

Tele-Global Examination of Mental State (Tele-GEMS): An open tool for the remote neuropsychological screening

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Supporting Data Sheet S1: Description of the sub-tasks of Tele-GEMS

Tele-GEMS is made up of nine sub-tasks tapping on different cognitive domains. A full description of the instruction is provided as follows:

- *Orientation* evaluates the capacity of orientation in time and space. The participant is asked to answer two questions about time orientation (e.g., *what year are we in?*) and two questions about space orientation (e.g., *what city are you in?*). One point is assigned to each correct answer (maximum 4).

- *Immediate Memory* evaluates the capacity of verbal short-term memory. The participant is asked to repeat a list of six words freely right after the examiner (1 per second). Then, the participant is informed that he/she would be asked to recall those words later. The six words were selected following a series of psycholinguistic criteria: all have two syllables and refer to non-living entities. No homophone words are included, and all words are balanced across lexical frequency parameters based on one of the most updated corpora of psycholinguistic features of the Italian language (i.e., Subtitle-based word frequency estimates for Italian, SUBTLEX-IT; 44). The semantic distance was also controlled considering all possible combinations within the words, based on the WEISS (i.e., Word-Embeddings Italian Semantic Space; 29). A mean semantic distance of 0.9 was found among the words included (where 1 indicates the more significant semantic distance between two words). For this task, one point is assigned to each correct word remembered (maximum 6).

- *Backward Months* evaluates verbal working memory. The participant is asked to list backward the months of the year starting from October, skipping one month at a time (e.g., August, June, and so on). This task requires working memory for going backward two months at a time while monitoring the correct familiar sequence of months. One point is assigned to each month correctly said concerning the previous one (maximum 5).

- *Spatial Representation* evaluates the ability to imagine the representation of a clock and its hands at four different times. The participant is asked to say whether the two hands of an imaginary clock are placed both on the right-hand side, both on the left-hand side, or the two opposite sides of the clock. One point for each correct answer (maximum 4).

Naming evaluates the ability to retrieve four different names. One point is assigned to each correct naming (maximum 4).

- *Delayed Memory* evaluates the ability to recall the words already repeated in the Immediate Memory task. One point is assigned to each correct word (maximum 6).
- *Verbal Comprehension* evaluates the ability to understand and execute a two-step verbal order (an action). The examinee asks: Say the letter 'A' twice after saying the letter 'B' once. One sole point is assigned if both verbal actions are correctly performed in the correct sequence (maximum 1).
- *Auditory Attention* evaluates the ability to maintain attention and select the correct answer among distractors. The examiner reads a series of 26 digits, and the examinee is asked to pronounce the word "VERDE" (tr. 'green') in correspondence to the number '2' and to pronounce the word "ROSSO" (tr. 'red') in correspondence to the number '4' in the list. Thus, this task requires sustaining attention while listening to a list of numbers, selecting two targets among two alternatives (i.e., '2' and '4'), and producing the correct corresponding answer. One point is assigned to each correct answer (maximum 8).
- *Verbal Fluency* examines the ability to select and produce as many words as possible in a time window of 1 minute. The participant is asked to pronounce as many words as possible,

starting with the letter 'T', excluding proper names of people or places. The verbal Fluency task requires following a rule while selecting the correct answers and the capacity to access the lexicon. One point is assigned to each word reported correctly within 1 minute.

- *Metaphor comprehension*, evaluating pragmatic abilities. The examiner reads to the examinee a sentence containing a metaphor. The participant is asked to choose the correct interpretation among three possible sentences, with a) literal, b) unrelated, and c) correct meaning. One point for the correct answer (maximum 1).

Supporting Data Sheet S2: Thresholds for determining Significant Changes in Tele-GEMS

Table S2 allows for determining if a significant change occurred in Tele-GEMS total scores. The use of this table poses that two measurements from the same individual (1st measurement and 2nd measurement) are available. To determine if a significant change occurred between the first and the second measurement, first find the observed value at 1st measurement in the central column of the table (values in bold typeface). The column on the right displays the threshold for a significant improvement. The column on the left reports the threshold for a significant worsening. A significant change occurred if the observed score at the second measurement falls outside these thresholds. No change occurred if the observed value falls within these thresholds (threshold value included). Precisely, it is estimated that at the second measurement, less than 5% of the population will exceed the upper thresholds, and less than 5% of the population will fall below the lower thresholds. The thresholds for significant change were determined through the method by Crawford & Garthwaite (2006). The range of values reported for Tele-GEMS is the range observed in the overall normative sample (601 participants). Gray cells indicate values extrapolated from the regression used to define significant changes, but they were not observed in the smaller sample that performed Tele-GEMS at the second measurement (50 participants), thus, they should be used with caution. The Test-Retest interval used to build these tables is two months. In some cases, the lower threshold at the second measurement can be higher than the observed value at the first measurement. This can happen if a practice effect is expected.

