The digital tree drawing test for screening of early dementia - A diagnostic study for a new tool based on arts therapy

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Background: Although the degenerative process in Alzheimer's disease (AD) cannot be stopped yet, early diagnosed patients can receive interventions that might improve their cognition and quality of life. People with mild cognitive impairment (MCI) have a high risk to develop AD and therefore it is important to distinguish them from people with normal cognitive decline associated with aging. Heymann and colleagues introduced a tablet-based tree drawing test and compared free tree drawings of cognitive impaired (MCI, early or moderate AD) and healthy subjects. They found a decline in picture size and detail, including a reduction of colors and line widths, with the progression of cognitive impairment. The current study introduces the digital tree drawing test (dTDT) which combines the complex tree drawing task with a new objective and extensive digital recording of drawing characteristics, including variables of psychomotor speed, pressure and spatial relations.

Sample: 187 persons (87 men and 100 women; mean age: 68.6 ± 10.6 years) recruited from the Memory Clinic of the Department of Psychiatry and Psychotherapy at the University Hospital of Tübingen from July 2015 to July 2016 were included in the study.
Patients with MCI (n=64, 35 women, 29 men) or eDAT (n=56, 40 women, 16 men) underwent physical, neurological, psychological, and psychiatric examinations as well as brain imaging.

Methods: After medical anamneses all participants performed the German version of the modified CERAD (Consortium to Establish a Registry for Alzheimer's Disease) neuropsychological test battery including the MMSE. In addition the dTDT with digitized pen technology was administered. Participants were asked to draw a tree from their memory with a stylus pen on a Microsoft Surface Pro 3 digitizer. Movements were sampled at a frequency of 120 Hz with a spatial accuracy of 0.25 mm. The subjects were free to choose between 12 different colours and three line widths and there was no time limit for painting. Figure 1 illustrates examples of tree drawings from (a) a subject of the control group, (b) a subject from the MCI group and (c) a subject from the eDAT group.

Statistics: The diagnostic values of combinations of dTDT variables were analyzed using stepwise logistic regression models adjusted for age, education level and gender. Receiver operating characteristic (ROC) curves of the logistic models and areas under curves (AUCs) were calculated and compared. Sensitivity and specificity, as well as cut off values, were calculated with the Youden-index.

Results: A combination of the four significant dTDT variables (Fig. 2) "less strokes per minute" (Odds ratio OR=0.97, 95% CI [0.95, 0.99]), "less volatile motion" (OR=0.98, 95% CI [0.98, 0.99]), "less line width changes" (Odds ratio (OR) =0.79, 95% CI [0.64, 0.97]), "less texture entropy" (OR=0.34, 95% CI [0.12, 0.96]) contributed best for discriminating between healthy and cognitive impaired subjects. The ROC-curve and its AUC of 0.84 (95% CI [0.79, 0.90]) revealed that the linear combination of these selected variables adequately differentiated between both groups (Fig. 3). Using maximum Youden-index (YI) calculation for cut-off selection, which maximized both, specificity and sensitivity, resulted in a specificity of 0.77 and a sensitivity of 0.78.

Discussion: The results presented in this study suggest that the objective digital recording of pen-stroke data during the drawing procedures may contribute to the screening of patient with early dementia, e.g., in combination with other neuropsychological tests. The dTDT is furthermore supposed to be less stress- and shameful for cognitive impaired patient than other neurological tests as (a) the participants can draw without any guidelines about what is right or wrong and are therefore not obviously confronted with their cognitive deficits (b) they do not have any time limits and (c) the creative activity of free drawing is supposed to increase the subjects well-being, whereas stress is known to affect cognition and memory functions. In addition, the process of drawing does not depend on hearing abilities and language skills, except for the understanding of the task instructions at the beginning. Thus the dTDT perfectly fits the goals of a person centered approach in the field of clinical diagnostics.

