**Supplementary table 1. Components of published super-ageing definitions**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Term (study)** | **Study type/objective** | **Sample (mean age)** | **Comparator group/s (mean age)** | **Cognitive domain/s** | **Tests (current study has available data ✓/x)** | **Cut-offs** | **Independent daily functioning required** |
| Cognition comparable to younger adults in ≥1 domain | | | | |  |  |  |
| SuperAgers |  |  |  |  |  |  |  |
| Harrison *et al* 2012 | Imaging: comparison of cortical volume on structural MRI | ≥80 (mean age 83.5) | Elderly controls (83.1), middle-aged controls (57.9) | Verbal episodic memory | RAVLT delayed recall (✓) | ≥9/normative mean for 50-65yo | Yes1 |
|  |  |  |  | Executive function, verbal fluency, language/naming | TMT-B (✓), CFT (✓), BNT-30 (✓) | At least average (≥-1 SD for age and education) | |
|  |  |  |  |  |  |  |  |
| Rogalski *et al* 2013 | Cohort study: initial structural neuroimaging, genetic and pathologic results | As above | As above | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Gefen *et al* 2014 | Longitudinal cognitive performance of SuperAgers | 82.2 |  | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Gefen et al 2015 | Imaging and neuropathological features of the anterior cingulate cortex in SuperAgers | 82.5 | Elderly controls (83.8), Middle-aged controls (58.4) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Cook *et al* 2017 | Imaging: MRI cortical volume change over 18 months | 83.3 | Cognitively average elderly adults (83.4) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Cook Maher *et al* 2017 | Psychological wellbeing of SuperAgers | 83.4 | 84.4 | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Huentelman *et al* 2018 | Genetic variations in SuperAgers | 83 | Cognitively average controls (82.8) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Janeczek *et al* 2018 | Neuropathology\_ acetylcholinesterase activity | 90.2 | Older adult (83.3), middle-aged (53) and young (23.9) controls | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Rogalski *et al* 2019 | Autopsy study of SuperAging cohort | 85.5 |  | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Cervenkova *et al* 2020 | Cognitive trajectories over 3 years | ≥ 80 | ≥ 80 | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Borelli *et al* 2021 | Imaging: metabolic (PET), amyloid (PiB-PET) and functional (fMRI) analysis of SuperAgers | 82.1 | Age matched controls (84.2), middle-aged controls (58.5) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Karpouzian-Rogers 2022 | Use of the NIHTB to determine if SuperAgers also had superior non-verbal memory | 84.2 | Cognitively average (84) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Nassif *et al* 2022 | Neuropathology: to determine whether entorhinal cortex integrity differentiated SuperAgers from cognitively average controls | 91.3 | Normal elderly (89.3), MCI, young controls | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| Successful healthy agers | | |  |  |  |  |  |
| Bezdicek *et al* 2020 | Longitudinal cognitive performance and functional capacity | 74.9 | Decliners (75.9) | Verbal episodic memory | PVLT delayed recall (x) | ≥9/normative mean for 50-65yo | Yes1 |
|  |  |  |  | Executive function, verbal fluency, language/naming | TMT-B (✓), CFT (✓), BNT-30 (✓) | ≥-1 SD for age and education | |
|  |  |  |  | Global cognition | MoCA (x) | Non-negative random slope over 5 years | |
|  |  |  |  |  |  |  |  |
| Superagers |  |  |  |  |  |  |  |
| de Godoy *et al* 2021 | Imaging: H-MR spectroscopy to investigate relationship between brain metabolite concentrations and late-life cognitive performance | ≥ 80yo | Age matched controls | Verbal episodic memory | RAVLT delayed recall (✓) | ≥ 9/normative mean for 50-65yo | Yes1 |