S2. Tele-GEMS thresholds for significant change				
Lower Threshold for parallel version Tele- GEMS B (2nd meas.)	Lower Threshold (2nd meas.)	Observed value (1st meas.)	Upper Threshold (2nd meas.)	Upper Threshold for parallel version Tele- GEMS B (2nd meas.)
29	56	37	83	63
30	57	38	83	64
31	57	39	84	65
32	58	40	84	65
33	58	41	84	66
33	59	42	85	67
34	59	43	85	67
35	60	44	85	68
36	60	45	86	69
37	60	46	86	70
37	61	47	86	70
38	61	48	87	71
39	62	49	87	72
40	62	50	87	73
41	63	51	88	73
42	63	52	88	74
42	64	53	89	75
43	64	54	89	75
44	65	55	89	76

45	65	56	90	77
46	66	57	90	78
46	66	58	90	78
47	67	59	91	79
48	67	60	91	80
49	67	61	91	81
50	68	62	92	81
50	68	63	92	82
51	69	64	93	83
52	69	65	93	84
53	70	66	93	84
54	70	67	94	85
54	71	68	94	86
55	71	69	94	87
56	71	70	95	87
57	72	71	95	88
57	72	72	96	89
58	73	73	96	90
59	73	74	96	90
60	74	75	97	91
61	74	76	97	92
61	74	77	98	93
62	75	78	98	93
63	75	79	98	94
64	76	80	99	95
64	76	81	99	96
65	77	82	100	96
66	77	83	100	97
67	77	84	100	98
68	78	85	-	99
68	78	86	-	99
69	79	87	-	100
70	79	88	-	-
71	79	89	-	-
71	80	90	-	-
72	80	91	-	-
73	81	92	-	-
74	81	93	-	-
74	81	94	-	-
75	82	95	-	-
76	82	96	-	-
77	83	97	-	-
77	83	98	-	-
78	83	99	-	-
79	84	100	-	-

Supporting Data Sheet S3: Results of the Regression-based analyses for deriving the cut-offs of Tele-GEMS

Linear Regression Model with Tele-GEMS score as a dependent variable						
	Term	Estimate (Standard Error)	t-value	p-value	Adjusted R ²	AIC (df)
Model 1	Intercept	100.84 (1.12)	89.72	<.001*	0.28	4374.80 (4)
	Age	-0.29 (0.01)	-15.29	<.001*		
	Sex	-0.40 (0.75)	-0.53	0.59		
Model 2	Intercept	85.63 (1.84)	46.53	<.001*	0.39	4283.33 (5)
	Age	-0.21 (0.01)	-11.10	<.001*		
	Sex	-0.24 (0.69)	-0.35	0.72		
	Education	0.80 (0.08)	10.02	<.001*		
Model 3	Intercept	78.38 (2.03)	38.51	<.001*	0.44	4226.97 (5)
	Age	-0.37 (0.01)	-20.38	<.001*		
	Sex	0.04 (0.66)	0.06	0.95		
	CRI	0.24 (0.01)	12.67	<.001*		
Model 4	Intercept	78.13 (2.04)	38.26	<.001*	0.43	4227.15 (6)
	Age	-0.34 (0.02)	-13.47	<.001*		
	Sex	-0.02 (0.66)	0.03	0.97		

Linear Regression Model with Tele-GEMS score as a dependent variable						
	Term	Estimate (Standard Error)	t-value	p-value	Adjusted R ²	AIC (df)
	Education	0.15 (0.11)	1.35	0.17		
	CRI	0.21 (0.02)	7.32	<.001*		
Model 5	Intercept	71.33 (2.65)	26.88	<.001*	0.45	4213.67 (7)
	Age	0.07 (0.11)	0.70	0.48		
	Age²	-0.00 (0.00)	-3.94	<.001*		
	Sex	-0.32 (0.66)	-0.49	0.62		
	Education	0.16 (0.11)	1.41	0.15		
	CRI	0.18 (0.02)	6.45	<.001*		
Model 6	Intercept	61.21 (3.23)	18.91	<0.001*	0.47	4188.47 (8)
	Age	0.04 (0.10)	0.45	0.65		
	Age²	-0.00(0.00)	-3.14	0.001*		
	Sex	0.01 (0.65)	0.02	0.97		
	Education	1.94 (0.35)	5.43	<0.001*		
	Education²	-0.05 (0.01)	-5.24	<0.001*		
	CRI	0.15 (0.02)	5.31	<0.001*		
Model 7	Intercept	57.45 (8.53)	6.73	<0.001*		

Linear Regression Model with Tele-GEMS score as a dependent variable						
	Term	Estimate (Standard Error)	t-value	p-value	Adjusted R ²	AIC (df)
	Age	0.03 (0.11)	0.30	0.76	0.47	4190.24 (9)
	Age²	-0.00(0.00)	-2.93	0.003*		
	Sex	0.01 (0.65)	0.02	0.98		
	Education	1.87 (0.38)	4.82	<.001*		
	Education²	-0.05 (0.01)	-4.65	<.001*		
	CRI	0.23 (0.17)	1.37	0.16		
	CRI²	-0.00 (0.00)	-0.47	0.63		

Table S3. Results of Regression Analyses with different demographic variables as predictors of interest and Tele-GEMS as dependent variables. The table shows the model name (first column); the name of the term entered in the regression model (second column); coefficient estimate and standard error within round brackets (third column); t-value associated with the term (fourth column); p-value (fifth column), with an asterisk "*" denotes significant terms; adjusted R² associated with each Model (sixth column); Akaike Information Criterion values (seventh column). The lower the AIC value, the better the model fits.

