Advantaged socioeconomic conditions in childhood are associated with higher cognitive functioning but stronger cognitive decline in older age

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Cognitive aging is characterized by large heterogeneity, which may be due to variations in childhood socioeconomic conditions (CSC). Although there is substantial evidence for an effect of CSC on levels of cognitive functioning at older age, results on associations with cognitive decline are mixed. We examined by means of an accelerated longitudinal design the association between CSC and cognitive trajectories from 50 to 96 years. Cognition included two functions generally found to decline with aging: delayed recall and verbal fluency. Data are from six waves of the Survey of Health, Aging, and Retirement in Europe (SHARE), conducted between 2004 and 2015 (n = 24,066 at baseline; 56% female, age 50+). We found a consistent CSC pattern in levels of cognitive functioning in later life. Older people with disadvantaged CSC had lower levels of cognitive functioning than those with more advantaged CSC. We also find that decline is almost 1.6 times faster in the most advantaged group compared with the most disadvantaged group. The faster decline for people with more advantaged CSC becomes less pronounced when we additionally control for adulthood socioeconomic conditions and current levels of physical activity, depressive symptoms, and partner status. Our findings are in line with the latency, pathway, and cumulative model and lend support to theories of cognitive reserve, stating that neuronal loss can no longer be repaired in people with more cognitive reserve once the underlying pathology is substantial and speed of decline is accelerated.

Significance

There is increasing evidence that socioeconomic conditions early in life have an impact on cognitive functioning in later life. Based on the large longitudinal sample from SHARE we find a clear pattern in cognitive functioning in old age, related to childhood socioeconomic conditions: Those from more affluent households show higher levels of fluid intelligence in old age and experience stronger decline over time in executive functions. The latter phenomenon is not often documented. Although modifications in cognitive functioning with aging are inevitable, life course socioeconomic circumstances impact the timing of this process. We conclude that the etiology of cognitive aging is the result of multiple social processes, defined by the socioeconomic conditions in childhood and all along the life course.

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Figure 4: The pathway model assumes that CSC presorts young people into trajectories that are more beneficial for cognitive functioning for people with more advantaged CSC compared with those with more disadvantaged CSC. An example of this pathway can be found in the study by Wahrendorf and Blane (46), who observed that children raised in families with more advanced socioeconomic conditions (43, 44) in older age, leading to higher levels of cognitive functioning and cognitive change and estimations of the associations between CSC and level of cognitive functioning and cognitive change in older age.

Theoretical Background. Expectations about associations between CSC and cognitive decline in our study is based on theoretical cognitive reserve, suggesting that growing up in stimulating environments results in higher levels of cognitive functioning. With respect to the speed of decline, two strands of reasoning for the proposed underlying mechanism can be distinguished. One is that people high in cognitive reserve have better capacities to maintain their cognitive functions and to compensate for neurological loss and cognitive decline (22, 37–39). Another is that because more pathology is required before cognitive decline becomes visible in people with more cognitive reserve, a faster decline can be observed once the pathology is substantial (see for a more extended discussion refs. 22, 37, and 40).

To understand potential pathways from CSC to cognitive functioning in older age, we refer to three often applied conceptual models in life course research: the latency model, the pathway model, and the cumulative model (41, 42). According to the latency model, childhood conditions have a direct effect on later life functioning independent of intermediate experiences. For example, children from highly educated people may be in a more cognitively stimulating environment in their first years of life leading to a more advanced brain development than children in more disadvantaged conditions (43, 44). A more advanced brain architecture directly enhances cognitive plasticity, i.e., the ability of the brain to create new neurons or reorganize the cortex (45) in older age, leading to better cognitive functioning and diminished cognitive decline.

The pathway model assumes that CSC presorts young people into trajectories that are more beneficial for cognitive functioning for people with more advantaged CSC compared with those with more disadvantaged CSC. An example of this pathway can be found in the study by Wahrendorf and Blane (46), who observed that children raised in families with more advanced socioeconomic positions experienced less labor market disadvantage and a higher quality of life in older ages. Also in line with the pathway model is the positive relation between father’s and mother’s education and the academic performance of the children, irrespective of the children’s levels of cognitive functioning (47). Associations between parents’ education, CSC, and own level of education may have been especially strong in countries where higher education was more likely for the elites. Educational reforms in Europe to ensure that all children, in particular the most deprived, benefit from effective schooling programs came only into effect in the late 1980s and 1990s (48, 49) and thus did not affect the current older (50+) study population.

