

Montreal Cognitive Assessment Hearing Impairment (MoCA-HI)

Version 1.0

Administration and Scoring Instructions

The Montreal Cognitive Assessment Hearing Impairment (MoCA-HI) was developed to facilitate the detection of cognitive impairment in subjects with a hearing impairment. The MoCA-HI assesses similar cognitive domains as the original MoCA: executive functions, language, orientation, calculations, conceptual thinking, memory, visuosperception, attention and concentration. Time to administer the MoCA-HI is approximately 10 minutes. The total possible score is 30 points. A score of 25 or above is considered normal.

The examiner shows the participant the first flashcard (1) with the instructions: *“Please read the instructions on the card out loud. Then please do what the instructions say. Are you ready to start?”*. Ensure the subject has understood the instructions and have successfully read the instructions out loud for this flashcard and the flashcards throughout the test.

1. Alternating Trail Making:

Administration: The examiner instructs the subject by showing the flashcard (2) to the participant: *“Please draw a line, going from a number to a letter in ascending order. Begin at [point to (1)] and draw a line from 1 then to A then to 2 and so on. End at [point to (E)].”*

Scoring: Allocate one point if the subject successfully draws the following pattern: 1 –A- 2- B- 3- C- 4- D- 5- E, without drawing any lines that cross. Any error that is not immediately self-corrected earns a score of 0.

2. Visuoconstructional Skills (Cube):

Administration: The examiner gives the following instructions by showing the flashcard (3) and pointing to the cube: *“Copy this drawing as accurately as you can”*

Scoring: One point is allocated for a correctly executed drawing.

- Drawing must be three-dimensional.
- All lines are drawn.
- All lines meet with little or no space.
- No line is added.
- Lines are relatively parallel, and their length is similar (rectangular prisms are accepted)
- The cube’s orientation in space must be preserved.

A point is not assigned if any of the above criteria are not met.

3. Visuoconstructional Skills (Clock)

Administration: The examiner must ensure that the subject does not look at his/her watch while performing the task and that no clocks are in sight. The examiner indicates the appropriate space and gives the following instruction by showing the flashcard (4): *“Draw a clock. Put in all the numbers and set the time to 10 past 11”*.

Scoring: One point is allocated for each of the following three criteria:

- Contour (1 pt.): the clock contour must be drawn (either a circle or a square). Only minor distortions are acceptable (e.g., slight imperfection on closing the circle). If the numbers are arranged in a circular manner but the contour is not drawn the contour is scored as incorrect.
- Numbers (1 pt.): all clock numbers must be present with no additional numbers. Numbers must be in the correct order, upright and placed in the approximate quadrants on the clock face. Roman numerals are acceptable. The numbers must be arranged in a circular manner (even if the contour is a square). All numbers must either be placed inside or outside the clock contour. If the subject places some numbers inside the clock contour and some outside the clock contour, (s)he does not receive a point for Numbers.
- Hands (1 pt.): there must be two hands jointly indicating the correct time. The hour hand must be clearly shorter than the minute hand. Hands must be centered within the clock face with their junction close to the clock center.

4. Naming:

Administration: The examiner shows and points to each figure on the flashcard (5, 6, 7, respectively) with instructions: *“Tell me the name of this animal”*.

Scoring: One point is given for each of the following responses: (1) lion (2) rhinoceros or rhino (3) camel or dromedary.

5. Memory:

Administration: The examiner shows the flashcard (8): *“This is a memory test. I am going to show you a list of words that you will have to remember now and later on. Read carefully. When I am through, tell me as many words as you can remember. It doesn’t matter in what order you say them”*.

The examiner shows and says the 5 words on the flashcards (9ⁱ-9^v) at a rate of one per 2 seconds. Then shows the flashcard (10) with instructions: *“Tell me as many words as you can remember”*. The examiner marks a check in the allocated space for each word the subject produces on this first trial. The examiner may not correct the subject if (s)he recalls a deformed word or a word that

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sounds like the target word. When the subject indicates that (s)he has finished (has recalled all words), or can recall no more words, the examiner shows the flashcard (11) with instructions: “*I am going to show the same list for a second time. Try to remember and tell me as many words as you can, including words you said the first time*”. The examiner shows the list a second time and says the 5 words on the flashcards (12ⁱ-12^v) at a rate of one per 2 seconds. Then shows the flashcard (13) with instructions: “*Tell me as many words as you can remember*”. The examiner marks a check in the allocated space for each word the subject produces on the second trial.

