# Socio-Environmental Crises and Cognitive Ageing. Exploring the Cognitive Impact of the COVID-19 Pandemic and Climate Crises on Older Adults' Memory and Verbal Fluency

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**Online Appendix**

## Supplementary Files

*Socio-environmental Crises and Cognitive Ageing. Exploring the Cognitive Impact of the COVID-19 Pandemic and Climate Crises on Older Adults' Memory and Executive Functioning.*

**Table S.1a. Sample description**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Total memory | 10.046 | 3.463 | 0 | 20 |
| Verbal fluency | 22.41 | 7.324 | 0 | 93 |
| **Periods:** Baseline change | .685 | .465 | 0 | 1 |
| 4-year follow-up | .146 | .353 | 0 | 1 |
| COVID | .169 | .375 | 0 | 1 |
| **Individual-level variables** | | | | |
| Age at interview | 67.706 | 9.14 | 50 | 97 |
| Age squared | 4667.574 | 1266.396 | 2500 | 9409 |
| Gender: female | .534 | .499 | 0 | 1 |
| Education: low | .112 | .315 | 0 | 1 |
| Intermediate | .564 | .496 | 0 | 1 |
| High | .324 | .468 | 0 | 1 |
| Partner in household | .763 | .425 | 0 | 1 |
| Household size | 1.963 | .698 | 1 | 5 |
| Lives in urban area | .342 | .474 | 0 | 1 |
| Time between interviews | 28.155 | 10.725 | 11 | 65 |
| Had dementia diagnosis | .022 | .146 | 0 | 1 |
| Had stroke | .037 | .188 | 0 | 1 |
| Physical health | .548 | .498 | 0 | 1 |
| Depression | 2.225 | 1.972 | 0 | 11 |
| **Regions**: Germany (region n.a.) | .028 | .165 | 0 | 1 |
| Baden-Württemberg | .106 | .308 | 0 | 1 |
| Bayern | .151 | .358 | 0 | 1 |
| Berlin | .023 | .15 | 0 | 1 |
| Brandenburg | .039 | .194 | 0 | 1 |
| Bremen | .010 | .099 | 0 | 1 |
| Hamburg | .015 | .122 | 0 | 1 |
| Hessen | .077 | .267 | 0 | 1 |
| Mecklenburg-Vorpommern | .024 | .152 | 0 | 1 |
| Niedersachsen | .098 | .297 | 0 | 1 |
| Nordrhein-Westfalen | .176 | .381 | 0 | 1 |
| Rheinland-Pfalz | .042 | .201 | 0 | 1 |
| Saarbrücken | .010 | .098 | 0 | 1 |
| Sachsen | .078 | .268 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| Sachsen-Anhalt | .034 | .181 | 0 | 1 |
| Schleswig-Holstein | .049 | .216 | 0 | 1 |
| Thüringen | .041 | .198 | 0 | 1 |
| Valid case numbers | 9666 | | | |

**Table S.1b: Construction of Analytical Sample**

| | **person-years** | **In % of previous step** |
|---|---|---|
| valid interview | 27,122 | 100% |
| coverscreen respondent or partner | 25,354 | 94% |
| at least 2 observations | **21,733** | 95% |
| valid subsequent wave | 20,019 | 92% |
| valid DV in both waves | 10,461 | 52% |
| no missing values on either controls | 10,155 | 97% |
| Excluding wave 7 (for COVID analysis) | 9,350 | 92% |

| Wave | All valid observations from regular panel wave (not SHARELIFE or Corona) | Participation rate to next regular interview (not SHARELIFE or Corona) |
|---|---|---|
| 1 | 1,212 | 87% |
| 2 | 1,868 | 65% |
| 4 | 1,592 | 68% |
| 5 | 4,765 | 91% |
| 6 | 4,388 | 82% |
| 7 | 3,804 | 11% |
| 8 | 1,011 | 69% |
| 9 | 3,093 | 0% |
| Total | **21,733** | |

Valid interviews in subsequent waves:

| | | |
|---|---|---|
| Wave 1 to Wave 2 | 1,048 | 87% |
| Wave 2 to Wave 4 | 1,516 | 99% |
| Wave 4 to Wave 5 | 1,494 | 95% |
| Wave 5 to Wave 6 | 4,432 | 93% |
| Wave 6 to Wave 7 | 4,356 | 99% |
| Wave 7 to Wave 8 | 3,633 | 96% |
| Wave 8 to Wave 9 | 980 | 97% |
| Total | **21,733** | 20,019 |

**Table S.2.** Identification of pandemic effects and reference periods for cognitive change computation

| | **Waves used for t** | **Waves used for t+1** | **Average duration since last interview in months** |
|---|---|---|---|
| Baseline change (comparisons between regular adjacent panel waves) | Wave 1: 2004<br>Wave 4: 2011<br>Wave 5: 2013 | Wave 2: 2006<br>Wave 5: 2013<br>Wave 6: 2015 | 23,5 – 27,8 |
| Longer follow-up | Wave 2: 2006 | Wave 4: 2011 | 51,5 |
| COVID | Wave 8: March 2019 – Mid-March 2020 | Wave 9: 2021-2022 | 25,5 |

Note: Dependent variables (Cognitive change) = cognitive level (t+1) – cognitive level (t). Wave 7 not used for computing pre-pandemic baseline change due to low case numbers.