The cumulative model emphasizes that adverse childhood conditions can have an enduring and cumulative negative effect, similar to a dose–response relationship (41). For example, the longer people live in poverty, the greater would be their aca- demic deficits (50) and consequently the more severe the cognitive decline. The cumulative model is also central in the cumulative inequality theory of Ferraro and Shippee (51) and the cumulative advantage/disadvantage theory of Dannefer (52).

Methodologically, these three models may not be easily disentangled in empirical studies, because a potential mediating effect of adulthood socioeconomic position fits with both the pathway model and the cumulative model. The three models are not mutually exclusive either but in fact may operate at the same time. Nevertheless, the models provide helpful conceptualizations of the potential associations between CSC and trajectories of cognitive functioning in later life. Based on these three models, we assume that people who had advantaged CSC have more favorable conditions for brain development throughout the life course than people with disadvantaged CSC, resulting in higher levels of functioning and lower rates of decline in older age.

In the present study we test associations between CSC and trajectories of cognitive functioning in later life. We hypothesize in line with the latency model that more advantaged CSC relates to higher levels of cognitive functioning (H1) irrespective of later life socioeconomic conditions. We further expect that decline is moderated by CSC, that is, that decline is smaller when CSC is more advantaged (H2). In line with the pathway and cumulative model, we expect that part of the positive associations between CSC and level (H3a) and cognitive decline (H3b) is mediated by adulthood socioeconomic position. A robustness check will be conducted to see whether potential associations of CSC with trajectories of cognitive functioning remains after controlling for current levels of physical activity, depressive symptoms, and partner status. This is because evidence shows that current physical activity is associated with memory (53), increases the reserve capacity (54, 55), and has strong associations with childhood physical activity (56, 57). More depressive symptoms are associated with lower cognitive functioning (58–60), and a disadvantaged socioeconomic position over the whole life course is associated with increased levels of depression and lower cognitive functioning in older men (61). Having a partner is consistently found to protect against loneliness, and loneliness may be inversely associated with cognitive functioning (6).

Results

The baseline characteristics of our study sample can be found in Table 1. Briefly, the baseline study sample consisted of 24,066 people (56% female), aged between 50 and 96. During the course of the study, 2,033 (8.4%) died, and 5,117 (21.3%) dropped out for other reasons. The average number of observations per respondent for delayed recall was 2.76 (total number of respondents was 23,201, and total number of observations was 59,552) and for verbal fluency 3.29 (total number of respondents was 24,066, and total number of observations was 76,333).

The results of the mixed-effects models are provided in Table 2 (delayed recall) and Table 3 (verbal fluency). All models are adjusted for confounders (country, birth cohort, no response in wave 5 and 6 or deceased during follow-up, and living with biological parents during childhood). The statistically significant negative associations between age and quadratic age (rows 2 and 3 of Tables 2 and 3) and cognitive functioning indicate overall accelerated cognitive decline with aging.

Model 1 provides the estimates for the association between CSC and the level and change of delayed recall (Table 2) and the level and change of verbal fluency (Table 3). The four entries (i.e., disadvantaged, middle, advantaged, and most advantaged) under CSC (main row 4) indicate the scale points difference in levels of cognitive functioning with the reference category (most disadvantaged). For example, compared with people with the most disadvantaged childhood conditions, people in the most...
advantaged socioeconomic position scored on average 1.27 more words for delayed recall (Table 2) and 5.39 more words for verbal fluency (Table 3) at the age of 73 (because age was centered at 73 y, the midpoint of the sample’s age range).

Level differences are significant and—except for one difference between most disadvantaged and disadvantaged group for verbal fluency—remain so for delayed recall and verbal fluency if socioeconomic conditions over the life course are added to the model (M2) and if we additionally control for current physical activity, level of depressive symptoms, and having a partner (M3). Although still significant, the differences become smaller, indicating that associations between CSC and the level of later life delayed recall and verbal fluency is partly explained by level of education (row 7 of Tables 2 and 3), occupation (row 8), and current financial situation (row 9) because adding these variables resulted in smaller associations between CSC and level of cognitive functioning. Additionally controlling for current level of physical activities (rows 10), depressive symptoms (rows 11), and partner status (rows 12) in model 4 does not lead to different conclusions.