At the end of the second trial, the examiner shows the flashcard (14): “*I will ask you to recall those words again at the end of the test*”.

Scoring: No points are given for Trials One and Two.

6. Attention:

Forward Digit Span: Administration: The examiner shows the flashcard (15): “*I am going to show you some numbers and when I am through, repeat them to me exactly as you saw them.*” Show the five-number sequence on the flashcards (16ⁱ-16^v) at a rate of one digit per 2 seconds.

Backward Digit Span: Administration: The examiner shows the flashcard (17): “*Now I am going to show some more numbers. When I am through, you must repeat them to me in the backward order.*” Show the three-number sequence on the flashcards (18ⁱ-18ⁱⁱⁱ) at a rate of one digit per 2 seconds. The examiner shows the flashcard (19): “*Repeat them to me in the backwards order.*” If the subject repeats the sequence in the forward order, the examiner may not ask the subject to repeat the sequence in backward order at this point.

Scoring: One point is allocated for each sequence correctly repeated (N.B.: the correct response for the backward trial is 2-4-7).

Vigilance: Administration: The examiner shows the flashcard (20): “*Looking at the row of numbers with a dark background, please read out loud the numbers in the CIRCLES and SQUARES. Do not read the numbers in the triangles.*” Show the flashcard (21) displaying the sequence of numbers on a black background with instructions: “*Start here*” [point to the beginning of the first row], “*go through both rows*” [run your finger across the top then bottom row from left to right] “*and stop here*” [point to the end of the second row].

Scoring: 1 point is allocated if the subject completes the task with 2 errors or less.

Serial 7s: Administration: The examiner shows the flashcard (22): “*Now I will ask you to count by subtracting 7 from 100 and then, keep subtracting seven from your answer until I tell you to stop.*” The examiner shows the flashcard (23): “*Keep going*” if necessary, as a prompt for the

subject to continue. The subject must perform a mental calculation, therefore, (s)he may not use his/her fingers nor a pencil and paper to execute the task. The examiner may not repeat the subject's answers. If the subject asks what her/his last given answer was or what number (s)he must subtract from his/her answer, the examiner responds by showing the flashcard (22) once more.

Scoring: This item is scored out of 3 points. Give no (0) points for no correct subtractions, 1 point for 1 correct subtraction, 2 points for two or three correct subtractions, and 3 points if the subject successfully makes four or five correct subtractions. Each subtraction is evaluated independently; that is, if the subject responds with an incorrect number but continues to correctly subtract 7 from it, each correct subtraction is counted. For example, a subject may respond "92-85-78-71-64" where the "92" is incorrect, but all subsequent numbers are subtracted correctly. This is one error, and the task would be given a score of 3.

7. Sentence construction

Administration: The examiner shows the flashcard (24): *"Please make a sentence using these words."* The examiner then shows the flashcard (25): CAT/SLEEPY/THE/VERY/WAS. Following the subject's response, the examiner shows the flashcard (26): *"Please make a sentence using these words."* The examiner then shows the flashcard (27): WEAR/DECIDED/A/BLUE/JULIE/TO/DRESS.

Scoring: One point is allocated for each sentence correctly constructed. Constructions must be exact and grammatically correct, with no omissions or inclusions of additional words. The correct answers are: "The cat was very sleepy" and "Julie decided to wear a blue dress".

8. Verbal fluency:

Administration: The examiner shows the flashcard (28): *"Now, I want you to tell me as many words as you can think of that begin with the letter F. I will tell you to stop after one minute. Proper nouns, numbers, and different forms of a verb are not permitted. Are you ready?"* [Pause] [Time for 60 sec]. Once the timer reaches 0, the examiner shows the flashcard (29): *"Stop."* If the subject names two consecutive words that begin with another letter of the alphabet, the examiner shows the flashcard (28) again, and points to the corresponding target letter if the instructions have not yet been repeated.

Scoring: One point is allocated if the subject generates 11 words or more in 60 seconds. The examiner records the subject's responses in the margins or on the back of the test sheet.

