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ORIGINAL RESEARCH

The Role of Fertility and Partnership History in Later-life Cognition

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Abstract

Cognitive ageing continues to be a significant burden for society and a primary contributor to individuals' diminishing independence and quality of life. Therefore, improving our understanding of life-course influences on cognitive function is a necessity for public health. Parenthood and marriage are two such influences that may affect cognition in old age. Using the Health and Retirement Study, the relationship between family histories and cognitive functioning in adults in the 'older' age group in the United States is investigated through a sequence-analysis approach. The results show that most of the relationship between fertility and partnership history and cognition later in life is explained by childhood health and socioeconomic conditions, and current sociodemographic characteristics. However, those individuals who have never been married, and in particular those who have never been married and have had no children, report a significantly lower level of cognitive functioning in older age, especially women.

Keywords Cognition · Life Course · Ageing · Sequence Analysis · Family Trajectories

Introduction

Cognitive ageing continues to be a significant burden on society and a major contributor to individuals' diminishing independence and quality of life (Cigolle et al., 2007); hence, it is the most feared aspect of ageing (Deary et al., 2007). In developed countries, such as the United States, individuals are living for longer than ever before (United Nations, 2015), so there is also an increasing prevalence of age-associated neurodegenerative dementias (Murman, 2015). Longer life expectancy presents an expanded timeframe in which cognitive ability may decline. In fact, the Alzheimer's

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Association projects that the number of people in the United States with a clinical diagnosis of Alzheimer's disease – the most common type of dementia – will increase to 13.8 million people in 2050 from 5.8 million in 2019 (Alzheimer Association, 2019). However, as people age, not everyone's cognitive abilities decline equally (Deary et al., 2009). Although existing findings are somewhat inconsistent regarding gender differences in cognitive decline in the normal process of ageing (Laws et al., 2016), greater resilience against age-related cognitive decline in older women compared with men has been argued in both cross-sectional studies (e.g. Barrett-Connor & Kritz-Silverstein, 1999) and longitudinal studies (e.g. McCarrey et al., 2016). Ultimately, improving our understanding of life-course influences on cognitive function is a necessity for public health (Read & Grundy, 2016). Identifying predictors of cognitive function in older age groups improves our understanding of health outcomes and is also necessary due to the increasing life expectancies in developed countries.

The sociological and family demography literature identifies marriage and parenthood as two of the primary life-course events that may influence cognition. Some past studies suggest that marriage and parenthood are associated with varied cognitive outcomes in old age (Hansen et al., 2009), but most of these studies focus on single events, e.g. age at birth of first child or marital disruption, and fail to take into account the interrelations among them. This approach implies that marital and fertility histories, and the specific events within these histories, are independent predictors of health. However, more recent studies suggest that this is not the case, instead arguing that fertility and marital histories are greatly intertwined and create interdependent effects on long-term health that often vary by gender (Barban, 2013; MacMillan & Copher, 2005; O' Flaherty et al., 2016). This shift in research approach can be partly attributed to the changes in family behaviour that have occurred in the United States and other Western countries in the last few decades (Barban, 2013), such as delay in marriage and rising levels of non-marital childbearing (Cherlin, 2005). Both types of history simultaneously influence roles, activities, and socioeconomic resources – all of which can influence cognition throughout adulthood (Agrigoroaei & Lachman, 2011). As such, the theoretical foundation of this work lies in the health-development model (Halfon & Hochstein, 2002). According to this model, health is the result of a continuous and cumulative process that develops during the life course (Halfon & Hochstein, 2002). The model argues that health at a specific point in time is determined by all the events that have happened beforehand and by the dynamic interaction between these events. Therefore, it is necessary to take into account the entire life course trajectory – or the 'family trajectory' (Elder, 1985) when analysing unions and childbearing – to fully understand health conditions among older adults and to disentangle their social determinants.

As such, the aim of this work is to utilise a sequence analysis approach to examine whether family trajectories are associated with cognitive functioning over time among older adults in the United States. Sequence-analysis techniques capture multiple characteristics of the family trajectory, such as complexity, ordering, and timing (Barban, 2013), and allow for a comprehensive analysis of fertility and marital indicators. Previous studies that have investigated family life-course trajectories as a holistic measure indicate that specific trajectories are linked to health outcomes at older ages, such as mortality and physical health (Kravdal et al., 2012; O' Flaherty et al., 2016).

Background and Hypotheses

Previous literature on the effects of marriage and parenthood on cognitive abilities has shown that people living with a partner (married or cohabiting) in the mid-life period are less likely to show cognitive impairment later in life compared to those who are single, separated, or widowed (Håkansson et al., 2009; Helmer et al., 1999; Knoester & Eggebeen, 2006). They also tend to show a slower cognitive decline over time (Karlamangla et al., 2009; Teresa E. Seeman et al., 2001; van Gelder et al., 2006). Being in a coresidential union is not the only factor that has positive effects on cognitive functioning and cognitive trajectories later in life, as parenthood is also associated with better outcomes. More specifically, childlessness has been found to be associated with worse cognitive functioning at older ages among both men and women (Hansen et al., 2009; Read & Grundy, 2016), and childless women tend to show a faster cognitive decline over time. High parity and the birth of one's first child at an early age are also associated with negative cognitive outcomes, albeit partially explained by socioeconomic characteristics and other health conditions (Read & Grundy, 2016). However, other studies have found mixed evidence on childlessness and cognition, e.g. no association or a positive association with cognitive abilities (Hesson, 2012; Low et al., 2005; Ryan et al., 2009; Smith et al., 1999). Additionally, grandparenthood – conceptualised as a long-term effect of childbearing – is associated with cognitive functioning. Previous studies have found that grandparenthood has some negative effect on cognition (Baker & Silverstein, 2008; Minkler & Fuller-Thomson, 1999), contradicting the results of other research that argues that being a grandparent and providing child care are associated with better verbal fluency (Arpino & Bordone, 2014) and physical health (Hughes et al., 2007).