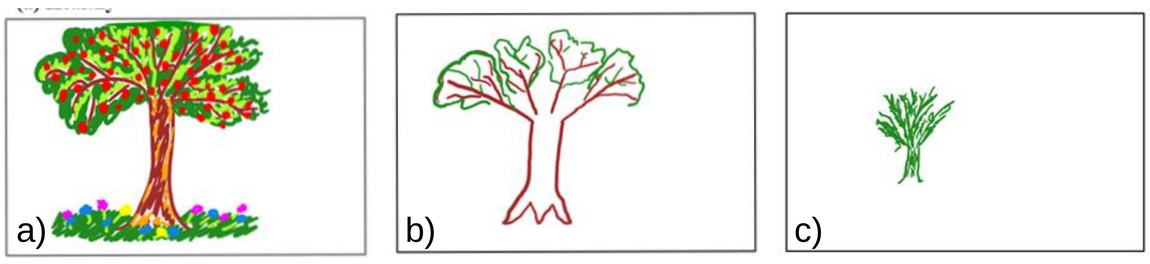

Fig. 1: Examples of digital tree drawings. (a) Healthy control, (b) Mild cognitive impaired, (c) Early demented of Alzheimer's type.

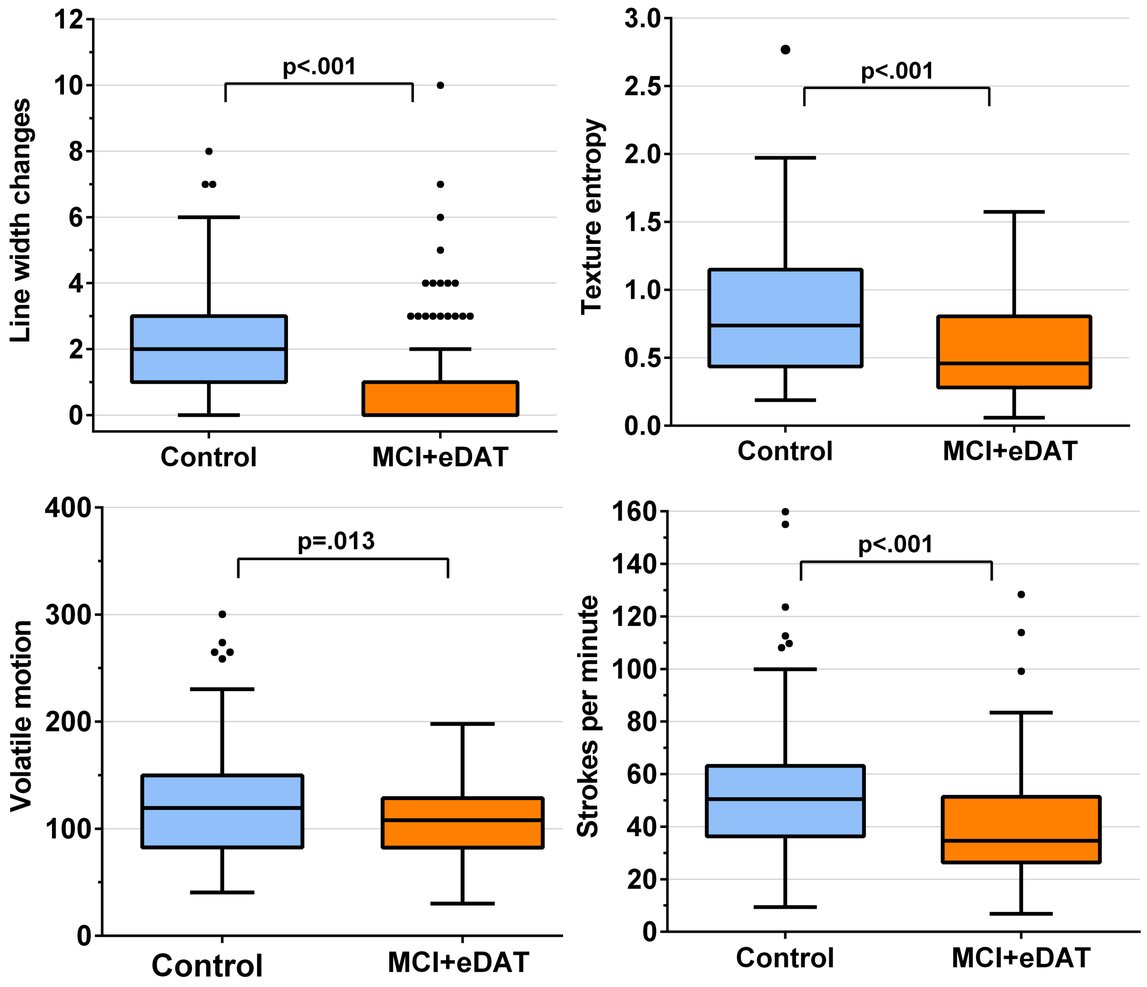

Fig. 2: Variables with significant between-group difference: "Line width", "Texture entropy", "Volatile motion", and "Strokes per minute".