|  |  |  |  | Executive function, attention, working memory, visuospatial, verbal fluency, language/naming | TMT-A and B (✓), digit span (✓), RCFT (x), category and letter fluency (✓), BNT-60 (x) | ≥ -1 SD for age and education | |
|  |  |  |  |  |  |  |  |
| Sun *et al* 2016 | Imaging: cortical thickness in regions comprising the default mode and salience networks | 67.8 | Typical older adults (66.2), young adults (24.5) | Verbal episodic memory | CVLT long delay free recall (x)2 | ≥ gender-adjusted normative mean for 18-32yo | No |
|  |  |  |  | Executive function | TMT-B (✓) | ≥ -1 SD mean for age | |
|  |  |  |  |  |  |  |  |
| Zhang et al 2020 | Imaging: fMRI connectivity within the default mode and salience networks | As above | As above | As above | As above | As above | No |
|  |  |  |  |  |  |  |  |
| Katsumi et al 2021 | Imaging: task-based fMRI involving visual recognition memory | As above | As above | As above | As above | As above | No |
|  |  |  |  |  |  |  |  |
| Katsumi *et al* 2022 | Incidence of post-operative delirium in SuperAgers and association with MRI cortical thickness | 75.5 | Typical older adults (75.9) | Verbal episodic memory | HVLT (x)2 | ≥ gender-adjusted normative mean for 16-29yo | No |
|  |  |  |  | Executive function | TMT-B (✓) | As above |  |
|  |  |  |  |  |  |  |  |
| Successful agers | |  |  |  |  |  |  |
| Harrison *et al* 2018 | Imaging: cortical thickness, hippocampal volume, WMH, PiB-PET | 74.9 | Typical older adults (75.9), young adults (24.1) | Verbal episodic memory  Executive function | CVLT long delay free recall (x)2  TMT-B (✓) | ≥ normative mean for 18-32yo  ≥ -1 SD mean for age No | |
|  |  |  |  |  | |  |  |
| SuperAgers |  |  |  |  |  |  |  |
| Maccora *et al* 2020 | Prevalence, clinical and demographic factors associated with SuperAgeing status | 70.4 F, 70.2 M | Normal controls (70.7 F, 70.6 M) | Verbal episodic memory | CVLT immediate and delayed recall (x)2 | Maintaining scores ≥ median for those of the same gender in their 20s | No |
|  |  |  |  | Global cognition | MMSE (✓) | ≥ 29 over 3 waves of follow up | |
|  |  |  |  |  |  |  |  |
| Dang *et al* 2019 | Risk of progression to MCI or dementia | 68.4 | Cognitively normal for age (68.5) | Verbal episodic memory | CVLT delayed recall (x)2 | ≥ normative mean for 30-40yo | No |
|  |  |  |  | Executive function, working memory, verbal fluency | Digit symbol substitution (✓), Stroop (x), digit span (✓), letter and category fluency (✓) | ≥ -1 SD mean for age | |
|  |  |  |  |  |  |  |  |
| Kim *et al* 2020 | Imaging: MRI DTI white matter integrity in SuperAgers | 71 | Typical ager (73) | Verbal episodic memory | SVLT (x) | ≥ average normative values for 45yo | No |
|  |  |  |  | Visual memory | RCFT (x) |  |  |
|  |  |  |  |  |  |  |  |
| Park *et al* 2021 | Imaging: fMRI patterns of functional connectome in superagers and development of machine learning-based predictive models | 71 | Typical ager (72.8) | As above | As above | As above | As above |
|  |  |  |  |  |  |  |  |
| High performing older adults | | |  |  |  |  |  |
| Cabeza *et al* 2002 | Imaging: PET prefrontal cortex activity in high-performing older adults | 68 | Low-performing older adults (69.9), young controls (25.3) | Memory composite | Logical memory (✓), verbal paired associates (x), CVLT long-delay cued recall (x) | Average standardised score comparable to young adults 20-35yo (standardised mean 0.62 vs 0.54) | No |
|  |  |  |  |  |  |  |  |
| Superior cognitive performance | | |  |  |  |  |  |
| Gardener *et al* 2021 | Imaging: MRI preservation of cortical thickness and volume on serial scans | 75.6 | Typical older adults (76.7) | Verbal episodic memory | CVLT delayed recall (x) | Z scores within 0.5 of 30-44yo | No |
|  |  |  |  | Executive function, working memory, verbal and visual memory, verbal fluency, language/naming | Digit span (✓), digit symbol coding (✓), Stroop (x), logical memory (✓), RCFT delay (x), letter and category fluency (✓), BNT (✓) | Z scores within 1.5 for age | |