Fertility and marital histories have been argued to influence cognition in old age in multiple ways. Meaningful social interactions, strong social networks, and consistent social support are widely recognised as protective factors for cognitive functioning in old age for both men and women (e.g. Seeman et al., 2011; Zunzunegui et al., 2003). The experiences of marriage and parenthood are thought to enhance these social connections through active social stimulation and involvement with a wider range of activities (Håkansson et al., 2009; Karlamangla et al., 2009). Further, marriage and having children may present consistent social and cognitive challenges, which are likely to have a protective effect against cognitive impairment later in life (Håkansson et al., 2009; Knoester & Eggebeen, 2006). Grandparenthood can also maintain and extend these social interactions and cognitive stimulation into old age (Arpino & Bordone, 2014). For those who have children, it is important to take into account the timing of the event. Age at the birth of one's first child and last child (the latter for those who have more than one child) have been found to be associated with varying levels of social relationships and resources (Fingerman & Charles, 2010). Very young parents, for example, have fewer social and economic resources with which to face parenthood (Falci et al., 2010), and early childbearing can interrupt educational and career progression, with possible cumulative negative effects that may result in lower cognition later in life (Emily Grundy & Read, 2015; Sironi et al., 2020). On the

contrary, late motherhood (> 35) is often linked to better cognitive function (Read & Grundy, 2016), given that older women are usually more educated and in a better socioeconomic position when they enter parenthood. Additionally, for women, there is a competing physiological argument for why fertility histories specifically may influence cognition, which is motivated by the role of different levels of exposure to oestrogen. Past literature has contended that longer exposure to oestrogen is advantageous for cognitive functioning (Behl, 2002; Heys et al., 2011; Read & Grundy, 2016; Ryan et al., 2012; Tierney & Kraus, 2013). Therefore, childless and low-parity women are hypothesised to have better cognitive functioning than those who have high parity.

With the theoretical and empirical literature outlined above in mind, three main hypotheses are proposed:

Hypotheses 1: Individuals who experience smooth marital and fertility trajectories, i.e. get married and have children, would have better cognitive functioning later in life than those who remain single and childless or experience disruptions, e.g. divorce or widowhood.

Hypothesis 2: The association between family pathways and cognitive abilities can also vary by gender, given the presence of both social and physiological mechanisms. Hence, the positive association between smooth partnership and fertility histories and cognitive functioning is expected to be weaker for childless and high-parity men (Hypothesis 2a) and weaker for high-parity women, but not for childless women because of the estrogen exposure hypothesis (Hypothesis 2b).

Hypothesis 3: These associations would be partly, or mostly, explained by early life socioeconomic background, childhood health, and levels of social support and social interactions.

This study will test these hypotheses by analyzing family trajectories and their relationships with cognitive function in older age (50 + years old) among a nationally representative sample of adult men and women in the United States through a sequence analysis approach.

Data and Methods

Data

For the current analysis, data from the Health and Retirement Study (HRS) were used. The HRS is a longitudinal panel study that surveys a representative sample of population over age 50 in the United States. The HRS started in 1992, and there are currently twelve waves of core data available from 1992 to 2014 with about 18–23,000 participants in any given wave. The core interview collects information on a range of factors related to well-being among older adults: income and wealth, health and health services, employment, family connections, biomarkers, etc. The initial cohort interviewed in 1992 was born between 1931 and 1941. A second study,

the Asset and Health Dynamics of the Oldest Old (AHEAD), was fielded in 1993 and included those born 1924 and earlier. In 1998, the two studies were combined, and two additional birth cohorts were enrolled. These two cohorts are the Children of the Depression (CODA), born 1924–1930 and the War Babies, born 1942–1947. The Early Baby Boomers or EBB cohort, born 1948–1953, was added in 2004. The Mid Baby Boomers or MBB, born 1954–1959, were added in 2010. In this work, the RAND HRS Data and Family Data were used, and information from 1992 to 2010 were combined to obtain data on fertility and partnership history, and background information on the respondents, i.e. on early life health and socioeconomic conditions. The cognitive outcomes are measured in 2010, since it is the wave with the largest sample size among the most recent waves. Hence, the starting sample includes 21,042 people who are 50 years old or older. 5,779 individuals were excluded, who do not answer the cognition questions, 579 respondents who have missing information on their fertility-partnership history, and 2,798 respondents that didn't have information on one or more of the controls variables. The final sample includes 11,886 respondents, with 6,755 women and 5,131 men.