**Table S.3. Summer Temperatures – regional averages and maxima**

| Region | **Average summer temperature: July-August** | **Maximum temperature: July** | **Maximum temperature: August** |
|---|---|---|---|
| Baden-Württemberg | 18.24 (1.18) | 35.05 (.98) | 33.34 (3.14) |
| | [16.75-20.1] | [33.83-36.33] | [29.07-36.5] |
| Bayern | 17.84 (1.14) | 32.13 (.67) | 30.54 (2.45) |
| | 816.1-19.7] | [31.33-33.07] | [27.13-33.33] |
| Berlin | 19.57 (1.61) | 33.34 (2.59) | 33.19 (3.58) |
| | [16.5-21.5] | [30.7-37.7] | [29.2-37.45] |
| Brandenburg | 19.04 (1.53) | 32.97 (2.11) | 32.9 (3.33) |
| | [16.1-21] | [31.15-36.05] | [28.35-36.4] |
| Bremen | 18.25 (1.41) | 31.41 (2.78) | 31.33 (3.53) |
| | [15.4-19.8] | [26.75-34.55] | [26.45-35.45] |
| Hamburg | 18.33 (1.38) | 31.05 (3.15) | 30.86 (3.06) |
| | [15.65-19.95] | [27.2-35] | [27-35.55] |
| Hessen | 18.35 (1.10) | 33.85 (1.23) | 32.65 (3.58) |
| | [17.25-20.45] | [32.65-36] | [27.65-36.35] |
| Mecklenburg-Vorpommern | 18.24 (1.28) | 31.57 (2.34] | 32.11 (3.34) |
| | [16-19.95] | [28.7-35.45] | [28.15-36.25] |
| Niedersachsen | 18.03 (1.20) | 32.49 (2.30) | 32.14 (3.66) |
| | 15.8-19.75] | [29.1-36.1] | [27.65-36.3] |
| Nordrhein-Westfalen | 18.19 (1.16) | 32.53 (1.78) | 31.69 (3.72) |
| | [ 16.45-20.2] | [30.1-34.93] | [27.37-35.9] |
| Rheinland-Pfalz | 18.5 (1.12) | 34.5 (.49) | 32.57 (2.94) |
| | [17.25-20.4] | [33.7-35.1] | [27.9-35.3] |
| Saarland | 18.35 (1.36) | 33.91 (1.55) | 33 (4.03) |
| | [16.35-20.3] | [32.1-35.65] | [26.75-36.5] |
| Sachsen | 18.61 (1.32) | 34.23 (2.22) | 33.44 (3.43) |
| | [16.2-20.55] | [30.95-37.2] | [28.3-37.25] |
| Sachsen-Anhalt | 18.81 (1.43) | 31.80 (2.63) | 31.41 (3.72) |
| | [16.2-20.8] | [28.43-35.6] | [26.6-34.77) |
| Schleswig-Holstein | 17.61 (1.12) | 31.01 (2.85) | 30.9 (3.13) |
| | [15.6-19.1] | [26.65-34.75] | [26.7-34.8] |
| Thüringen | 18.01 (1.42) | 30.96 (4.35] | 31.38 (3.46) |
| | [15.4-20.1] | [22.1-36.1] | [27.15-35.05] |
| Germany | 18.28 (1.03) | 32.68 (2.54) | 32.09 (3.30) |
| | [16.8-20.1] | [22.1-37.7] | [26.45-37.45] |

Notes. First row in each cell: Means and standard deviations (in parentheses). Second row in each cell: range

**Table S.4: Robustness analysis – COVID-19 and cognitive functioning, with and without controlling for health**

| Cognitive Indicator | **Total memory** | | | **Verbal fluency** | | |
|---|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (1) | (2) | (3) |
| Controls | Without health | With health | With childhood circumstances | Without health | With health | With childhood circumstances |
| Baseline change | | | | | | |
| Longer follow-up | -0.177* | -0.174* | -0.156 | -0.496*** | -0.498*** | -0.484*** |
| | (0.078) | (0.077) | (0.085) | (0.077) | (0.077) | (0.082) |
| COVID | -0.105** | -0.096** | -0.116** | -0.000 | -0.001 | -0.016 |
| | (0.034) | (0.034) | (0.036) | (0.034) | (0.034) | (0.034) |
| Time between surveys (in months) | 0.006* | 0.005 | 0.004 | 0.009*** | 0.009*** | 0.008** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| Control Variables included | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -0.374 | -0.211 | -0.134 | 0.925 | 1.055* | 1.426* |
| | (0.529) | (0.534) | (0.591) | (0.524) | (0.530) | (0.565) |
| N | 9307 | 9497 | 8084 | 9226 | 9492 | 8076 |