9. Abstraction:

Administration: The examiner asks the subject to explain what each pair of words has in common and shows the flashcard (30): “*Now I am going to show you two words. I would like you to tell me what category they belong to.*” The examiner shows the flashcard (31): “*An orange and a banana.*” If the subject responds correctly, the examiner shows the flashcard (32): “*Yes, both items are part of the category Fruits.*” If the subject answers in a concrete manner, the examiner gives one additional prompt by showing the flashcard (33): “*Tell me another category to which these items belong to.*” If the subject does not give the appropriate response (*fruits*), the examiner shows the flashcard (34): “*Yes, and they also both belong to the category Fruits.*” No additional instructions or clarifications are given. After the practice trial, the examiner shows the flashcard (35): “*Now, a train and a bicycle.*”. Following the response, the examiner administers the second trial by showing the flashcard (36): “*Now, a ruler and a watch.*” A prompt flashcard (33; one for the entire abstraction section) may be given if none was used during the example.

Scoring: Only the last two pairs are scored. One point is given for each pair correctly answered. The following responses are acceptable:

- train-bicycle = means of transportation, means of travelling, you take trips in both
- ruler-watch = measuring instruments, used to measure

The following responses are **not** acceptable:

- train-bicycle = they have wheels
- ruler-watch = they have numbers

10. Delayed recall:

Administration: The examiner gives the following instruction by showing the flashcard (37): “*I showed some words to you earlier, which I asked you to remember. Tell me as many of those words as you can remember.*” The examiner makes a check mark (✓) for each of the words correctly recalled spontaneously without any cues, in the allocated space.

Scoring: One point is allocated for each word recalled freely **without any cues**.

Memory index score (MIS):

Administration: Following the delayed free recall trial, the examiner shows the flashcard (38): “*I will give you some hints to see if it helps you remember the words.*”. The examiner will then provide a category (semantic) cue using the specific flashcard for each word the subject was unable to recall. For example, the examiner will show the flashcard (39ⁱ): “*The first word was a body part.*” If the subject is unable to recall the word with the category cue, the examiner provides him/her with a multiple-choice cue flashcard (39ⁱⁱ; NB., the examiner should identify the three relevant multiple-choice options and write them down on the

flashcard; the words in parentheses are to be used if the subject mentions one or two of the multiple-choice responses during the category cueing). All non-recalled words are prompted in this manner using the relevant flashcards (39ⁱ-39^x). The examiner identifies the words the subject was able to recall with the help of a cue (category or multiple-choice) by placing a check mark (✓) in the appropriate space.

The cues for each word are presented below:

Target Word	Category Cue	Multiple Choice
FACE	body part	nose, face, hand (shoulder, leg)
VELVET	type of fabric	denim, velvet, cotton (nylon, silk)
CHURCH	type of building	church, school, hospital (library, store)
DAISY	type of flower	rose, daisy, tulip (lily, daffodil)
RED	color	red, blue, green (yellow, purple)

Scoring: To determine the MIS (which is the sub-score), the examiner attribute points according to the type of recall (see table below). The use of cues provides clinical information on the nature of the memory deficits. For memory deficits due to retrieval failures, performance can be improved with a cue. For memory deficits due to encoding failures, performance does not improve with a cue.

MIS Scoring				Total
Number of words recalled spontaneously	...	multiplied by	3	...
Number of words recalled with a category cue	...	multiplied by	2	...
Number of words recalled with a multiple-choice cue	...	multiplied by	1	...
Total MIS (Add all points)				.../15

11. Orientation:

Administration: The examiner shows the flashcards (40ⁱ) awaiting a response: “Tell me the date today.” If the subject does not give a complete answer, then prompt by showing the relevant flashcards: (40ⁱⁱ) “Now tell me the month”; (40ⁱⁱⁱ) “Now tell me the year”; (40^{iv}) “Now tell me the day”. Then show the flashcard (40^v): “Now tell me the name of this place, and which city it is in.”

Scoring: One point is allocated for each item correctly answered. The date and place (name of hospital, clinic, office) must be exact. No points are allocated if the subject makes an error of one day for the day and date.

TOTAL SCORE: Sum all subscores listed on the right-hand side. Add 2 point(s) for subject who has 12 years or fewer of formal education if they have a score of less than or equal to 28, for a possible maximum of 30 points. A final total score of 25 and above is considered normal.

Notes on this version:

The MoCA-H reported here is based on interim analysis of data collected as part of the European SENSE-Cog project¹ supported by the European Union's Horizon 2020 research and innovation programme under grant agreement number 668648.

