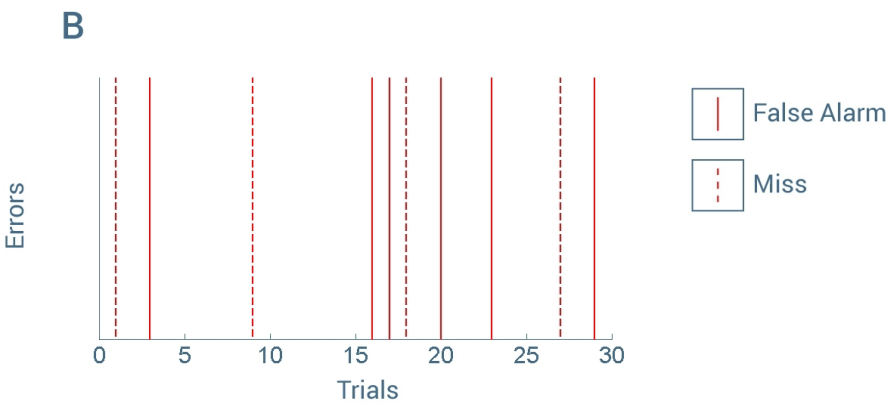
The long-term memory task consists of two phases. In the first phase, the subject is instructed to remember 15 sequentially presented abstract figures. In the second phase, 30 figures were presented, of which 15 were previously presented in the first phase (the 'targets'). The subject needs to decide whether a figure was either previously presented or whether it was a new figure by either pressing the space bar or witholding a button press, respectively.

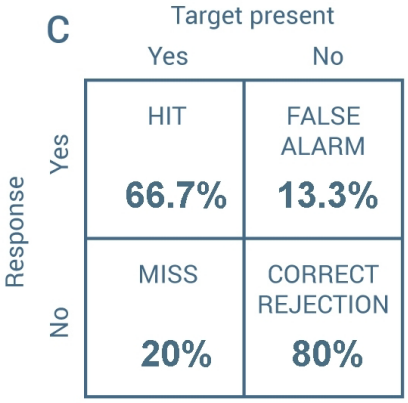


LONG-TERM MEMORY TEST PERFORMANCE



Figures A-C (left, below) show the performance of the subject. Figure A shows the error percentage. This is the percentage of misses (target present but no response) and false alarms (responses to non-targets).- The performance data for figure A is depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graph. Figure B shows the distribution of the errors across trials and Figure C shows the confusion matrix.



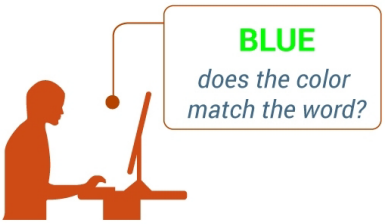


[1]Rey, A. (1964). L'examen clinique en psychologie. Paris: Presses Universitaires de France.
[2]Estévez-González, A., Kulisevsky, J., Boltes, A., Otermín, P., & Carmen García-Sánchez. (2003). Rey verbal learning test is a useful tool for differential diagnosis in the preclinical phase of Alzheimer's disease: comparison with mild cognitive impairment and normal aging. International Journal of Geriatric Psychiatry, 18, 1021-1028.
[3]Squire, L.R., & Wixted, J.T. (2011). The cognitive neuroscience of human memory since H.M. Annual Review of Neuroscience, 34, 259-288.
[4]Parrot, A.C. (2001). Human psychopharmacology of ecstasy (MDMA): a review of 15 years of emperical research. Human Psychopharmacology, 16, 557-577.
[5]Schoeler, T., & Bhattacharyya, S. (2013). The effect of cannabis use on memory function: An update. Substance Use and Rehabilitation, 4, 11-27.