Methods

Measures of Cognition

The HRS has selected a set of measures related to cognitive function that include immediate and delayed word recall, the serial 7 s test (i.e. counting down from one hundred by sevens), counting backwards, naming tasks (e.g., date-naming), and vocabulary questions. In addition to the individual cognitive functioning measures, the HRS also derived three cognition summary indices, which are the ones used in this analysis. The *total recall index* summarizes the immediate and delayed word recall tasks, and ranges from 0 to 20 (10 + 10). The *mental status index* sums scores from counting (i.e. serial 7's, and backwards counting from 20), naming, and vocabulary tasks (i.e. object, date, and President/Vice-President naming tasks), and ranges from 0 to 15. Finally, a total cognition score sums the total recall and mental status indices, and so ranges from 0 to 35.

Fertility and Partnership History

In order to build fertility and partnership histories, data from the core HRS interviews were used, taking place every two years, and from the RAND Family Data. In each wave, individuals are asked questions about their marital status, and if married, they are asked the beginning and end dates for each marriage (and the reason for the end of marriage), up to the fourth marriage. From these questions, it is possible to reconstruct their partnership history, and know if they are single and never married, married, divorced, or widow in each year. The HRS doesn't collect data on cohabitations, so it is not possible to observe co-residential unions that are not marriages. The RAND Family Data provide us with very detailed information on the year of birth of each of the respondents' children. Hence, the number of children for each individual is known, as well as the age at childbearing. By combining these data on

Table 1 Cognitive Outcomes

	Men		Women	
	Mean	SE	Mean	SE
Word Recall (0–20)	9.2	0.05	10.0	0.05
Mental Status Index (0–15)	12.9	0.04	12.5	0.04
Total Cognition Summary Score (0–35)	22.1	0.08	22.4	0.08
N	5,131		6,755	

partnership and fertility, individual trajectories that consider events over time are created (see more in the Analytical Strategy section).

Control Variables

Both cognitive functioning in older age and fertility-partnership histories are determined and influenced by confounders that need to be considered in the analysis. Most notably, childhood health and cognition, and early life socioeconomic conditions are important determinants of health later in life (Haas, 2007, 2008; Peck, 1994; Rahkonen et al., 1997) and are also associated with fertility-partnership trajectories (Geronimus & Korenman, 1992; Penman-Aguilar et al., 2013). In terms of early life health, the following variables were included: retrospective information on *learning problems in childhood* (before age 16), *self-reported health* during childhood, and if the respondent has ever experienced a *concussion* or *disability* in childhood. As for family background, the included confounders are: the *family financial socioeconomic conditions* ('poor or varied', 'average', 'well off'), if the family needed *financial help* during childhood, if the respondent's *father was ever unemployed*, if the respondent has *lived with grandparents as a child*, and if the respondent's *mother worked during childhood*. Since cognition is influenced by social support in older age, the average number of *hours of contact with children* in the last 12 months (average across all the children), whether the respondent is used as *childcare for grandchildren and great-grandchildren*, the *number of grandchildren*, participation in *volunteer work*, and if there are *'good friends' living nearby* are also included as controls. Finally, current sociodemographic characteristics were taken into account: age at interview in 2010, ethnicity, region of residence, marital status, employment status, education level, wealth quintile, smoking and physical activity, the number of chronic conditions ever had, and the CESD Depression score. All of the analyses are performed separately for men and women.

Analytical Strategy

After presenting some descriptive statistics[1] on the sample and the variables used in the analysis, the sequence analysis (Abbot & Tsay, 2000; Abbott, 1995; Aisenbrey &

[1] Descriptive statistics and the sequence analysis are weighted using Wave 10 (2010) person-level analysis weight.

Table 2 Partnership & Fertility

	Men		Women	
	Mean/%	SE	Mean/%	SE
% Ever Married	86.8		82.4	
# Marriages	1.26	0.01	1.16	0.01
% Ever Divorced	34.3		30.6	
% Ever Widow	5.2		9.8	
% Ever Had a Child	87.3		88.4	
# Children	3.08	0.04	3.14	0.03
N	5,131		6,755	

Fasang, 2010) is implemented to build fertility-partnership trajectories. Adopting a life course perspective, the following events between age 14 and age 50 for each individual were considered: getting married, getting divorced, becoming widow, and having a child. Therefore, the possible states an individual can be in every year are 'being single (S)', 'being married (M)', 'being divorced (D)', 'being widow (W)', and 'being a parent of *n* children (*n*C)'.[2] In the sequence analysis,[3] each family trajectory is represented by a string of characters, which resembles the one used to code DNA molecules in biological sciences (Barban & Sironi, 2019; Sironi et al., 2015). Once that a family trajectory for each individual has been created, a matrix of dissimilarities between pairs of sequences is computed. The chosen method to compute the dissimilarity matrix is the Longest Common Subsequences metric (LCS) proposed by Elzinga (2010), in which the dissimilarity measure is based on the length of common distinct subsequences between trajectories.[4] Once the dissimilarity matrix is computed, in order to identify a limited number of typologies, the cluster analysis is performed, and a specific number of clusters for men and for women is chosen inspecting the respective dendograms (see Figs. 7 and 8 in the Appendix). Finally, a multivariate regression analysis was performed to study the relationship between cognition in older age and fertility-partnership trajectories, including a variable that shows to which cluster – derived through the sequence analysis – each respondent belongs, and each group of confounders.

Results

Sample Characteristics

Table 1 reports the sample characteristics on cognitive functioning. The average word recall score among men is 9.2, while it is slightly higher (10) among women. The average mental status index is very similar among men and women, i.e. 12.9 and 12.5, respectively. Finally, the average total cognition score is 22.1 for men and 22.4 for women.

