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.

socioeconomic position | cognition | life course | life span | aging

With aging, fluid cognitive abilities such as verbal fluency and memory become slower and less efficient (1), but the level of functioning and the speed at which the decline occurs varies greatly across individuals (2). Positive associations with the level of cognitive functioning are well established. Absence of physical illness (3); lower levels of depressive symptoms (4); physical activity (5); having a partner (6); higher education (7–14); and more complex environments, i.e., an environment involving a high number of ill-defined or apparently contradictory circumstances (15), and having multiple roles in a social network (16) are related to higher levels of functioning. In contrast, factors related to cognitive decline are less frequently detected. Evidence exists for an association between stronger decline and physical illness (3, 17), depressive symptoms (4, 18), physical inactivity (5, 18), not having a partner (6), and lower education (9, 14), although results on the latter are mixed (17, 19, 20). Research on factors associated with cognitive decline is nevertheless important because accelerated cognitive decline may be indicative for the preclinical phase of Alzheimer's disease (9, 17, 18), loss of autonomy, lowered well-being, and increased societal costs.

In research on cognitive aging, there has been increased interest in associations between circumstances very early in life, such as childhood socioeconomic conditions (CSC) (21), and later life cognitive functioning. Studies consistently find a clear socioeconomic pattern in the level of cognitive functioning (18–20, 22–30) indicating that more advantaged CSC is associated with higher levels of functioning. It is less clear whether CSC is also associated with cognitive decline because findings are inconclusive. Although the majority do not find an association between CSC and cognitive decline in later life (17, 21, 25–27, 29, 30, 31–34), there are a number of notable exceptions (18, 24, 28, 35, 36). Some of the studies observe less cognitive decline in older age with more advantaged CSC (18, 24, 36), whereas others observe more cognitive decline in old age with more advantaged CSC for women only (35) or men and women (28).

The studies examining an association between CSC and later life cognitive decline differ with respect to a number of factors that could have contributed to the inconsistent findings. One is that some studies may have been underpowered (19) because those finding an association between CSC and cognitive decline were among the studies with the largest sample sizes (n > 6,000). Another is that studies differ substantially in the operationalization of CSC capturing different aspects of CSC. Differences across studies also exist in the cognitive assessments, although

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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most studies include measures of fluid intelligence. Finally, the analytical methods applied to assess cognitive change varied across the studies, which may be another factor contributing to the inconsistencies (19).

The particular aim of our study is to extend current insights in associations between CSC and level of cognitive functioning and decline in later life, while addressing some of the limitations of previous research in this field. We maximize power to detect correlates of cognitive change by (*i*) using the SHARE data, a 12-y large-scale population-based sample of older adults with repeated measurements of cognitive functions on the same participants over time (2004–2015, assessments every 2 y); (*ii*) using indicators of cognitive functioning generally found to decline with aging; (*iii*) using multiple indicators of CSC to capture its different aspects; and (*iv*) applying an accelerated longitudinal design that is well suited to detect changes. In doing so, we were able to provide fairly accurate descriptions of level 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 later life cognitive decline in our study is based on theories of cognitive reserve, suggesting that growing up in stimuli-rich 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 from 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 academic 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). According to these theories, disadvantages encountered in early life tend to accumulate over the life, either by inducing new adverse events or by the increasing effects of endured exposure.

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%) participants 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