COGNITIVE TESTS REPORT

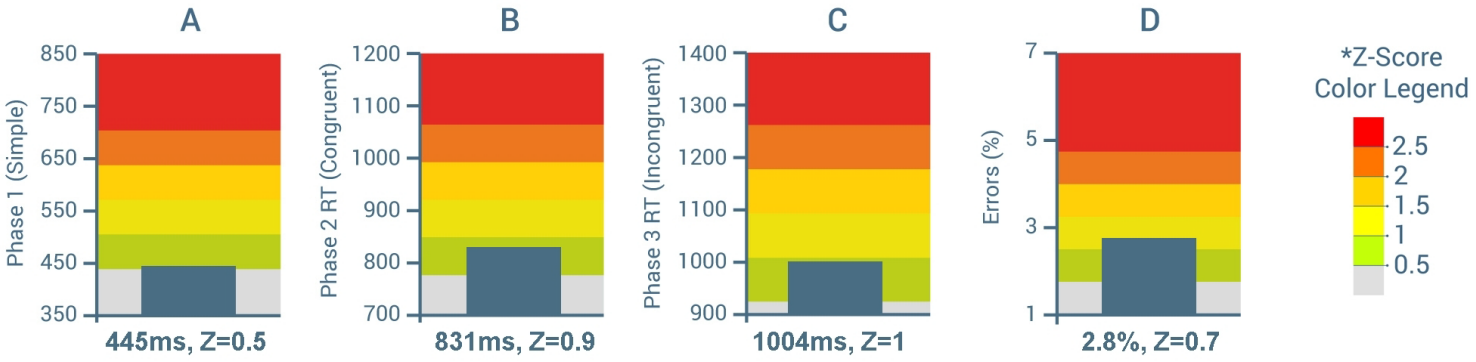
STROOP TEST

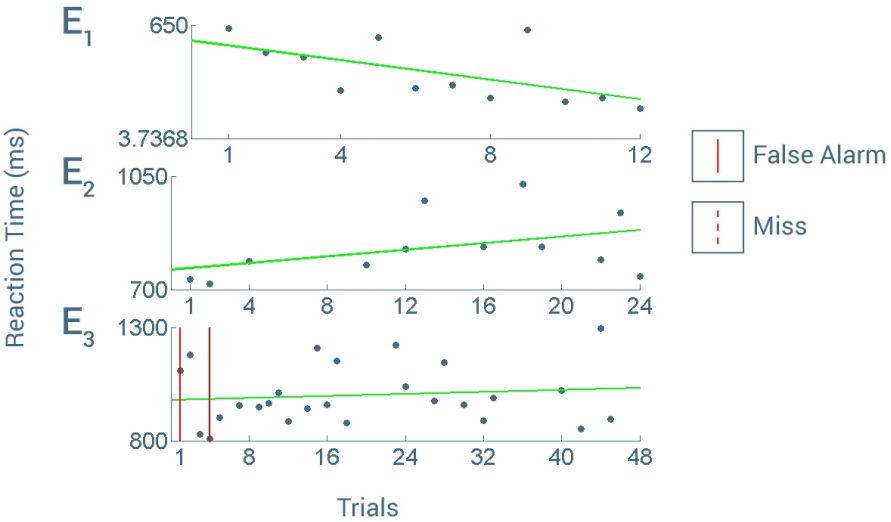
In the Stroop test, subjects are presented with words referring to a color, like 'blue', 'red' or 'green'. These 'color words' are then presented in a color that either matches the color word, like 'RED', which is referred to as the 'congruent condition' or in a color that does not match the color word, like 'BLUE', which is referred to as the 'incongruent condition'. Subjects are generally slower to respond to the incongruent condition, which is called the 'Stroop effect'. This Stroop effect measures interference control as part of the executive functioning of a subject. Impaired performance on the Stroop test has been demonstrated for patients with ADHD[1], TBI[2], and schizophrenia[3].



The Stroop test that is implemented here consists of 3 phases. In phase 1, subjects are instructed to press the space bar as soon as a color word is presented on the screen. The color of all the words in this phase is white (on a black background). In phase 2 and 3 all words are presented in either congruent or incongruent colors. Subjects are instructed to press the space bar only when the word matches the color (phase 2) or only when the word does not match the color (phase 3). Figures A-F (below) show the performance of the subject. Figures A-C show the reaction times in milliseconds for phase 1-3, figure D shows the error percentage across all conditions. The performance data for figure A-D are depicted in relation with the normative data (see Z-Score color legend*). Individual z-scores are depicted below the graphs. Figures E_1-E_3 show the distribution of the reaction times and errors across trials for phase 1-3 and Figure F shows the confusion matrix.

STROOP TEST PERFORMANCE





F

Response	Target present: Yes	Target present: No
Yes	HIT **97.2%**	FALSE ALARM **2.8%**
No	MISS **0%**	CORRECT REJECTION **100%**

[1]*Lansbergen, M.M., Kenemans, J.L., and Van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: A review and meta-analysis. Neuropsychology, 21 (2), 251–262.*

[2]*Ben-David, B.M., Nguyen, L.L.T., & Van Lieshout, P.H.H.M. (2011). Stroop effects in persons with traumatic brain injury: selective attention, speed of processing, or color-naming? A meta-analysis. Journal of the International Neuropsychological Society, 17, 354–363.*

[3]*Cohen, J.D. & Servan-Schreiber, D. (1992). Context, cortex and dopamine: A connectionist approach to behavior and biology in schizophrenia. Psychological Review, 99(1), 45-77.*