The interaction terms between CSC and age (row 5) and CSC and quadratic age (row 6) and the cognitive outcomes provide the basis of the test of our second hypothesis (i.e., rate of decline is smaller when CSC is more advantaged). The four entries under row 5 (i.e., age × disadvantaged, age × middle, age × advantaged, and age × most advantaged) present the scale points difference in total linear change with the reference category (most disadvantaged). The four entries under row 6 (i.e., age² × disadvantaged, age² × middle, age² × advantaged, and age² × most advantaged) present the scale points difference in total nonlinear change with the reference category (most disadvantaged). The total amount of change can be derived from the combination of the coefficients for linear and nonlinear change (Table 4). The decline in delayed recall paralleled in the five groups, indicating that CSC differences in delayed recall remain with aging. Decline in verbal fluency was, compared with the most disadvantaged group, significantly faster in middle and most advantaged groups. These associations are only partially attenuated by life course socioeconomic conditions (M2). Controlling for physical and mental health and partner status (M3) does not lead to different conclusions.

### Discussion

This study examines associations between CSC and trajectories of delayed recall and verbal fluency at older age. We observe a clear CSC pattern in levels of verbal fluency and delayed recall in older age; that is, the more advantaged the CSC, the higher the levels of delayed recall and verbal fluency in later life. We further observe that cognitive decline is also related to CSC but only for verbal fluency and not delayed recall. People with a more advantaged CSC experience more decline in verbal fluency than people with the most disadvantaged CSC. Associations between CSC and level of functioning are partly mediated by socioeconomic conditions throughout the life course but not by current levels of physical activity, depressive symptoms, and having a partner or not. Hence, our study lends support to all three potential pathways from CSC to later life cognitive functioning, the latency model, the pathway model, and the cumulative model.

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**Table 1. Characteristics of the study sample**

| Variables                        | Most disadvantaged (n = 4,405) | Disadvantaged (n = 6,055) | Neutral (n = 7,776) | Advantaged (n = 4,457) | Most advantaged (n = 1,373) |
|----------------------------------|-------------------------------|---------------------------|---------------------|------------------------|-----------------------------|
| Delayed recall, M, SD            | 2.22                          | 2.63                      | 3.01                | 3.21                   | 3.33                        |
| Verbal fluency, M, SD            | 2.48                          | 2.99                      | 3.45                | 3.67                   | 3.78                        |
| Age, M, SD                       | 65.99                         | 63.35                     | 61.06               | 60.46                  | 61.07                       |
| Gender                           | 2,416                         | 3,416                     | 4,421               | 5,421                  | 6,421                       |
| Birth cohort N, %                |                               |                           |                     |                        |                             |
| >1945                            | 1,222                         | 2,374                     | 3,931               | 5,055                  | 6,055                       |
| 1919–1928                        | 646                           | 647                       | 536                 | 301                    | 124                         |
| 1929–1938                        | 1,517                         | 1,563                     | 1,514               | 752                    | 235                         |
| 1939–1945                        | 1,020                         | 1,471                     | 1,795               | 1,027                  | 327                         |
| Attrition N, %                   |                               |                           |                     |                        |                             |
| No drop out                      | 3,009                         | 4,164                     | 5,515               | 3,248                  | 756                         |
| Dropped out                      | 802                           | 1,313                     | 1,753               | 963                    | 286                         |
| Deceased                         | 594                           | 578                       | 508                 | 246                    | 107                         |
| Living with biological parents N, % |                               |                           |                     |                        |                             |
| Both parents                     | 4,000                         | 5,452                     | 7,074               | 4,024                  | 1,245                       |
| One parent                       | 340                           | 482                       | 562                 | 334                    | 95                          |
| No biological parents            | 65                            | 121                       | 140                 | 99                     | 33                          |
| Adult life education and occupational class N, % |       |                           |                     |                        |                             |
| High education                   | 4,194                         | 5,481                     | 6,113               | 2,856                  | 581                         |
| High occupational class          | 289                           | 6,562                     | 777                 | 25,06%                 | 38,93%                      |
| Current ability to make ends meet with the household income | | | | | |
| Easily                           | 790                           | 1,745                     | 2,373               | 2,326                  | 846                         |
| Fairly easily                    | 1,325                         | 2,944                     | 3,465               | 3,284                  | 361                         |
| With great difficulty            | 878                           | 829                       | 557                 | 201                    | 29                          |
| With some difficulty             | 1,412                         | 1,537                     | 1,481               | 600                    | 137                         |
| High level of physical activities | 2,694                         | 4,089                     | 5,773               | 3,471                  | 1,098                       |
| Depressive symptoms, M, SD       | 2.89                          | 2.90                      | 2.13                | 1.98                   | 1.89                        |
| Having a partner                 | 3,280                         | 4,504                     | 5,891               | 3,389                  | 1,031                       |