[2] Only up to the 5th childbirth. Also, there is no distinction between different spouses, and so the number of marriages, divorces and widowhoods are included in the regression models as controls.

[3] The sequence analysis has been performed using the package TraMineR, which is available in the open source statistical environment R (Gabadinho et al., 2011).

[4] This metric can be used for sequences of unequal length and is equivalent to the special case of Optimal Matching with a unit-cost and a substitution cost of 2.

Table 3 Control Variables

	Men		Women	
	Mean/%	SE	Mean/%	SE
Demographics				
Age at Interview (2010)	66.6	0.20	68.7	0.19
Ethnicity (%)				
White	78.1		76.8	
Black	10.4		11.8	
Hispanic	8.4		8.8	
Other	3.1		2.6	
Region of Residence (%)				
North East	16.3		17.3	
Midwest	24.1		25.1	
South	38.8		37.4	
West	20.8		20.1	
Other	0.07		0.08	
Marital Status (%)				
Married/In a Partnership	71.4		51.3	
Separated/Divorced	13.4		16.2	
Widow	6.8		24.9	
Never Married	8.4		7.7	
Socioeconomic Status				
Employment Status (%)				
Working Full-time	30.7		20.3	
Working Part-time	3.5		5.9	
Unemployed	4.7		3.1	
Partly Retired	9.3		7.1	
Retired	49.1		53.9	
Disabled	1.9		2.4	
Not in the Labor Force	0.8		7.3	
Education Level (%)				
Less than High School	15.0		16.4	
High School or GED	32.9		36.3	
Some College	23.9		26.1	
College Degree or More	28.2		21.2	
Wealth Quintile (%)				
1	14.6		17.4	
2	18.0		18.7	
3	20.1		19.9	
4	22.0		21.9	
5	25.3		22.1	
Adult Health				
Smoking (%)				
Never Smoked	33.6		50.2	

Table 3 (continued)

	Men		Women	
	Mean/%	SE	Mean/%	SE
Former Smoker	49.0		36.6	
Current Smoker	17.4		13.2	
Physical Activity (%)				
Sedentary	13.3		9.8	
Light PA p. Week or More	12.5		24.6	
Moderate PA p. Week or More	33.2		34.2	
Vigorous PA p. Week or More	41.0		31.5	
# Chronic Conditions Ever Had (0–8)	1.95	0.03	2.09	0.02
CESD Depression Scale (0–8)	1.24	0.03	1.55	0.03
Social Support				
# Hours Contact w/ Children (p. Year)	143.6	3.2	162.2	2.9
% Provide Childcare for Grandchildren	20.9		21.6	
# Grandchildren	5.0	0.1	6.0	0.1
% Doing Volunteer Work	36.2		40.3	
% Have Friends Near	63.9		64.4	
Family Background (Childhood)				
Family SES in Childhood (%)				
Poor/Varied	29.5		28.2	
Average	62.5		64.2	
Well Off	8.0		7.7	
% Family Got Financial Help	13.5		14.5	
% Father Unemployed	18.3		18.7	
% Lived with Grandparents	23.9		24.4	
% Mother Working	54.8		52.6	
Childhood Health				
% with Learning Problems	5.2		2.4	
Self-Reported Health (%)				
Excellent	55.9		53.1	
Very Good	24.8		24.5	
Good	14.2		15.8	
Fair	4.2		5.1	
Poor	0.8		1.5	
% Had a Concussion	13.3		6.1	
% with Disability in Childhood	4.1		3.8	
N	5,131		6,755	

As reported in Table 2, more than 82% of the sample has been married at least once. Among men, 34.3% have experienced divorce and 5.2% widowhood. For women, the proportion of those who have ever divorced is lower (30.6%), but there are more women than men who have become widows (9.8%), possibly due to a higher life expectancy among women. 88% of the sample has experienced parenthood and had on average 3 children.

Fig. 1 Clusters derived from cluster analysis. Men ▶

Table 3 shows the background and early life characteristics of the sample. The mean age at interview is 66.6 for men and 68.6 for women. More than three quarters of the sample identify as White, while 11% and 8–9% identify as Black and Hispanic, respectively. 71.4% of men are married, while only 51.3% of women are married or in a partnership, which is also reflected in the higher proportion of widows among women (24.9% vs. 6.8%). Half of the sample is retired, while 30.7% of men and 20.3% of women are still employed full-time. The level of education is slightly higher among men, with 28.2% having a college degree or more, while this is true only for 21.2% of women. 17.4% of men and 13.2% of women are current smokers, while 13.3% of men and 9.8% of women report to be sedentary. The average number of hours per year of contact with children is 143.6 among men and 162.2 among women. About 21% of both men and women provide childcare for grandchildren or great-grandchildren, and have 5 or 6 grandchildren on average. 36.2% of men and 40.3% of women are involved in voluntary work, and 64% of both men and women declare to have good friends living close to them.

Almost one third of the sample reports their family socioeconomic status to be poor (or varied) during childhood, and 14% got some sort of financial help. 18% of the respondents' fathers were unemployed, and 24% have lived with grandparents at some point before turning 16. 5.2% of men and 2.4% of women reported learning problems in childhood, while 13.3% of men and 6.1% of women had a concussion before age 16.