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	1.37	2.63	1.32	3.01	1.24	3.21	1.12	3.33	1.05
Verbal fluency, M, SD	2.48	1.82	2.99	1.64	3.45	1.30	3.67	1.05	3.78	0.86
Age, M, SD	65.99	8.94	63.35	9.03	61.06	8.63	60.46	8.57	61.07	9.06
Gender										
Female	2,416	56.42%	3,416	56.42%	4,412	56.74%	2,459	55.17%	756	55.06%
Male	1,989	43.58%	2,639	43.58%	3,364	43.26%	1,998	44.83%	617	44.94%
Birth cohort N, %										
>1945	1,222	27.74%	2,374	39.21%	3,931	50.55%	2,377	53.33%	687	50.04%
1919–1928	646	14.67%	647	10.69%	536	6.89%	301	6.75%	124	9.03%
1929–1938	1,517	34.44%	1,563	25.81%	1,514	19.47%	752	16.87%	235	17.12%
1939–1945	1,020	23.16%	1,471	24.29%	1,795	23.08%	1,027	23.04%	327	23.82%
Attrition N, %										
No drop out	3,009	68.31%	4,164	68.77%	5,515	70.92%	3,248	72.87%	980	71.38%
Dropped out	802	18.21%	1,313	21.69%	1,753	22.54%	963	21.61%	286	20.83%
Deceased	594	13.49%	578	9.55%	508	6.53%	246	5.52%	107	7.79%
Living with biological parents N, %										
Both parents	4,000	90.81%	5,452	90.04%	7,074	90.97%	4,024	90.29%	1,245	90.68%
One parent	340	7.72%	482	7.96%	562	7.23%	334	7.49%	95	6.92%
No biological parents	65	1.48%	121	2.00%	140	1.80%	99	2.22%	33	2.40%
Adult life education and occupational class N, %	4,194		5,481		6,113		2,856		581	
High education, N, %	211	4.79%	574	9.48%	1,663	21.39%	1,601	35.92%	792	57.68%
High occupational class	289	6.56%	777	12.83%	1,949	25.06%	1,735	38.93%	807	58.78%
Current ability to make ends meet with the household income										
Easily	790	17.93%	1,745	28.82%	3,273	42.09%	2,326	52.19%	846	61.62%
Fairly easily	1,325	30.08%	1,944	32.11%	2,465	31.70%	1,330	29.84%	361	26.29%
With great difficulty	878	19.93%	829	13.69%	557	7.16%	201	4.51%	29	2.11%
With some difficulty	1,412	32.05%	1,537	25.38%	1,481	19.05%	600	13.46%	137	9.98%
High level of physical activities	2,694	61.16%	4,089	67.53%	5,773	74.24%	3,471	77.88%	1,098	79.97%
Depressive symptoms, M, SD	2.89	2.09	2.46	1.93	2.13	1.70	1.98	1.62	1.89	1.61
Having a partner	3,280	74.46%	4,504	74.39%	5,891	76.76%	3,389	76.04%	1,031	75.09%

Distribution of characteristics was based on the sample of 24,066 respondents who answered to verbal fluency.

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., age^2 × disadvantaged, age^2 × middle, age^2 × advantaged, and age^2 × 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.

Table 2. Associations between childhood socioeconomic circumstances and trajectories of delayed recall at older age

Row	Variables	M1		M2		M3	
		Coefficient (95% CI)	*p*	Coefficient (95% CI)	*p*	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	Age^2 (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	Age^2 × CSC (ref. most disadvantaged)						
	Age^2 × 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
	Age^2 × 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
	Age^2 × 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
	Age^2 × 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)			0.51 (0.44–0.58)	<0.001	0.49 (0.42–0.56)	<0.001
	Age × educ			0.04 (−0.04–0.12)	0.318	0.02 (−0.06–0.10)	0.596
	Age^2 × educ			0.02 (−0.03–0.06)	0.414	0.02 (−0.03–0.06)	0.497
8	Low-skill job during active life (ref. high-skill job)			−0.34 (−0.41–0.28)	<0.001	−0.33 (−0.39–0.26)	<0.001
	Age × job			−0.02 (−0.09–0.05)	0.636	0.00 (−0.07–0.07)	0.986
	Age^2 × job			0.03 (−0.01–0.08)	0.100	0.04 (−0.00–0.08)	0.070
9	Current financial situation (ref. easily)						
	Fairly easily			−0.05 (−0.11–0.01)	0.095	−0.01 (−0.07–0.05)	0.737
	Age × fairly easy			0.11 (0.05–0.16)	<0.001	0.14 (0.08–0.19)	<0.001
	Age^2 × fairly easy			0.05 (0.01–0.08)	0.011	0.06 (0.02–0.09)	0.002
	Some difficulty			−0.39 (−0.48–0.30)	<0.001	−0.16 (−0.26–0.07)	<0.001
	Age × some difficulty			0.10 (0.01–0.19)	0.031	0.17 (0.08–0.26)	<0.001
	Age^2 × some difficulty			0.05 (−0.00–0.11)	0.063	0.06 (0.00–0.12)	0.036
	Great difficulty			−0.24 (−0.31–0.17)	<0.001	−0.13 (−0.19–0.06)	<0.001
	Age × great difficulty			0.12 (0.05–0.19)	0.001	0.17 (0.10–0.24)	<0.001
	Age^2 × great difficulty			0.08 (0.04–0.12)	<0.001	0.09 (0.04–0.13)	<0.001
10	Current physical activity					−0.25 (−0.31–0.20)	<0.001
	Age × PA					−0.06 (−0.11–0.00)	0.033
	Age^2 × PA					0.02 (−0.01–0.05)	0.244
11	Current depressive symptoms					−0.12 (−0.14–0.11)	<0.001
	Age × dep.					−0.04 (−0.05–0.03)	<0.001
	Age^2 × dep.					−0.01 (−0.02–0.00)	0.151
12	Current partner status					0.04 (−0.01–0.10)	0.136
	Age × PS					−0.01 (−0.06–0.04)	0.733
	Age^2 × PS					0.03 (−0.00–0.06)	0.082
Fit	AIC (df)	308,038.6 (79,245)		307,050.2 (79,230)		306,440.7 (79,221)	