Distribution of characteristics was based on the sample of 24,066 respondents who answered to verbal fluency.
Table 2. Associations between childhood socioeconomic circumstances and trajectories of delayed recall at older age

| Row | Variables | M1 Coefficient (95% CI) | p | M2 Coefficient (95% CI) | p | M3 Coefficient (95% CI) | p |
|-----|-----------|-------------------------|---|-------------------------|---|-------------------------|---|
| 1   | Intercept | 3.46 (3.26–3.65)        | <0.001 | 3.85 (3.64–4.05) | <0.001 | 4.12 (3.91–4.33) | <0.001 |
| 2   | Age (10-y follow-up) | −0.48 (−0.69–0.26) | <0.001 | −0.57 (−0.80–0.34) | <0.001 | −0.51 (−0.75–0.27) | <0.001 |
| 3   | Age² (10-y follow-up) | −0.08 (−0.16–0.00) | 0.060 | −0.17 (−0.27–0.08) | <0.001 | −0.20 (−0.30–0.09) | <0.001 |
| 4   | CSC (ref. most disadvantaged) | | | | | | |
|     | Disadvantaged | 0.56 (0.39–0.72) | <0.001 | 0.48 (0.32–0.65) | <0.001 | 0.49 (0.32–0.65) | <0.001 |
|     | Middle | 1.05 (0.90–1.21) | <0.001 | 0.85 (0.69–1.00) | <0.001 | 0.84 (0.68–0.99) | <0.001 |
|     | Advantaged | 1.32 (1.15–1.49) | <0.001 | 0.98 (0.81–1.15) | <0.001 | 0.97 (0.80–1.14) | <0.001 |
|     | Most advantaged | 1.92 (1.68–2.16) | <0.001 | 1.41 (1.17–1.65) | <0.001 | 1.41 (1.17–1.65) | <0.001 |
| 5   | Age × CSC (ref. most disadvantaged) | | | | | | |
|     | Age × disadvantaged | 0.09 (−0.01–0.18) | 0.089 | 0.09 (−0.00–0.19) | 0.061 | 0.09 (−0.01–0.18) | 0.083 |
|     | Age × middle | 0.07 (−0.03–0.17) | 0.167 | 0.08 (−0.02–0.18) | 0.112 | 0.07 (−0.03–0.17) | 0.175 |
|     | Age × advantaged | 0.12 (0.00–0.23) | 0.048 | 0.12 (0.00–0.24) | 0.045 | 0.11 (−0.01–0.22) | 0.075 |
|     | Age × most advantaged | 0.14 (−0.03–0.32) | 0.110 | 0.15 (−0.02–0.33) | 0.092 | 0.15 (−0.03–0.33) | 0.097 |
| 6   | Age² × CSC (ref. most disadvantaged) | | | | | | |
|     | Age² × disadvantaged | −0.07 (−0.13–0.02) | 0.007 | −0.06 (−0.11–0.01) | 0.024 | −0.06 (−0.11–0.01) | 0.02 |
|     | Age² × middle | −0.14 (−0.19–0.09) | <0.001 | −0.11 (−0.17–0.06) | <0.001 | −0.11 (−0.17–0.06) | <0.001 |
|     | Age² × advantaged | −0.14 (−0.20–0.08) | <0.001 | −0.11 (−0.17–0.05) | <0.001 | −0.11 (−0.17–0.05) | <0.001 |
|     | Age² × most advantaged | −0.20 (−0.28–0.12) | <0.001 | −0.16 (−0.24–0.07) | <0.001 | −0.15 (−0.24–0.07) | <0.001 |
| 7   | Low-middle educ (ref. high) | | | | | | |
|     | Age × educ | 0.51 (0.44–0.58) | <0.001 | 0.49 (0.42–0.56) | <0.001 | 0.49 (0.42–0.56) | <0.001 |
|     | Age² × educ | 0.04 (−0.04–0.12) | 0.318 | 0.02 (−0.06–0.10) | 0.596 | 0.02 (−0.06–0.10) | 0.497 |
| 8   | Low-skill job during active life (ref. high-skill job) | | | | | | |
|     | Age × job | −0.02 (−0.09–0.05) | 0.636 | 0.00 (−0.07–0.07) | 0.986 | 0.00 (−0.07–0.07) | 0.986 |
|     | Age² × job | 0.03 (−0.01–0.08) | 0.100 | 0.04 (−0.00–0.08) | 0.070 | 0.04 (−0.00–0.08) | 0.070 |

**CI, confidence interval; CSC, childhood socioeconomic conditions; educ, level of education; job, low-skill job; PA, physical activity; dep., depressive symptoms; PS, partner status. All models are adjusted for confounders (country, birth cohort, no response in wave 5 and 6, deceased during follow-up, and living with biological parents during childhood). Age was centered at 73 y, the midpoint of the sample’s age range.**