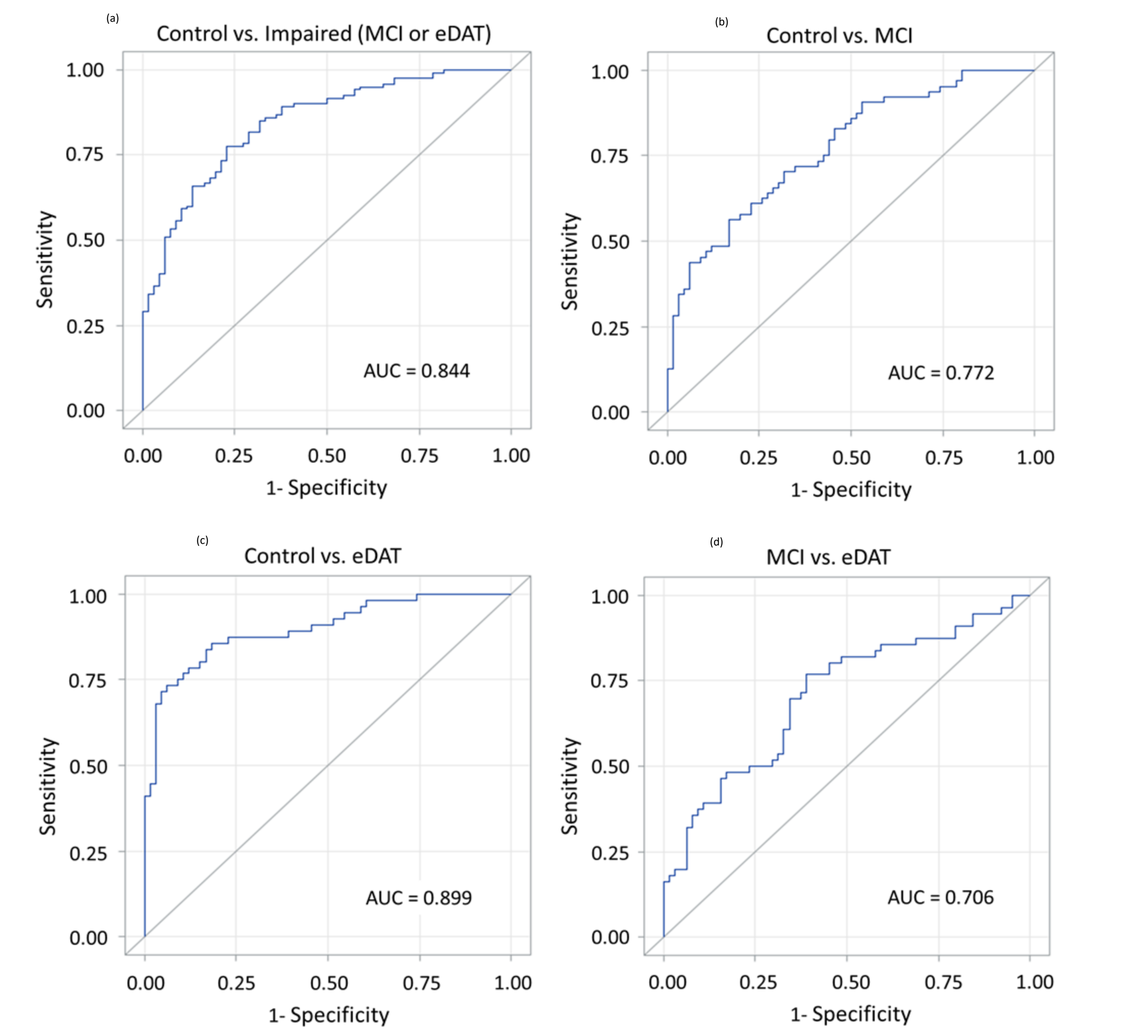

Fig. 3: ROC curves of (a) control versus cognitive impaired subjects, (b) control versus MCI, (c) control versus eDAT and (d) MCI versus eDAT, adjusted for gender, age and education.

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