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		M2		M3	
		Coefficient (95% CI)	*p*	Coefficient (95% CI)	*p*	Coef. (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	Age^2 (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)	0.072	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
	Advantaged	3.39 (2.81–3.98)	<0.001	2.13 (1.55–2.72)	<0.001	2.18 (1.60–2.76)	<0.001
	Most advantaged	4.86 (4.04–5.68)	<0.001	2.98 (2.16–3.79)	<0.001	3.06 (2.25–3.87)	<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	Age^2 × CSC (ref. most disadvantaged)						
	Age^2 × 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
	Age^2 × 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
	Age^2 × 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
	Age^2 × 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)			1.45 (1.21–1.69)	<0.001	1.38 (1.14–1.62)	<0.001
	Age × educ			0.03 (−0.23–0.29)	0.842	−0.04 (−0.29–0.22)	0.785
	Age^2 × educ			0.20 (0.06–0.35)	0.007	0.20 (0.05–0.34)	0.009
8	Low-skill job during active life (ref. high-skill job)			−1.39 (−1.61–1.17)	<0.001	−1.33 (−1.55–1.11)	<0.001
	Age × job			0.14 (−0.09–0.37)	0.239	0.20 (−0.02–0.43)	0.079
	Age^2 × 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
	Age^2 × 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 (−0.00–0.45)	0.052	0.39 (0.17–0.61)	0.001
	Age^2 × 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
	Age^2 × great difficulty			0.27 (0.08–0.45)	0.004	0.29 (0.10–0.47)	0.003
10	Current physical activity					−1.39 (−1.57–1.20)	<0.001
	Age × PA					−0.13 (−0.30–0.04)	0.134
	Age^2 × PA					0.04 (−0.08–0.15)	0.517
11	Current depressive symptoms					−0.30 (−0.35–0.25)	<0.001
	Age × dep.					0.04 (−0.12–0.21)	0.622
	Age^2 × dep.					−0.04 (−0.15–0.07)	0.455
12	Current partner status					0.33 (0.14–0.51)	0.001
	Age × PS					−0.13 (−0.18–0.09)	<0.001
	Age^2 × PS					−0.03 (−0.06–0.00)	0.024
Fit	AIC (df)	495,610.4 (79,130)		494,327.6 (79,115)		493,704.9 (79,106)	

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.

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

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	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 $1.2(-0.88) + 1.2^2(-0.48) + 1.2(-0.66) + 1.2^2(-0.15) = -2.76$ for people aged 73 with the most advantaged CSC and $1.2(-0.88) + 1.2^2(-0.48) + 1.2(0) + 1.2^2(0) = -1.75$ for people aged 73 with the most disadvantaged CSC.