Our finding that a more advantaged CSC is associated with higher levels of cognitive functioning in later life is in line with most other longitudinal studies in this field (17, 18, 24–30, 32–36). However, inconsistent with most previous studies is our finding that compared with people with most disadvantaged CSC, people with most advantaged CSC have stronger declines in verbal fluency. As discussed in the introduction, one possible explanation lies in the power to find significant results. Our study sample was at least two times bigger than samples of the other studies, and together with the advanced analytical models, long follow-up and frequent follow-up waves (one baseline and five follow-up waves), this may have contributed to the detection of significant associations between CSC and cognitive change. Other studies that found associations between CSC and rate of decline also had long follow-up and a large sample size (24, 27) or were based on persons aged 65 and older (24, 26) when cognitive decline starts to accelerate, which may explain why, in the absence of large numbers, the associations still reached the level of statistical significance. A similar study to ours, based on the Health Retirement Study (24), did not find associations between CSC and rate of decline, despite a large sample size of US citizens aged 65 and older adults living in the community. What differs between their and our study is the capturing of cognitive change. Although Lyu and Burr (24) included a linear slope to estimate linear decline, we included a linear and quadratic slope to account for potential accelerated cognitive decline. This may
Table 3. Associations between childhood socioeconomic circumstances and trajectories of verbal fluency at older age

| Row | Variables | M1 (Coefficient (95% CI)) | p | M2 (Coefficient (95% CI)) | p | M3 (Coeff. (95% CI)) | p |
|-----|-----------|--------------------------|---|--------------------------|---|-----------------------|---|
| 1   | Intercept | 18.64 (17.99–19.29)     | <0.001 | 20.64 (19.95–21.32) | <0.001 | 21.21 (20.50–21.91) | <0.001 |
| 2   | Age (10-y follow-up) | 0.65 (–1.35–0.05) | 0.070 | –1.02 (–1.77–0.28) | 0.007 | –0.88 (–1.64–0.11) | 0.024 |
| 3   | Age² (10-y follow-up) | –0.12 (–0.40–0.15) | 0.370 | –0.55 (–0.87–0.24) | 0.001 | –0.48 (–0.81–0.14) | 0.005 |
| 4   | CSC (ref. most disadvantaged) | | | | | | |
|     | Disadvantaged | 0.83 (0.27–1.39) | 0.004 | 0.51 (–0.04–1.06) | 0.702 | 0.56 (0.01–1.10) | 0.046 |
|     | Middle | 2.67 (2.13–3.20) | <0.001 | 1.83 (1.30–2.36) | <0.001 | 1.87 (1.34–2.39) | <0.001 |
|     | Advantage | 3.39 (2.81–3.98) | <0.001 | 2.13 (1.55–2.72) | <0.001 | 2.18 (1.60–2.76) | <0.001 |
| 5   | Age × CSC (ref. most disadvantaged) | | | | | | |
|     | Age × disadvantaged | 0.31 (–0.62–0.01) | 0.060 | –0.28 (–0.60–0.04) | 0.083 | –0.30 (–0.62–0.01) | 0.061 |
|     | Age × middle | –0.49 (–0.81–0.18) | 0.002 | –0.45 (–0.77–0.13) | 0.006 | –0.47 (–0.79–0.15) | 0.004 |
|     | Age × advantaged | –0.41 (–0.79–0.04) | 0.030 | –0.34 (–0.72–0.05) | 0.084 | –0.37 (–0.75–0.01) | 0.058 |
|     | Age × most advantaged | –0.82 (–1.38–0.26) | 0.004 | –0.67 (–1.25–0.10) | 0.022 | –0.66 (–1.24–0.09) | 0.023 |
| 6   | Age² × CSC (ref. most disadvantaged) | | | | | | |
|     | Age² × disadvantaged | –0.10 (–0.27–0.08) | 0.276 | –0.05 (–0.22–0.12) | 0.571 | –0.06 (–0.23–0.11) | 0.485 |
|     | Age² × middle | –0.19 (–0.36–0.03) | 0.023 | –0.11 (–0.28–0.06) | 0.215 | –0.12 (–0.29–0.05) | 0.177 |
|     | Age² × advantaged | –0.04 (–0.23–0.14) | 0.646 | 0.07 (–0.13–0.26) | 0.488 | 0.05 (–0.14–0.25) | 0.598 |
|     | Age² × most advantaged | –0.28 (–0.55–0.02) | 0.036 | –0.14 (–0.42–0.13) | 0.311 | –0.15 (–0.43–0.12) | 0.282 |
| 7   | Low-middle educ (ref. high) | | | | | | |
|     | Age × educ | 0.03 (–0.23–0.29) | 0.842 | –0.04 (–0.29–0.22) | 0.785 |
|     | Age² × educ | 0.20 (0.06–0.35) | 0.007 | 0.20 (0.05–0.34) | 0.009 |
| 8   | Low-skil job during active life (ref. high-skill job) | | | | | | |
|     | Age × job | 0.14 (–0.09–0.37) | 0.239 | 0.20 (–0.02–0.43) | 0.079 |
|     | Age² × job | 0.24 (0.11–0.38) | <0.001 | 0.25 (0.12–0.39) | <0.001 |
| 9   | Current financial situation (ref. easily) | | | | | | |
|     | Fairly easily | –0.66 (–0.86–0.46) | <0.001 | –0.53 (–0.73–0.33) | <0.001 |
|     | Age × fairly easy | 0.14 (–0.05–0.33) | 0.138 | 0.25 (0.06–0.43) | 0.009 |
|     | Age² × fairly easy | 0.07 (–0.05–0.19) | 0.229 | 0.11 (–0.01–0.22) | 0.082 |
|     | Some difficulty | –1.54 (–1.77–1.30) | <0.001 | –1.18 (–1.42–0.95) | <0.001 |
|     | Age × some difficulty | 0.22 (–0.06–0.45) | 0.052 | 0.39 (0.17–0.61) | 0.001 |
|     | Age² × some difficulty | 0.22 (0.08–0.36) | 0.002 | 0.24 (0.10–0.38) | 0.001 |
|     | Great difficulty | –2.26 (–2.56–1.95) | <0.001 | –1.56 (–1.87–1.24) | <0.001 |
|     | Age × great difficulty | 0.22 (–0.08–0.51) | 0.150 | 0.45 (0.16–0.75) | 0.003 |
|     | Age² × great difficulty | 0.27 (0.08–0.45) | 0.004 | 0.29 (0.10–0.47) | 0.003 |
| 10  | Current physical activity | | | | | | |
|     | Age × PA | –0.13 (–0.30–0.04) | 0.134 |
|     | Age² × PA | 0.04 (–0.08–0.15) | 0.517 |
| 11  | Current depressive symptoms | | | | | | |
|     | Age × dep. | 0.04 (–0.05–0.15) | 0.221 |
|     | Age² × dep. | –0.04 (–0.15–0.07) | 0.455 |
| 12  | Current partner status | | | | | | |
|     | Age × PS | –0.13 (–0.18–0.09) | <0.001 |
|     | Age² × PS | –0.03 (–0.06–0.00) | 0.024 |