**Table S.5: Robustness analysis – summer temperatures and cognitive functioning: health, childhood, interview month**

| | Total memory | | | | Verbal fluency | | | |
|---|---|---|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| Controls | Without health | With health | With interview month | With childhood circumstances | Without health | With health | With interview month | With childhood circumstances |
| Average temperature: | -0.028* | -0.025 | -0.030* | -0.029* | -0.026 | -0.027 | -0.022 | -0.021 |
| July-August | (0.014) | (0.014) | (0.014) | (0.012) | (0.014) | (0.014) | (0.014) | (0.017) |
| Maximum temperature: | -0.009 | -0.007 | -0.006 | -0.004 | 0.010 | 0.010 | 0.010 | 0.012 |
| July-August | (0.009) | (0.009) | (0.009) | (0.008) | (0.007) | (0.007) | (0.008) | (0.008) |
| Interview month: January | | | -0.076 | | | | 0.019 | |
| February | | | 0.015 | | | | 0.034 | |
| March | | | 0.000 | | | | 0.000 | |
| April | | | 0.036 | | | | 0.011 | |
| May | | | 0.018 | | | | 0.064 | |
| June | | | 0.035 | | | | -0.205* | |
| July | | | 0.064 | | | | -0.150** | |
| August | | | 0.048 | | | | -0.013 | |
| September | | | 0.066 | | | | -0.034 | |
| October | | | 0.062 | | | | -0.036 | |
| November | | | -0.026 | | | | -0.058 | |
| December | | | -0.088* | | | | -0.044 | |
| Control Variables included? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.307 | 0.414 | -0.017 | -0.160 | 1.620*** | 1.725*** | 1.221* | 1.413 |
| | (0.582) | (0.568) | (0.600) | (0.726) | (0.425) | (0.431) | (0.589) | (0.734) |
| N | 10109 | 10043 | 10109 | 8859 | 10102 | 10102 | 10038 | 8852 |

Note: Average and Maximum Summer Temperatures estimated separately. Case numbers in the model with childhood circumstances reduced due to non-participation of certain respondents in the retrospective SHARELIFE waves.