Cut-offs of Tele-GEMS

Table S3 shows the cut-offs of Tele-GEMS based on Age, Education, and the Cognitive Reserve Index (CRI) deriving from the Cognitive Reserve Index questionnaire (CRIq). Education was grouped based on the Italian educational system. Educational level ≤ 5 refers to years of education from 0 to primary school; 8 = middle school; 13 = high school; 16 = bachelor's degree; 18 = master's degree; > 18 Ph.D. or any specialization occurred after the University period.

The ranges of CRI reported here are consistent with Nucci, Mondini, and Mapelli (2012).

Notably, some cut-offs in Table S3 are equal, suggesting that low variability could be expected on Tele-GEMS for some combination of socio-demographic variables (e.g., among young individuals with bachelor's and master's degrees). The author's recommendation is to use, consistently, as reference cut-offs (for research or clinical purposes), either the cut-off values provided in this table or the cut-off values provided in the Shiny App at the link: <https://osf.io/t3bma/>

CRI ≤ 70		AGE														
		≤ 20	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	≥ 86
Education	≤ 5	67	67	66	65	64	63	62	61	59	57	55	53	51	49	37
	8	71	70	70	69	68	67	66	64	63	61	59	57	55	52	42
	13	74	74	73	73	72	71	69	68	67	65	63	61	59	56	46
	16	75	75	74	74	73	72	70	69	67	66	64	62	59	57	46
	18	75	75	74	74	73	72	70	69	67	66	64	62	59	57	46
	> 18	74	74	73	73	72	71	69	68	66	65	63	61	59	56	46

CRI 71-84		AGE														
		≤ 20	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	≥ 86
Education	≤ 5	68	68	67	66	66	64	63	62	60	58	57	55	52	50	40
	8	72	71	71	70	69	68	67	65	64	62	60	58	56	54	43
	13	75	75	75	74	73	72	71	69	68	66	64	62	60	57	47
	16	76	76	75	75	74	73	71	70	68	67	65	63	61	58	47
	18	76	76	75	75	74	73	71	70	68	67	65	63	60	58	47
	> 18	75	75	74	74	73	72	71	69	68	66	64	62	60	57	47

CRI: 85-114		AGE														
		≤ 20	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	≥ 86
Education	≤ 5	72	71	71	70	69	68	67	65	64	62	60	58	56	53	51
	8	75	75	74	73	73	71	70	69	67	66	64	62	59	57	54
	13	79	79	78	77	76	75	74	73	71	69	67	65	63	61	58
	16	80	79	79	78	77	76	75	73	72	70	68	66	64	62	59
	18	80	79	79	78	77	76	75	73	72	70	68	66	64	62	59
	> 18	79	78	78	77	76	75	74	73	71	69	67	65	63	61	58

CRI: 115-129		AGE														
		≤ 20	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	≥ 86
Education	≤ 5	75	75	74	73	72	71	70	69	67	65	64	61	59	57	54
	8	79	78	78	77	76	75	74	72	71	69	67	65	63	61	58
	13	82	82	82	81	80	79	78	76	75	73	71	69	67	64	62
	16	83	83	82	82	81	80	78	77	75	74	72	70	67	65	63
	18	83	83	82	82	81	80	78	77	75	74	72	70	67	65	63
	> 18	82	82	81	81	80	79	77	76	74	73	71	69	67	64	62

CRI: ≥ 130		AGE														
		≤ 20	20-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	≥ 86
Education	≤ 5	81	81	80	80	79	78	76	75	73	72	70	68	65	63	61
	8	85	85	84	83	82	81	80	79	77	75	73	71	69	67	64
	13	89	88	88	87	86	85	84	82	81	79	77	75	73	70	68
	16	90	89	89	88	87	86	85	83	82	80	78	76	74	71	69
	18	89	89	89	88	87	86	85	83	82	80	78	76	74	71	69
	> 18	89	88	88	87	86	85	84	82	81	79	77	75	73	70	68

Table 3. Cut-offs of Tele-GEMS based on Age, Education, and Cognitive Reserve Index (CRI). Education was grouped on the basis of the Italian educational system. The educational level are 5 = primary school, 8 = middle school, 13 = high school, 16 = bachelor's degree, 18 = master's degree, higher than 18 = Ph.D. or any specialization occurred after the University period.