Cl, confidence interval; CSC, childhood socioeconomic conditions; educ, level of education; job, low-skill job; PA, physical activity; dep., depressive symptoms; PS, partner status. All models are adjusted for confounders (country, birth cohort, no response in wave 5 and 6, deceased during follow-up, and living with biological parents during childhood). Age was centered at 73 y, the midpoint of the sample’s age range.

Explain why an association between more advantaged CSC with higher levels of cognitive functioning is significant in our study.

We are aware of only one other study using SHARE that examines the association between CSC and cognitive decline (27). In that study, no association between CSC and cognitive decline was observed, despite the large sample size and long follow-up. However, their measure of CSC captured slightly different aspects than we used. In addition to the domains they use to define CSC, we also include the main breadwinner’s level of occupation. Parental occupation may be a crucial factor for cognitive reserve (28, 34). Parental occupation is strongly correlated with parental education, which may enhance a person’s cognitive reserve either by means of genes or through social pathways (e.g., education or occupation) or both. However, we cannot analyze which part of the association between CSC and parental occupation or education may be due to genes, unless there is information on genes. The Swedish Adoption/Twin study has this information, and based on that data it is concluded that the association between CSC and levels of functioning is largely attributable to genes (25).

Our finding that more advantaged CSC relates to stronger decline in verbal fluency is in contrast with studies observing an association between a more advantaged CSC and lower levels of cognitive decline (18, 24, 36), although findings in these three studies are a bit ambiguous. In one study, the weaker decline was only observed for women with more advantaged CSC, whereas for men with more advantaged CSC a stronger decline was observed.
Childhood socioeconomic conditions are associated with age-related cognitive decline. Interventions targeting these conditions in childhood might delay cognitive decline in older age. However, one needs to be cautious when interpreting these findings as causality cannot be inferred from cross-sectional data alone. A better understanding of the etiology of cognitive decline might only be achieved by longitudinal research, some of which we reviewed before. A key question is to what extent the observed differences between high and low childhood socioeconomic conditions can be attributed to differences in genes. Evidence for heritability is indeed an inadmissible factor in research on later life conditions, but one may argue that socio-economic circumstances influence gene expression. Therefore, one might wonder whether the observed differences between high and low childhood socioeconomic conditions are due to differences in heritability or in non-genetic factors.

