

Title: Screening older adults for amnesic mild cognitive impairment and early-stage Alzheimer's disease using upper-extremity dual-tasking

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Supplementary Information 1 – UEF categorical index

To construct models, the following steps were followed: 1) descriptive analysis of UEF parameters: outlier detection using box plots and histograms and testing of distribution normality using Shapiro-Wilk W test; 2) univariate analysis: UEF parameters with significant association with cognitive status were selected for subsequent steps; 3) testing of collinearity between UEF parameters: using variance inflation factor (VIF) values. A VIF cutoff value larger than 10 was considered an indication of collinearity presence⁵⁰; 4) stepwise parameter selection: UEF and demographic parameters were selected based on Akaike information criterion (AIC) values; and 5) model evaluation: using 10-fold cross-validation, in which the sample was randomly divided into $k = 10$ equal parts, with the same number of participant assignment in each cognitive group. At each k^{th} iteration, $k - 1$ partitions were used as the training dataset and the left out partition was used as the validation dataset. The mean and standard deviation across training sets were calculated for area under receiver operating characteristic (ROC) curves, AIC within training sets, and sensitivity and specificity within testing sets were calculated. For UEF categorical cognitive index, the probability equations were derived using parameter estimates (β_i) and magnitude of independent variables (a_i) as follows. Two UEF cognitive categorical indexes were derived for normal self-selected pace elbow flexion within two cognitive conditions of counting backward by ones and threes (Table S1).

$$P[CN] = \frac{1}{1 + \exp -(\beta_1 + \beta_3 a_3 + \beta_4 a_4 + \beta_5 a_5)} \quad (A1)$$

$$P[MCI] = \frac{1}{1 + \exp -(\beta_2 + \beta_3 a_3 + \beta_4 a_4 + \beta_5 a_5)} - \frac{1}{1 + \exp -(\beta_1 + \beta_3 a_3 + \beta_4 a_4 + \beta_5 a_5)} \quad (A2)$$

$$P[AD] = 1 - \frac{1}{1 + \exp -(\beta_2 + \beta_3 a_3 + \beta_4 a_4 + \beta_5 a_5)} \quad (A3)$$

Table S1: UEF categorical cognitive index, Independent variables (a_i) and parameter estimates (β_i) are presented

Independent Variables	Parameter Estimates	
	Normal self-selected pace counting backward by ones	Normal self-selected pace counting backward by threes
Intercept, [CN]	$\beta_1 = -1.2051$	$\beta_1 = -1.5121$
Intercept, [MCI]	$\beta_2 = 0.9933$	$\beta_2 = 0.7976$
a_3 : Flexion number, n	$\beta_3 = 0.0530$	$\beta_3 = 0.0838$
a_4 : ROM variability, %	$\beta_4 = -0.0911$	$\beta_4 = -0.0446$
a_5 : Flexion variability, %	$\beta_5 = -0.0277$	$\beta_5 = -0.0202$

CN: Cognitive normal
MCI: mild cognitive impairment
AD: Alzheimer's disease
ROM: range of motion

Supplementary Information 2 – UEF score

To develop the UEF cognitive score, parameters selected from the categorical index were used. First, each continuous UEF parameter were split into three categories based on mean values for each cognitive group. That is parameter mean values were considered as reference values (W) and the mid-points between reference values were considered as cut-offs. Next, the distance between each category and the lowest (reference) category in regression units was determined, by multiplying the β (parameter estimates from the categorical index model) by the difference between the category W and the reference category W_{REF} , or $\beta (W - W_{ref})$. Then, each categorical independent variable was assigned a point value by dividing the distance $\beta (W - W_{ref})$ by a base constant that represents a coefficient value corresponding to one point (flexion number was selected here since it provided the smallest distance $\beta(W - W_{ref})$). Point values were rounded to the nearest integer. The UEF cognitive score (from 0: CN to 1: AD) for a given participant was determined by the sum of points corresponding to performance results from UEF dual-task test and the maximum possible points ($[\text{maximum} - \text{total}]/\text{total}$) (see Supplementary Information 1 for details regarding UEF categorical cognitive index). Two UEF cognitive scores were derived for normal self-selected pace elbow flexion within two cognitive conditions of counting backward by ones and threes.

Counting backward by ones (0: CN - 1: AD):

UEF cognitive score: The total score = (16 - total point) / 16

Variable	Variable Ranges	Points (0-16)	Parameter Estimate (β)	Reference Value (W)	$\beta (W-W_{ref})$	Points $\beta (W-W_{ref}) / B_{ref} \uparrow$
Flexion number, n	< 35	0	0.053	34.23	0	0
	35 - 42	1		37.09	0.15158	1
	>42	5		47.31	0.69324	4.573426573
ROM variability, %	< 10	4	-0.0911	8.40	0	0
	10 - 13	2		10.64	-0.204064	-1.346246207
	> 13	0		14.6	-0.56482	-3.726217179
Flexion variability, %	< 19	7	-0.0277	11.50	0	0
	19 - 37	4		25.58	-0.390016	-2.573004354
	> 37	0		47.57	-0.999139	-6.59149624

CN: Cognitive normal
MCI: mild cognitive impairment
AD: Alzheimer's disease
ROM: range of motion

Counting backward by threes (0: CN - 1: AD):

UEF cognitive score: The total score = (22 - total point) / 22

Variable	Variable Ranges	Points (0-22)	Parameter Estimate (β)	Reference Value (W)	$\beta (W-W_{ref})$	Points $\beta (W-W_{ref}) / B_{ref} \uparrow$
Flexion number, n	< 22	0	0.0838	19.73	0	0
	22 - 30	3		23.88	0.34777	3.045911575
	> 30	12		35.97	1.360912	11.91942265
ROM variability, %	< 12	4	-0.0446	10.56	0	0
	12 and 17	3		13.12	-0.114176	-1
	> 17	0		20.42	-0.439756	-3.8515625
Flexion variability, %	< 34	6	-0.0202	25.57	0	0
	34 - 51	3		42.78	-0.347642	-3.044790499
	> 51	0		59.46	-0.684578	-5.995813481

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