|  |  |  |  |  |  | For ≥3 time points up to 54 months | |
|  |  |  |  |  |  |  |  |
| Resilient-agers | |  |  |  |  |  |  |
| Bott *et al* 2017 | Association between genetic, inflammatory, cardiovascular, lifestyle and neuroanatomical factors with changes in cognitive processing speed in older adults | 69.2 | Average-agers (70.9), sub-agers (72) | Cognitive processing speed | Computerised test (x)3 | Scores within 1.25 SD of young adult comparator group in their 20s and <0.5 SD change at follow up (mean 2.5 years) | Yes1 |
|  |  |  |  |  |  |  |  |
| Superior cognition for age in ≥1 domain | | |  |  |  |  |  |
| Supernormals | |  |  |  |  |  |  |
| Lin *et al* 2017 | Imaging: relationships between amyloid deposition and connectivity within the cingulate cortex and between the cingulate cortex and other regions involved in memory | 73.5 | Healthy controls (72.3), MCI (73) | Episodic memory composite | MMSE memory (✓), ADAS-Cog (x), RAVLT (✓), logical memory (✓) | ≥ 1.5 SD of sample across available study visits (≥ 1 follow up) | No |
|  |  |  |  |  |  |  |  |
| Mapstone *et al* 2017 | Plasma metabolomics in older adults with superior memory | 83.2 | Normal controls (83.3) | Verbal episodic memory | RAVLT learning, retrieval and recognition composite (✓) | Scores ≥ 90th percentile of sample | No |
|  |  |  |  | Global cognition, executive function, attention, verbal fluency, language/naming, visuospatial | MMSE (✓), TMT-A and B (✓), CFT (✓), BNT-60, forward and backward digit span (✓), HVOT (x) | > -1.35 or >10th percentile all other domain composite scores | |
|  |  |  |  |  |  |  |  |
| Baran and Lin 2018 | Imaging: comparison of cortical amyloid deposition and glucose metabolism between Supernormals, normal cognition and cognitive impairment | 73.9 | Normal controls (74.6), MCI (71.3), AD (73.2) | Episodic memory composite | RAVLT (✓), ADAS-Cog (x), MMSE (✓), logical memory test (✓) | Mean Z scores 1.51 for memory 1.05 for executive function compared with normal controls and scores ≥ 1 SD above normal population mean with consistently high performance over 5-year period | Yes |
|  |  |  |  | Executive function composite | Digit symbol  substitution (✓), digit  span backwards (✓),  TMT-A  and B (✓), CFT (✓),  CDT (x) | | |
|  |  |  |  | Function | CDR | 0 |  |
|  |  |  |  |  |  |  |  |
| Optimal Memory Performers | | |  |  |  |  |  |
| Dekhtyar *et al* 2017 | To determine demographic factors and imaging (amyloid PET, structural MRI) biomarkers that distinguish top memory performers | 77.5 | Typical performers (78.9) | Composite memory | Memory capacity test (x), face name associative memory exam (x), selective reminding test (x) | Performance in the top 20% with maintenance at 3-year follow up | Yes1 |
|  |  |  |  |  |  |  |  |
| Exceptional episodic memory | | |  |  |  |  |  |
| Wagner 2022 | Longitudinal study assessing impact of lifestyle factors on cognition | ≥ 80yo women | Cognitively average age-matched women | Verbal episodic memory | TICS 10-word list immediate and delayed recall (x), EBMT immediate and delayed recall (x) | Composite score ≥ 1.5 SD sample mean | No |
| Top Cognitive Performers | |  |  |  |  |  |  |
| Dominguez *et al* 2021 | Imaging: MRI cortical thickness in the cingulate cortex and whole brain and association with Top Cognitive Performance | 2 cohorts: 74.1, 94.1 | Non-TCP (74.3, 93.8) | Verbal episodic memory and executive function | Logical memory delayed (✓) and TMT-B (✓) for ≤ 90yo, CVLT delayed recall (x)2 and TMT-B (✓) for ≥ 90yo | Within the top 50th percentile of the sample for younger group, within the top 50% expected for age for older group | Yes1 |
|  |  |  |  |  |  |  |  |
| Successful cognitive aging | | |  |  |  |  |  |
| Yang *et al* 2022 | Examination of early and late life lifestyle and clinical factors associated with cognition | 73.8 | Older adult controls (74.8), MCI (76.1) | Verbal episodic memory | RAVLT delayed recall (✓) | >1.5 SD age and education adjusted sample mean for either | No |