Table 4. Estimated levels at baseline and after 12 y, and the total change for verbal fluency and delayed recall by CSC group

| Cognitive functions | Estimated baseline level for people aged 73 | Total change 12 y | Estimated level after 12 y |
|---------------------|---------------------------------------------|------------------|--------------------------|
| Verbal fluency       |                                             |                  |                          |
| Most disadvantaged   | 21.21                                       | −1.75            | 19.46                    |
| Disadvantaged        | 21.77                                       | −2.19            | 19.58                    |
| Middle               | 23.08                                       | −2.48            | 20.60                    |
| Advantaged           | 23.39                                       | −2.22            | 21.17                    |
| Most advantaged      | 24.27                                       | −2.76            | 21.51                    |
| Delayed recall       |                                             |                  |                          |
| Most disadvantaged   | 4.12                                        | −0.90            | 3.22                     |
| Disadvantaged        | 4.61                                        | −0.88            | 3.73                     |
| Middle               | 4.96                                        | −0.97            | 3.99                     |
| Advantaged           | 5.09                                        | −0.93            | 4.16                     |
| Most advantaged      | 5.53                                        | −0.94            | 4.59                     |

The cell entries are based on the estimated coefficients for the models 3 in Tables 2 and 3. For example, the 12-y amount of change in verbal fluency is 1.2(−0.88) + 1.2(−0.48) + 1.2(−0.66) + 1.2(−0.15) = −2.76 for people aged 73 with the most advantaged CSC and 1.2(−0.88) + 1.2(−0.48) + 1.2(0) + 1.2(0) = −1.75 for people aged 73 with the most disadvantaged CSC.

In conclusion, our study provides support for the "long arm of childhood" (67). Childhood socioeconomic conditions are associated with level of cognitive functioning and decline for some cognitive functions in later life. Our findings are in line with three often-applied conceptual models in life course research: the latency model, the pathway model, and the cumulative model. We corroborated the view that models of cognitive aging should include multiple time frames (68) because trajectories of cognition in old age are the product of multiple life course processes, both biological latency (69) and social pathways and cumulative. Although we cannot unravel the pathways, support for these models emphasizes the importance of childhood conditions in the etiology of later life cognitive decline and dementia. Interventions aiming to reduce later life cognitive decline and dementia should thus take into account not only conditions in the current life but all phases of the life course.

Methods

Study Design and Participants. Data are derived from the six waves of the Survey of Health, Aging, and Retirement in Europe (SHARE), which is described in detail elsewhere (69). Briefly, SHARE is a multidisciplinary and cross-national panel database of microdata on health, socioeconomic status, and social and family networks of more than 120,000 individuals aged 50 or older. Baseline data were collected in 2004 and every 2 y thereafter, spanning cognitive trajectories from 50 to 96 y in delayed recall and verbal fluency. Delayed recall and verbal fluency were assessed at the first, second, fourth, fifth, and sixth wave. Retrospective life course data on childhood and adult life socioeconomic conditions were collected in the third wave (SHARE-LIFE). We included data for participants aged 50–96 y, who participated in the third wave and had at least one observation of delayed recall or verbal fluency. We excluded people with suspicion of dementia as indicated with scores greater than 2 on the time orientation question at baseline. During waves 1–4, SHARE was reviewed and approved by the Ethics Committee of the University of Mannheim. Waves 4–6 of SHARE and the continuation of the project were reviewed and approved by the Ethics Council of the Max Planck Society. All participants provided written informed consent.

Outcomes. We used two indicators of fluid cognitive functions that are often found to decline with aging: delayed recall and verbal fluency. Delayed recall was assessed with the 10-words delayed recall test as an indicator of cognitive impairment and dementia (70). During the interview, participants listened to a list of 10 words that were read out loud by the interviewer. Immediately after reading the wordlist, the participants were asked to recall as many words as possible. This was asked again after a delay time in which the verbal fluency and numeracy tests took place. The latter delayed recall score is the number of words that the respondent is able to recall, which ranges from 0 to 10.
As a test of executive functioning and thereby an indicator of cognitive impairment, we used the verbal fluency test (71). Participants had to name as many different animals as they could think of in 60 s. The score that we used consisted of the total number of correctly named animals.

