**SUPPLEMENTARY MATERIALS**

 **How long have you exercised in your life?**

**The effect of Motor Reserve and Current Physical Activity on cognitive performance**

Veronica Pucci1,2, Carolina Guerra1, Amanda Barsi1, Massimo Nucci3 and Sara Mondini1,2

*1Department of Philosophy, Sociology, Education and Applied Psychology, FISPPA, University of Padova*

2 *Human Inspired Technology Research-Centre, University of Padova*

3*Department of General Psychology, University of Padova*

**Supplementary Material 1 - Towards a validation of Motor Reserve Index questionnaire and Current Physical Activity questionnaire**

Motor Reserve Index questionnaire (MRIq) and Current Physical Activity questionnaire (CPAq) were developed *ad hoc* for this study and their psychometric properties were considered. Content Validity was assessed using the Content Validity Index (Polit & Beck, 2006), Internal Consistency was calculated through the Cronbac’s alpha and test retest reliability was derived through the Perarsons’*r*.

*Content Validity*

A gold standard measure of Motor Reserve is not available in literature. For this reason none tool can be used to assess convergent validity and we decided to assess the Content Validity, which is defined as the degree to which elements of an instrument are relevant to and representative of the targeted (in this case Motor Reserve) (Cook & Beckman, 2006; Haynes et al., 1995).

With this aim, a pool of 13 experts of cognition and physical activity were asked to evaluate the items of the questionnaires as essential or not for assessing the amount of physical activity carried out by a person. Content Validity Ratio (CVR) for each item was calculated with this formula:

(Ne-N/2)/(N/2)

where Ne corresponds to the total number of experts which considered the item as essential, and N corresponds to the total number of experts (N=13). CVR of items ranged from 0.23 to 1. Content Validity Index (CVI=0.59) was calculated as the average score of CVR of each item. Supplementary Table 1 shows more detail of the process to calculate CVI.

Even if 2 items resulted with a low CVR, (Item1 = 0.23; Item7 = 0.23) no item has been removed from the questionnaire in order to allow the discrimination between people completely physically inactive and people less active.

| Item | Exp1 | Exp2 | Exp3 | Exp4 | Exp5 | Exp6 | Exp7 | Exp8 | Exp9 | Exp10 | Exp11 | Exp12 | Exp13 | Ne | CVR |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 8 | 0.23 |
| 2 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 9 | 0.39 |
| 3 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 0.85 |
| 4 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 10 | 0.54 |
| 5 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 10 | 0.54 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 1 |
| 7 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 8 | 0.23 |
| 8 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 9 | 0.39 |
| 9 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 10 | 0.54 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 1 |
| 11 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 0.39 |
| 12 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 | 0.54 |
| 13 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 9 | 0.39 |
| 14 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 | 0.54 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 1 |
| 16 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 10 | 0.54 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | CVI = 0.53 |

**Supplementary Table 1**. The table shows the judgment of the 17 items of each of the 13 experts. “0” = experts who judged item as no essential; “1” = experts who judged item as essential; Ne = total number of experts who judged each item as essential; CVR = Content Validity Ratio, calculated as (Ne-N/2)/(N/2), where N is the sample size of experts (13); CVI = Content Validity Index, average of CVR scores.

The two questionnaires were then administered to a sample of 350 individuals (220, female; see Supplementary Table 2 for the descriptive statistics of the sample).

|  | Mean | SD | Mode | Median | Min | Max |
| --- | --- | --- | --- | --- | --- | --- |
| Age | 55.8 | 17.2 | 55 | 58 | 19 | 96 |
| Education | 13.1 | 4.2 | 13 | 13 | 4 | 29 |
| CRI-Total | 114.5 | 20.0 | 126 | 112 | 70 | 194 |
| CRI-Education | 106.5 | 14.9 | 106 | 105 | 66 | 203 |
| CRI-WorkingActivity | 106.7 | 16.8 | 93 | 104 | 69 | 163 |
| CRI-LeisureTime | 119.5 | 23.5 | 95 | 117 | 71 | 194 |

**Supplementary Table 2**. Descriptive statistics of the sample (N=350) who underwent the Motor Reserve Index questionnaire and the Current Physical Activity questionnaire.

***Note***. CRI = Cognitive Reserve Index.

*Internal Consistency*

Internal consistency was calculated through Cronbach's alpha on all items. A standardized alpha was used based on the correlations. Results showed an high internal consistency for MRI (0.83, ranging from 0.81 to 0.84) and slightly higher for CPA (0.54, ranging from 0.48 to 0.54). This low Cronbach’s alpha is not surprising. In fact, since the items evaluated the amount of physical activity in different areas of the life, it is possible that an individual is very active in one of these areas (e.g., workplace activity) but not in another (e.g., physical exercise). In other words, a poor correlation between the items does not reflect a poor psychometric property. In fact, MRIq and CPAq can be considered as *reflective* tools (Borsboom et al., 2003), measuring a latent construct. Within this framework, an high Cronbach’s alpha is not required. We reported here the values as an additional description of the questionnaires’ properties. A very similar result was found by Nucci and collaborators (2012) when developing and validating the Cognitive Reserve Index questionnaire.