Sequence and Cluster Analysis

Figures 1 and 2 show the index plots for men and women's clusters, respectively. Figures are based on 50 randomly chosen sequences from each cluster. Eight clusters were identified for men: the first cluster – *Married, 5+children* (21.5% of the sample) – is characterized by a short period of time spent as single, a very fast transition to marriage and childbearing. Most of the men in this cluster have 5 or more children by age 50. Cluster 2 – *Single, No children* (6.3%) – includes mostly men that have never been married and haven't had any kids. The third cluster – *Married/Divorced, with children* (14.2%) – is mainly populated by men who get married and have a child by age 30, and by age 50 are either married or divorced with 2–3 children. In Cluster 4 – *Married, 2 children* (15.7%) – the majority of men get married and have two children by age 50. Cluster 5 – *Married, 3 children* (17.4%) – is very similar to Cluster 4, but in this Cluster, men have 3 children. In Cluster 6 – *Single, with children* (8.2%) – most men haven't got married by age 50 but have at least one child. The seventh cluster – *Married, 4 children* (12.5%) – replicates Cluster 1, 4, and 5, but most men have 4 children by age 50. Finally, Cluster 8 – *Married/Divorced, No children* (4.3%) – consists of men who got married, and by age 50 are still married or got divorced but have not had children.

Women's clusters are very similar, except that 9 clusters were selected in this case. Cluster 1 is *Single, with children* (14.4%) and is more common among women than men. Cluster 2 is *Married, 2 children* (18.6%) and in Cluster