(18). Another study included proxies for the assessment of cognitive functioning (36), which may have influenced the measures of cognitive functioning. At the same time, our finding that more advantaged CSC relate to stronger declines in verbal fluency is in line with current understandings of cognitive reserve. Cognitive reserves are mostly acquired through stimulating activities or experiences over the life course. Living in an advantaged socioeconomic environment is probably linked with experiencing higher levels of mental stimulation and increased encouragement for learning and curiosity. Recently, a metaanalysis supported the view that proxies of cognitive reserves (such as education, occupation, and stimulating activities) are positively associated with levels of cognition (62). Our study confirmed this result for the levels of cognitive functioning and went further by examining its impact on the rate of decline. We thus showed that despite this advantage for respondents living in high CSC, there comes a time when the neuronal loss can no longer be compensated by cognitive reserve, and we observed an accelerated decline, as if advantaged respondents were catching up, a result in line with the reserve theory (37). Why decline in verbal fluency is associated with CSC and not delayed recall is beyond the scope of this research, and we can only speculate about potential reasons. One is that the aspects of CSC that we included in our study only associate with decline in executive functions but not memory. Another is that executive functions are more sensitive to CSC and life course socioeconomic position than memory. Future research is necessary to examine this more closely.

Our study corroborates the view that the etiology of cognitive aging is the result of multiple processes occurring throughout the life course, being both biological, such as by genes (34), through a latency process, and social, through pathways and cumulative processes. The latency model assumes that childhood is a critical phase in the development of the human brain and that environments rich in cognitive stimuli stimulate the reserve capacity of the brain as evidenced by higher scores on cognitive performance tests. The association between CSC and cognitive decline is partly explained by adulthood socioeconomic position, which is in line with the pathway and the cumulative model. These models assume that more advantaged CSC presorts children into trajectories that lead to better adulthood and later life socioeconomic conditions, which in turn is related to decelerated cognitive decline.

The strengths of our study include the large sample size, repeated measurements every 2 y, a 12-y follow-up, and the application of advanced analytical models. Furthermore, our CSC index captures four different aspects of CSC rather than focusing on parental education or occupation alone. Our study has also a number of limitations. One is that information on the early and adult life socioeconomic circumstances was based on self-report, which is subject to recall bias or social desirability. Nevertheless, previous research suggests that the validity of information about the socioeconomic conditions in childhood in self-reports is sufficient (63). Another limitation is that attrition has been selective, as is often the case in longitudinal studies with older people. However, we adjust for attrition in all mixed effect analyses and include respondents with only one wave participation, which might have led to a less severe selection bias. Finally, although we do include educational attainment which may partly compensate the potentially confounding influence of genes, we cannot rule out the role of genes, which according to Ericsson et al. (34) are the factor that is largely responsible for associations between CSC and later life cognitive functioning. However, there are pros and cons for the role of genes, and the debate whether heritability is indeed an inadmissible factor in research on later life health has not yet come to a conclusion (64–66).

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) 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. For example, stimulating children with low CSC to follow higher education early in life as aimed in the later educational reforms at the end of the previous century, and lifting people out of trajectories of poverty in middle age and later life, could partly undo an accumulation of disadvantages over the life course and contribute to better life of all older people and a reduction of health care expenditures.

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 (SHARELIFE). 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 educational level, and not reaching tertiary education level was 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 born generation, reflecting the economic revival after the economic crises (after 1936). Meanwhile, later born cohorts score higher on cognitive functioning (75). To control for potential bias arising from cohort differences we add interaction terms between age and birth cohort and between CSC and birth cohort (1919–1928, 1929–1938, 1939–1945, and 1945 and later) (76). We control for potential country differences in educational systems by adding countries as fixed effects in the models.

Covariates are current physical inactivity, depressive symptoms, and partner status. Physical inactivity was based on two items measuring the habitual frequency of moderate and vigorous physical activity. Participants engaging in either moderate or vigorous physical activity less than once a week were classified as physically inactive. Depressive symptoms were assessed with the Euro-Depression scale, a geriatric depression scale including 12 items (77). Partner status was a time-varying variable, indicating whether people were living with a partner (married or in a registered partnership) or not during each wave. Time-varying covariates (physical inactivity, depression, and partner status) were assessed at the first, second, fourth, fifth, and sixth waves, and we used the mode to obtain a global measure for the period the individuals were followed.

Analytical Approach. Trajectories of delayed recall and verbal fluency were estimated in an accelerated longitudinal design (78) using linear and nonlinear mixed-effect models (79). Such models do not require an equal number of responses from all participants (80), which minimizes information bias due to nonresponses during follow-up. Accelerated longitudinal designs, also called cohort-sequential designs (81), link longitudinal data of one birth cohort with the same longitudinal data from another birth cohort 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 (χ^2) 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 life 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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