Supplementary Table 3 shows Cronbach's alpha values obtained for the 17 items of MRI and for the CPA.

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MRI | .82 | .82 | .82 | .81 | .81 | .82 | .83 | .82 | .83 | .82 | .84 | .82 | .83 | .83 | .84 | .82 | .83 |
| CPA | .54 | .52 | .52 | .51 | .52 | .51 | .57 | .53 | .52 | .54 | .55 | .54 | .51 | .48 | .52 | .56 | .58 |

**Supplementary Table 3.** The table shows the Cronbach’s alpha values for each of the 17 items of the MRI and CPA.

*Test-retest reliability*

To calculate the test-retest reliability, a sub-sample of 20 participants was reassessed after around two months: Pearson’s *r* are acceptable (*r*=0.73 for MRI and *r*=0.67 for CPA), indicating a good test-retest reliability.

**Supplementary Material 2 - Cognitive Function Dementia (CFD - Jahn & Hessler, 2020)**

The CFD test is a comprehensive tool to assess all types of cognitive impairment. Tests are administered in a standard sequence on a touchscreen computer, and the whole administration lasts about 60 minutes. CFD detects subtle differences among healthy participants, avoiding the ceiling effect. The tests included in the CFD battery are listed below.

*Vienna Verbal Fluency Test*:it is a task to assess richness of vocabulary and executive functioning. The task consists of a two-minute generation of words within a semantic category (i.e., animal, sem-FLU) and a specific phoneme (i.e., letter L, phon-FLU).

*Auditory Word List Learning Test:* a list of 12 words to learn and recall with delay. The test includes a learning phase (WL-T0) followed by a recall phase with two different delays: after 5 minutes (WL-T1) and after 20 minutes (WL-T2) and a final recognition phase (WL-Rec).

*Perception and Attention Functions - Alertness:* this test measures 1) alertness, a general readiness to react to simple visual stimuli (AL-1), and 2) the ability to modulate the attentional level when an auditory cue is presented before the stimulus (AL-2).

*Perception and Attention Functions – Divided Attention:* the test measures the ability to simultaneously orient attention towards several information channels. Visual and auditory stimuli are presented simultaneously, and the participant must respond only when one of the target stimuli changes twice in sequence. Reaction times are measured (RTs).

*Trail-Making Test – Langensteinbach Version (TMT;* Reitan, 1955) *Part A:* it evaluates the processing speed in detecting simple numerical stimuli using part A of the TMT test. The score (TMT-A) depends on both processing time and accuracy (number of errors).

*Trail-Making Test – Langensteinbach Version (TMT;* Reitan, 1955) *– Part B:* part B of the TMT (measure of executive functioning) measures the ability to rapidly switch between two different reference systems (numbers and letters), tapping each stimulus in sequence. The score (TMT-B) considers processing time and accuracy.

*Backward CORSI Block-Tapping Test*:this test evaluates visuospatial working memory and executive functioning. The participant must watch the same sequence of blocks in a matrix and reproduce it backward. The length of the sequence increases as the test progresses until the participant is unable to perform the sequence correctly. The score is theImmediate Block Span Backwards *(*bk*-CORSI).*

*Vienna Object Naming Test:* the test measures the ability to retrieve the names of objects. In the case of anomia, a cue (phonemic or semantic) can be given. The score is the number of named objects without cues (ob-NAM).

*Visuoconstruction Test*: this test evaluates visual constructive ability and requires participants to reconstruct a complex figure in 60 seconds, starting from two triangles. The final score is the number of figures correctly completed (FIG).

**References**

Borsboom, D., Mellenbergh, G., & Heerden, J. (2003). The Theoretical Status of Latent Variables. *Psychological review*, *110*, 203-19. 10.1037/0033-295X.110.2.203.

Cook, D. A., & Beckman, T. J. (2006). Current concepts in validity and reliability for psychometric instruments: theory and application. *The American journal of medicine*, *119*(2), . <https://doi.org/10.1016/j.amjmed.2005.10.036>

Haynes, S. N., Richard, D. C. S., & Kubany, E. S. (1995). Content validity in psychological assessment: A functional approach to concepts and methods. *Psychological Assessment*, *7*, 238-247. <http://dx.doi.org/10.1037/1040-3590.7.3.238>

Jahn, T., & Hessler, J. (2020). *Manual Cognitive Function Dementia*, Version 2. Schuhfried.

Nucci, M., Mapelli, D., & Mondini, S. (2012). Cognitive Reserve Index questionnaire (CRIq): a new instrument for measuring cognitive reserve. *Aging Clinical and Experimental Research, 24*(3), 218–226. https://doi.org/10.3275/7800

Polit, D. F., & Beck, C. T. (2006). The content validity index: are you sure you know what's being reported? Critique and recommendatio*ns. Research in nursing & health*, *29*(5), 489–497. <https://doi.org/10.1002/nur.20147>

Reitan, R. M. (1955). The Relation of the Trail Making Test to Organic Brain Damage. J*ournal of Consulting Psychology, 19*, 393-394.

http://dx.doi.org/10.1037/h0044509