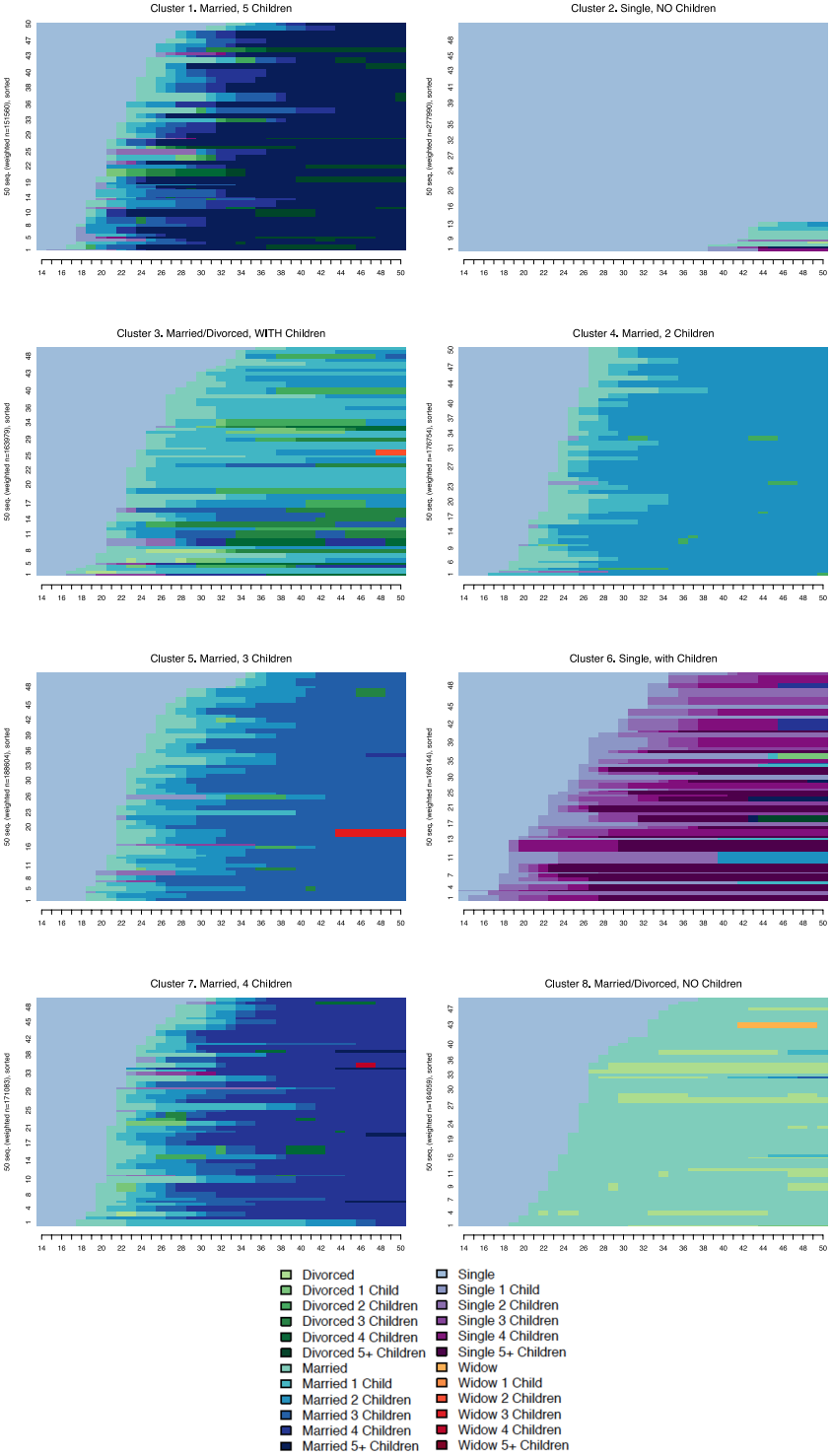

Cluster 1. Married, 5 Children
Cluster 2. Single, NO Children
Cluster 3. Married/Divorced, WITH Children
Cluster 4. Married, 2 Children
Cluster 5. Married, 3 Children
Cluster 6. Single, with Children
Cluster 7. Married, 4 Children
Cluster 8. Married/Divorced, NO Children
Divorced
Divorced 1 Child
Divorced 2 Children
Divorced 3 Children
Divorced 4 Children
Divorced 5+ Children
Married
Married 1 Child
Married 2 Children
Married 3 Children
Married 4 Children
Married 5+ Children
Single
Single 1 Child
Single 2 Children
Single 3 Children
Single 4 Children
Single 5+ Children
Widow
Widow 1 Child
Widow 2 Children
Widow 3 Children
Widow 4 Children
Widow 5+ Children

Fig. 2 Clusters derived from cluster analysis. Women ▶

3—*Married/Divorced, No children* (4.7%) – there are more women who by age 50 are married or divorced but haven't had any children. In Cluster 4 – *Married, 3 children* (14.9%) –, Cluster 5 – *Married, 4 children* (12%) –, Cluster 6 – *Married, 5 + children* (20.4%) –, and Cluster 7 – *Married, 1 child* (5.4%) – there are women who transition to marriage and motherhood very fast, and just have a different number of children by age 50. Cluster 8 – *Divorced, with children* (5.7%) – is also new with respect to men's clusters, and most of these women are divorced and with children by age 50. Finally, Cluster 9 – *Single, No children* (3.8% – is very similar to Cluster 2 for men, with most women remaining single and childless between age 14 and 50.

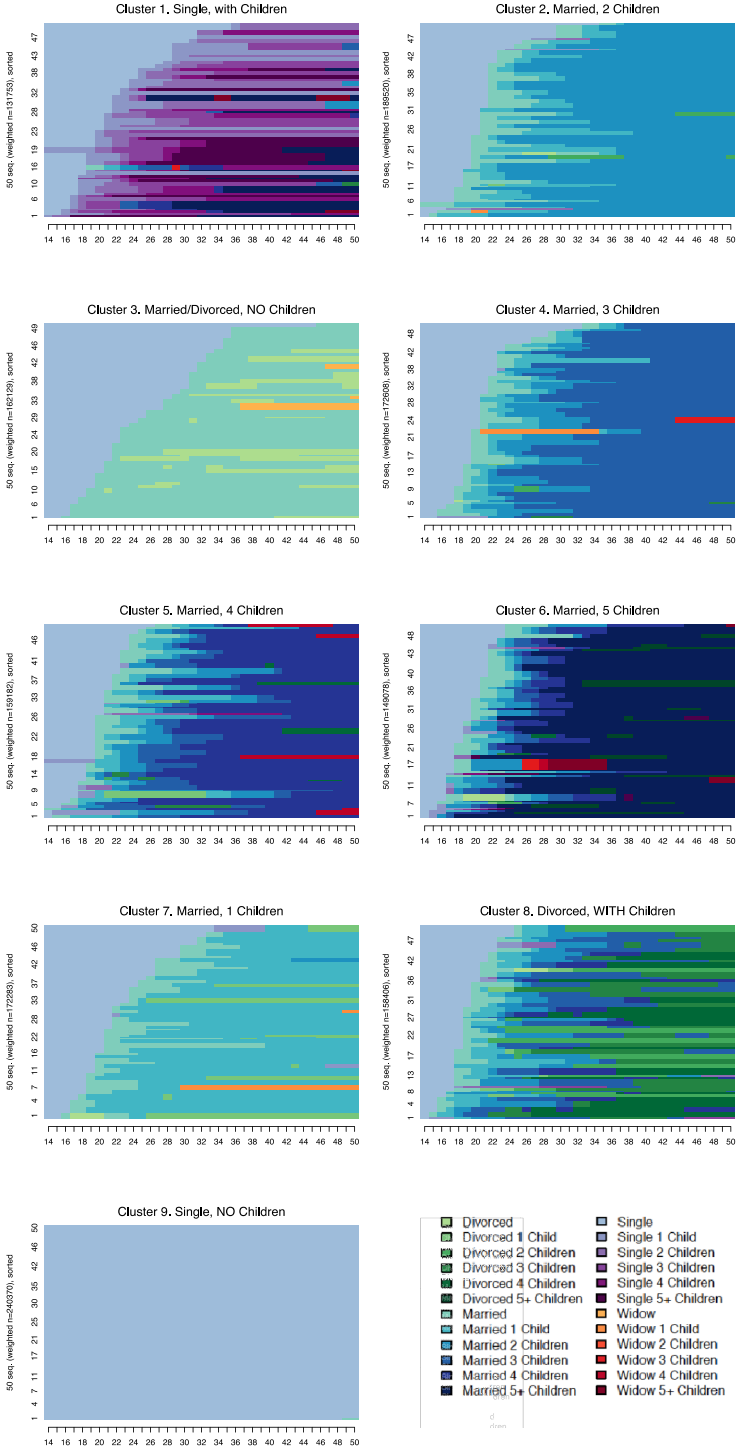
Fertility-Partnership History and Cognitive Functioning