Data collection for validation of the MoCA-H was interrupted by the COVID-19 pandemic. The present interim version of the MoCA-H and associated psychometric performance data have been made available for immediate use. Data collection will recommence, and psychometric data will be updated following completion of data collection once testing restrictions are lifted.

ROC analysis completed for this version of the MoCA found the best performance with a sensitivity of 95.74% and specificity of 85.71% was achieved at a cut-point of ≤ 24 points indicative of cognitive impairment, with a 2-point adjustment for education. (12 years or less of education). Table 1 displays the potential cut-points and their respective sensitivity and specificity levels with adjustments related to education and age. Best performances are highlighted.

Table 1: ROC analysis for English language version of Moca-H										
Cut-point	Unadjusted			2pt education adjustment			2pt education + 1 pt. age adjusted			
	Sensitivity	Specificity	Youden	Sensitivity	Specificity	Youden	Sensitivity	Specificity	Youden	
≤ 30	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	
≤ 29	100.00%	9.52%	9.52%	100.00%	21.43%	21.43%	100.00%	26.19%	26.19%	
≤ 28	100.00%	26.19%	26.19%	100.00%	40.48%	40.48%	100.00%	42.86%	42.86%	
≤ 27	100.00%	42.86%	42.86%	100.00%	52.38%	52.38%	100.00%	52.38%	52.38%	
≤ 26	100.00%	59.52%	59.52%	97.87%	61.90%	59.77%	97.87%	71.43%	69.30%	
≤ 25	100.00%	71.43%	71.43%	97.87%	76.19%	74.06%	97.87%	78.57%	76.44%	
≤ 24	95.74%	76.19%	71.93%	95.74%	85.71%	81.45%	93.62%	90.48%	84.10%	
≤ 23	89.36%	83.33%	72.69%	85.11%	90.48%	75.59%	82.98%	90.48%	73.46%	
≤ 22	85.11%	90.48%	75.59%	78.72%	95.24%	73.96%	76.60%	95.24%	71.84%	
≤ 21	78.72%	92.86%	71.58%	72.34%	95.24%	67.58%	68.09%	95.24%	63.33%	
≤ 20	74.47%	95.24%	69.71%	65.96%	97.62%	63.58%	65.96%	97.62%	63.58%	
≤ 19	68.09%	95.24%	63.33%	63.83%	100.00%	63.83%	57.45%	100.00%	57.45%	
≤ 18	57.45%	97.62%	55.07%	55.32%	100.00%	55.32%	55.32%	100.00%	55.32%	
≤ 17	55.32%	100.00%	55.32%	48.94%	100.00%	48.94%	44.68%	100.00%	44.68%	
≤ 16	53.19%	100.00%	53.19%	44.68%	100.00%	44.68%	38.30%	100.00%	38.30%	
≤ 15	46.81%	100.00%	46.81%	38.30%	100.00%	38.30%	36.17%	100.00%	36.17%	
AUC	0.955			0.964			0.965			

Table 2 shows that (a) people with HI were on average older than those without, by around 6 years; and (b) people with dementia were older than those without, by around 2 years. However, differences in mean scores between males and females were much lower (table 3).

Table 2: Mean ages							
Group	MOCA	<=12 yrs.		>=13 yrs.		All	
		n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
NCI	8.1	66	74.5 (7.8)	69	70.0 (6.5)	135	72.2 (7.5)
NCIH	Moca-H	79	80.1 (7.4)	44	76.5 (9.6)	123	78.8 (8.4)
DEM	8.1	55	74.9 (6.2)	38	74.3 (6.7)	93	74.7 (6.4)
DEMH	Moca-H	77	80.8 (6.6)	33	79.2 (5.4)	110	80.3 (6.3)

Table 3: Mean MoCA scores by gender							
Group	MOCA	Male		Female		All	
		n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
NCI	8.1	52	24.72(3.79)	83	26.24(3.30)	135	25.65(3.56)
NCIH	Moca-H	65	24.17(3.77)	58	23.62(3.90)	123	23.91(3.83)
DEM	8.1	47	17.55(5.09)	46	16.72(5.12)	93	17.14(5.10)
DEMH	Moca-H	65	16.94(6.20)	45	14.33(5.14)	110	15.87(5.90)

Reference:

1. Dawes, P., et al., *Protocol for the development of versions of the Montreal Cognitive Assessment (MoCA) for people with hearing or vision impairment*. *BMJ open*, 2019. **9**(3): p. e026246.