|  |  |  |  | Executive function | TMT-B (✓) |  |  |
|  |  |  |  | General cognition, memory, visuospatial ability, attention, executive function | MMSE (✓), RAVLT (✓), complex figure test copy and delay (x), CDT (x), symbol digit test (✓), TMT-A and B (✓), Stroop Color and Word Test (x) | ≥ -1.5 SD for all | |
|  |  |  |  |  |  |  |  |
| Cognitively elite | |  |  |  |  |  |  |
| Saint-Martin *et al 2017* | Effect of cognitive reserve on cognitive trajectories and active lifestyles in later life | 66.9 | Cognitively normal (74.8), cognitively impaired (74.8) | Composite information processing and attention | TMT-A (✓), Stroop part 1 and 2 (x), WAIS coding subtest (x) | Performance above the sample mean for all | No |
|  |  |  |  | Composite executive function | TMT-B (✓), Stroop part 3 (x), letter and category fluency (✓), WAIS similarities (x) | Follow up: stable, worsened or improved | |
|  |  |  |  | Composite memory | MMSE (✓), BVRT (✓),  Grober and Buschke  selective reminding test (x) | | |
|  |  |  |  |  |  |  |  |
| Super-cognition | |  |  |  |  |  |  |
| Yu *et al* 2020 | Lifestyle factors associated with super-cognition | 67.3 | Normal controls (67.4) | RBANS: immediate memory, visuospatial, language, attention, delayed memory | Word list learning (✓)1, story (✓), figure copy (x)4 , line orientation (x), picture naming (✓), category fluency (✓), digit symbol test (✓), list recall (✓), list recognition (✓), delayed recall story (✓), figure recall (x) | Score ≥ 1 SD above age and education appropriate norms in ≥ 1 domain and ≥ average performance in all other domains | Yes |
|  |  |  |  | Function | CDR | 0 |  |
|  |  |  |  |  |  |  |  |
| Maintenance of cognitive performance over time | | | |  |  |  |  |
| Bezdicek et al 2020 | |  |  |  | MoCA only |  |  |
| Maccora et al 2020 | |  |  |  | Whole definition | |  |
| Gardener et al 2021 | |  |  |  | Whole definition | |  |
| Bott et al 2017 | |  |  |  | Whole definition | |  |
| Lin et al 2017 | |  |  |  | Whole definition | |  |
| Baran and Lin 2018 | |  |  |  | Whole definition | |  |
| Dekhtyar et al 2017 | |  |  |  | Whole definition | |  |
| Saint-Martin et al 2017 | |  |  |  | Sub-analysis of those stable, worsened or improved | | |
|  |  |  |  |  |  |  |  |
| 1 Required for all participants, not super-agers specifically  2 RAVLT substituted for this study, HVLT for SCS participants  3 TMT-A substituted  4 Block design substituted for visuospatial measures for MAS and OATS participants, visuospatial subdomain of ACE-R for SCS | | | | |  |  |  |

ADAS-Cog: Alzheimer’s Disease Assessment Scale – Cognitive Subscale, ADNI EF: Alzheimer’s Disease Neuroimaging Initiative composite executive function score, ADNI-MEM: Alzheimer’s Disease Neuroimaging Initiative composite memory score, BNT-30: 30-item Boston Naming Test, BNT-60: 60-item Boston Naming Test, BVRT: Benton Visual Retention Test, CDR: Clinical Dementia Rating scale, CDT: Clock Drawing Test, CFT: Category Fluency Test, CVLT: California Verbal Learning Test, EBMT: East Boston Memory Test, fMRI: functional magnetic resonance imaging, H-MR: proton magnetic resonance spectroscopy, HVLT: Hopkins Verbal Learning Test, HVOT: Hooper Visual Organisation Test, MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment, MRI: magnetic resonance imaging, NIHTB: National Institutes of Health Toolbox, PiB-PET: Pittsburgh compound B positron emission tomography, PVLT: Philadelphia Verbal Learning Test, RAVLT: Rey Auditory Verbal Learning Test, RBANS: Repeatable Battery for the Assessment of Neuropsychological Status, RCFT: Rey Complex Figure Test, SD: standard deviation, SVLT: Seoul Verbal Learning Test, TICS: Telephone Interview for Cognitive Status, TMT-A and B: Trail Making Test Parts A and B, WAIS-R: Wechsler Adult Intelligence Scale-Revised, WMS-R: Wechsler Memory Scale-Revised, WTAR: Wechsler Test of Adult Reading