**Childhood Socioeconomic Conditions.** CSC were operationalized in accord with the study by Wahrendorf and Blane (46) as the sum score of four binary indicators of socioeconomic conditions at the age of 10: (i) the main breadwinner’s occupational position, (ii) number of books at home, (iii) overcrowding, and (iv) housing quality. Each of these indicators has been shown to be relevant to assess long-term effects of CSC on health (72–74). The main breadwinner’s occupational position was constructed by reclassifying the 10 main occupational groups of the International Standard Classification of Occupations (ISCO) into low (skill levels 1 and 2) and high occupational position (skill levels 3 and 4) (74). Participants who had no more than 10 books at home were coded as socially disadvantaged (72). The household was coded overcrowded when more than one person per room lived there, and the household was coded disadvantaged if lacking all of the following characteristics: fixed bath, cold running water supply, hot running water supply, inside toilet, and central heating (73). We combined the information of the four items to compute a five-categorical variable ranging from most disadvantaged to most advantaged.

**Adulthood Socioeconomic Conditions.** We used three indicators of socioeconomic conditions in adulthood, highest educational attainment, main occupational position during adult life, and current satisfaction with household income, and added these to the models as potential mediators. The highest educational attainment was based on the International Standard Classification of Education. A tertiary education level was classified as high education, all other levels were classified as low and middle educational level. Educational attainment was measured at a participant’s first measurement occasion. The main occupational position was based on the ISCO classification described previously. Participants who never did paid work were included in the disadvantaged occupational position. Satisfaction with the current household income was based on the question “Is the household able to make ends meet?” and answer categories ranged from 1 (“with great difficulty”) to 4 (“easily”). This question was assessed at the first, second, fourth, fifth, and sixth wave, and we used the mode to obtain a measure of satisfaction with household income for the period the individuals were followed.

**Confounders and Covariates.** Living with biological parents at the age of 10 (both parents/one biological parent/no biological parent) was added as confounder to the models. Earlier born cohorts in our study sample are born in the depression era in the beginning of the 1930s in Europe. Indeed, people with the most advantaged backgrounds come from later birth cohorts, reflecting the economic revival after the economic crises (after 1936). Meanwhile, later born cohorts score higher on cognitive functioning (75). To reflect the economic predictors was 4.24 for verbal fluency and 4.12 for delayed recall, resulting in a total time span of 46 y (50–96 y). Linear and nonlinear mixed-effect models are models that account for the nested structure of the data (e.g., multiple observations within a single participant). All models had a random intercept and random linear and quadratic slope for participants, indicating that we estimated each participant’s growth trajectory. The quadratic slope was added to account for potential accelerated decline. For both cognitive outcomes, we followed a stepwise modeling strategy. First, we estimated model 1 (M1), which tested the association between CSC and level of cognitive functioning and interaction terms between CSC and age and quadratic age to examine whether CSC was associated with (non) linear change in cognitive functioning. A statistically significant interaction indicated that the rate of cognitive decline is different across the CSC subgroups. Age was centered at the midpoint of the sample’s age range (73 y). In model 2 (M2) we further added adult life socioeconomic circumstances (educational attainment, main occupational position, and satisfaction with household income) and their interactions with age and age squared as potential mediators. This allowed us to examine to what extent an association between CSC and level and decline is direct (the latency model) or via the socioeconomic position in middle age (pathway and cumulative model). In model 3 (M3), we estimated whether our findings were robust against physical inactivity, depressive symptoms, and partner status, which implies testing M2 plus physical inactivity, depressive symptoms, and partner status and their interactions with age and age squared. All models were adjusted for the confounders country, birth cohort, living with biological parents during childhood, and two types of participant attrition (participants who did not respond to wave 5 and 6, and dying during follow-up).

All bivariate associations (χ²) between the four dichotomous components of CSC and the bivariate associations between the three dichotomous components of adulthood socioeconomic conditions and between the components of CSC and adulthood socioeconomic conditions were highly statistically significant at P < 0.001. The bivariate correlation between CSC and level of cognitive functioning and the three components of adult socioeconomic position (education, income, and skills) and level of cognitive functioning is moderate and ranges from 0.20 to 0.30 for both cognitive functions. We further checked for multicollinearity using the variance inflation factor (VIF), with a lower score indicating lower risks for multicollinearity. A VIF score higher than 10 is usually seen as indicative of high multicollinearity (82). In all final models, the highest VIF across socioeconomic predictors was 4.24 for verbal fluency and 4.12 for delayed recall, indicating low risks for multicollinearity. All models were estimated by using the R language lmerTest package, version 2.0e30 (www.r-project.org).

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