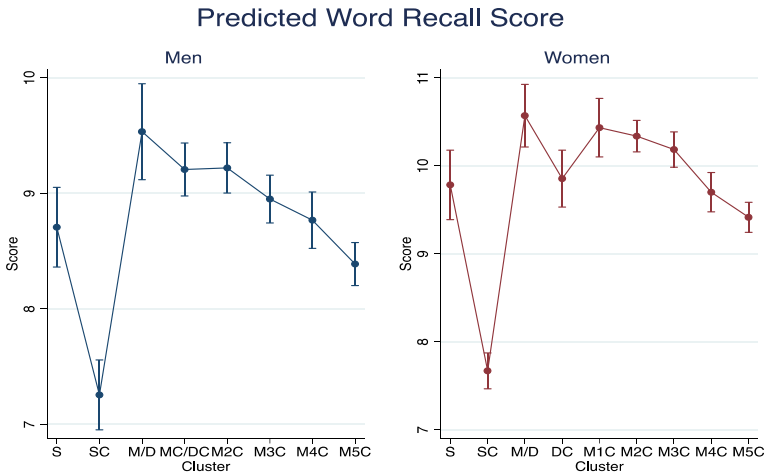
The next step is to investigate the relationship between belonging to a specific fertility-partnership cluster and cognitive functioning in older age. The first step is to present the predicted cognition scores based on the cluster, without taking into account any confounders. As Fig. 3 shows, there are notable differences in the predicted scores, depending on the fertility-partnership trajectory. As it is reported in the top panel of Fig. 3, the predicted word recall score for men (on the left) and women (on the right). The lowest score is registered for both men and women in the '*Single, with children*' cluster, and it is significantly lower than for the other clusters. This is true not only for the word recall score, but also for the mental status index and total cognition score. For both men and women, the highest word recall score is observed among the '*Married/Divorced, No children*' cluster, and among men, this score is significantly higher than that for those in the clusters '*Single, No children'*, '*Married, 4 children'*, and '*Married, 5 children*', while among women, it is higher than that for those in the clusters '*Single, No children'*, '*Divorced, with children'*, '*Married, 4 children'*, and '*Married, 5 children*'.

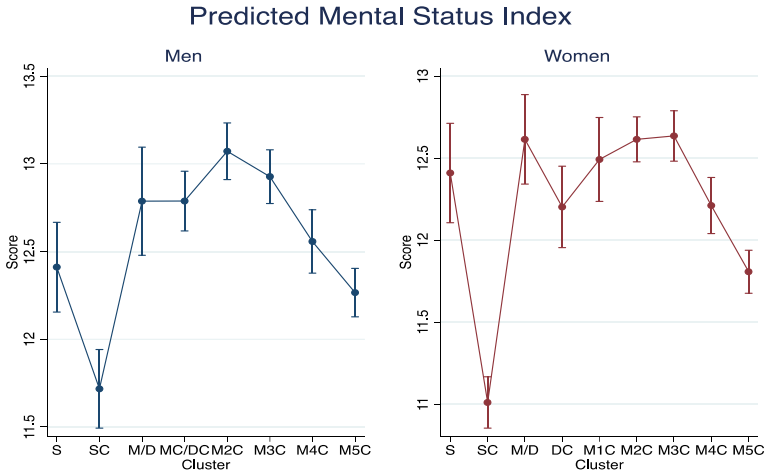
A very similar picture can be observed for the mental status index score, even if in this case the highest score is reported by men belonging to the cluster '*Married, 2 children*' and women belonging to the cluster '*Married, 3 children*' and it is significantly higher than those '*Single, with children*', '*Married, 4 children*', and '*Married, 5 + children*'. The bottom panel of Fig. 3 reports the results for the total cognition score, and the trend is comparable to that observed for word recall and mental status index.

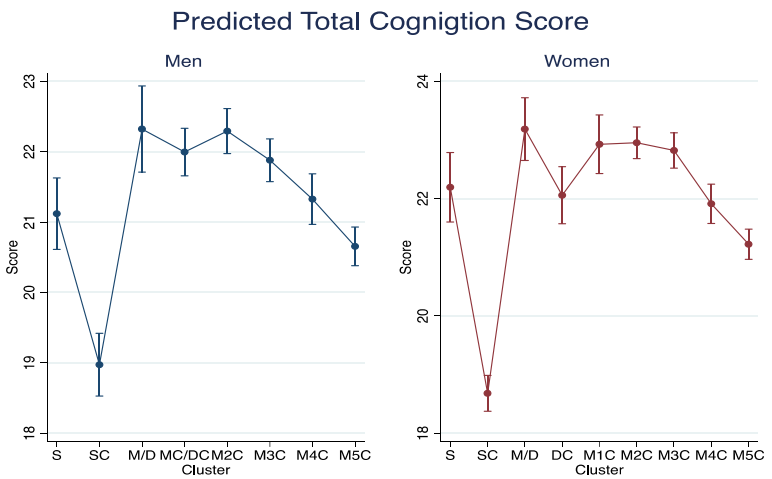
In the multivariate linear regression models, including all of the confounders[5] discussed above, the results change quite substantially, especially for men. Figure 4

[5] Separate regression models, including each group of the confounders (i.e. sociodemographic characteristics, childhood health, childhood socioeconomic status, and social capital) step by step, have been performed as a robustness checks and the results show very similar findings to the full model (available upon request).