**Table S.6: Social stratification in crises' impacts**

| Social stratification characteristic | **Age groups** | | **Gender** | | **Education** | | **Income** | | **Urban vs. rural** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cognitive indicators | Total memory | Verbal fluency | Total memory | Verbal fluency | Total memory | Verbal fluency | Total memory | Verbal fluency | Total memory | Verbal fluency |
| Controls included | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Baseline change | | | | | | | | | | |
| COVID-19 | -0.177 | -0.079 | -0.096* | 0.007 | -0.097* | -0.012 | -0.071 | 0.437 | -0.082* | -0.004 |
| Longer follow-up | -0.079 | -0.398*** | -0.162 | -0.532*** | -0.215** | -0.465*** | -0.450* | -0.814*** | -0.196* | -0.474*** |
| Average summer temperature | 0.011 | -0.034 | | | | | | | | |
| Max summer temperature | 0.031* | 0.021 | | | | | | | | |
| Age group: 50-58 | | | | | | | | | | |
| 59-65 | 0.120* | -0.036 | | | | | | | | |
| 66-73 | 0.144 | -0.038 | | | | | | | | |
| 74-100 | 0.143 | -0.132 | | | | | | | | |
| Covid*age 59-65 | 0.029 | 0.022 | | | | | | | | |
| Covid*age 66-73 | 0.126 | 0.091 | | | | | | | | |
| Covid*age 74-100 | 0.077 | 0.109 | | | | | | | | |
| Longer*age 59-65 | -0.063 | -0.153 | | | | | | | | |
| Longer*age 66-73 | -0.157 | -0.115 | | | | | | | | |
| Longer*age 74-100 | -0.267** | -0.070 | | | | | | | | |
| 59-65 | 0.946 | 0.268 | | | | | | | | |
| 66-73 | 0.498 | -0.688 | | | | | | | | |
| 74-100 | 1.530** | -0.346 | | | | | | | | |
| Average temp*age 59-65 | -0.049 | -0.019 | | | | | | | | |
| Average temp* age 66-73 | -0.022 | 0.035 | | | | | | | | |
| Average temp* age 74-100 | -0.082** | 0.012 | | | | | | | | |
| Max temp*age 59-65 | -0.043** | -0.032** | | | | | | | | |
| Max temp*age 66-73 | -0.038* | -0.000 | | | | | | | | |
| Max temp*age 74-100 | -0.057*** | -0.007 | | | | | | | | |
| Gender | | | 0.028 | 0.022 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Gender*Covid | | -0.012 | -0.015 | | | | |
| Gender*Longer | | -0.018 | 0.065 | | | | |
| Gender | | 0.135 | 0.069 | | | | |
| Average | | -0.025 | -0.024 | | | | |
| Max Temperature | | -0.013 | 0.012 | | | | |
| Gender*Average | | -0.006 | -0.003 | | | | |
| Gender*Max. | | 0.008 | -0.004 | | | | |
| | | | | | | | |
| Education: lower | | | | -0.008 | 0.043 | | |
| Intermediate (ref.) | | | | 0.000 | 0.000 | | |
| Higher | | | | 0.046 | 0.007 | | |
| Lower*Covid | | | | 0.024 | 0.069 | | |
| Lower*Longer | | | | 0.052 | -0.075 | | |
| Higher*Covid | | | | -0.023 | 0.019 | | |
| Higher*Longer | | | | 0.102 | -0.058 | | |
| Lower | | | | 0.651 | 0.235 | | |
| Intermediate (ref.) | | | | 0.716 | 0.017 | | |
| Higher | | | | 0.000 | 0.000 | | |
| Lower*Avg | | | | -0.040 | 0.000 | | |
| Lower*Max | | | | -0.027 | -0.010 | | |
| Higher*Avg | | | | -0.021 | 0.013 | | |
| Higher*Max | | | | -0.006 | -0.014 | | |
| | | | | | | | |
| Income quartiles (lowest) | | | | | | | |
| Second | | | | | | -0.082 | -0.024 |
| Third | | | | | | -0.053 | 0.026 |
| Fourth | | | | | | -0.040 | 0.046 |
| Fifth | | | | | | -0.057 | 0.059 |
| Covid*Income: 2nd | | | | | | 0.034 | -0.391 |
| Covid*Income: 3rd | | | | | | -0.057 | -0.448 |
| Covid*Income: 4th | | | | | | -0.057 | -0.442 |
| Covid*Income: 5th | | | | | | 0.002 | -0.462 |
| Longer*Income: 2nd | | | | | | 0.279 | 0.311 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Longer*Income: 3rd | | | | 0.194 | 0.295 | | |
| Longer*Income: 4th | | | | 0.291 | 0.390* | | |
| Longer*Income: 5th | | | | 0.363 | 0.250 | | |
| Income: 2nd quartile | | | | -0.622 | 1.545 | | |
| Income: 3rd quartile | | | | -0.903 | 1.313 | | |
| Income: 4th quartile | | | | -1.306 | 0.810 | | |
| Income: 5th quartile | | | | -0.890 | 1.522 | | |
| Average temp | | | | -0.085 | 0.034 | | |
| Max. temp | | | | -0.040 | 0.076 | | |
| Average temp*Income 2nd | | | | 0.034 | -0.086 | | |
| Average temp* Income 3rd | | | | 0.051 | -0.071 | | |
| Average temp* Income 4th | | | | 0.074 | -0.041 | | |
| Average temp* Income 5th | | | | 0.050 | -0.081 | | |
| Max temp*Income 2nd | | | | 0.010 | -0.056 | | |
| Max temp*Income 3rd | | | | 0.045 | -0.066 | | |
| Max temp*Income 4th | | | | 0.044 | -0.065 | | |
| Max temp*Income 5th | | | | 0.009 | -0.077 | | |
| | | | | | | | |
| Urban | | | | | | -0.049 | 0.016 |
| Urban*Covid | | | | | | -0.057 | 0.005 |
| Urban*Longer | | | | | | 0.049 | -0.046 |
| Urban | | | | | | 0.071 | 0.535 |
| Average temp | | | | | | -0.026 | -0.013 |
| Max. temp | | | | | | -0.006 | 0.014 |
| Urban*Average temp | | | | | | -0.006 | -0.029 |
| Urban*Max temp | | | | | | -0.008 | -0.012 |

Note: separate models for each interaction. For climate crisis, gender, education and age group main effects are presented for the interaction with average summer temperatures. Case numbers – temperatures: n(memory)= 10109, n(verbal fluency)=10102. Case numbers – Covid: n(memory)=9307, n(verbal fluency)=9299.

**Supplementary Figures**

**Figure S.1: Period Dummies adjusting for unobserved confounders (Fixed Effects Models)**