Cluster 1. Single, with Children
Cluster 2. Married, 2 Children
Cluster 3. Married/Divorced, NO Children
Cluster 4. Married, 3 Children
Cluster 5. Married, 4 Children
Cluster 6. Married, 5 Children
Cluster 7. Married, 1 Children
Cluster 8. Divorced, WITH Children
Cluster 9. Single, NO Children
Divorced
Divorced 1 Child
Divorced 2 Children
Divorced 3 Children
Divorced 4 Children
Divorced 5+ Children
Married
Married 1 Child
Married 2 Children
Married 3 Children
Married 4 Children
Married 5+ Children
Single
Single 1 Child
Single 2 Children
Single 3 Children
Single 4 Children
Single 5+ Children
Widow
Widow 1 Child
Widow 2 Children
Widow 3 Children
Widow 4 Children
Widow 5+ Children


Predicted Word Recall Score
Men
Women
Score
Cluster
S SC M/D MC/DC M2C M3C M4C M5C
S SC M/D DC M1C M2C M3C M4C M5C


Predicted Mental Status Index
Men
Women
Score
Cluster
S SC M/D MC/DC M2C M3C M4C M5C
S SC M/D DC M1C M2C M3C M4C M5C


Predicted Total Cognigtion Score
Men
Women
Score
Cluster
S SC M/D MC/DC M2C M3C M4C M5C
S SC M/D DC M1C M2C M3C M4C M5C

◂**Fig. 3** Cognitive Functioning by Cluster

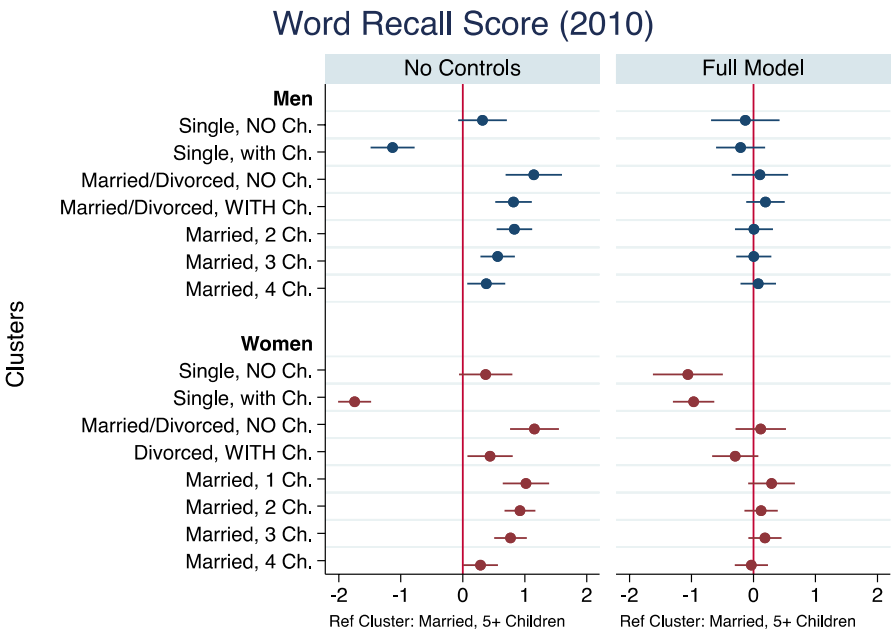


Fig. 4 Word Recall Score

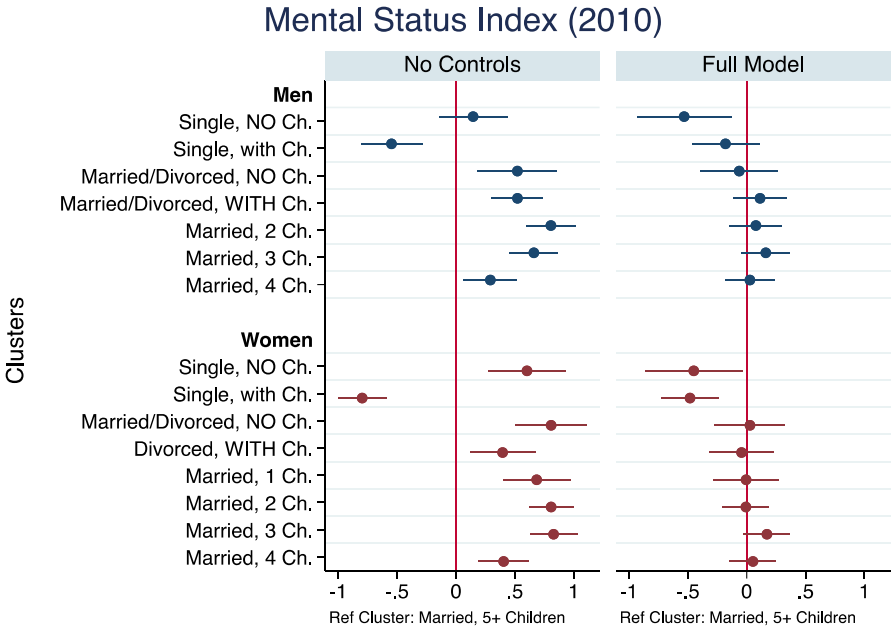


Fig. 5 Mental Status Index

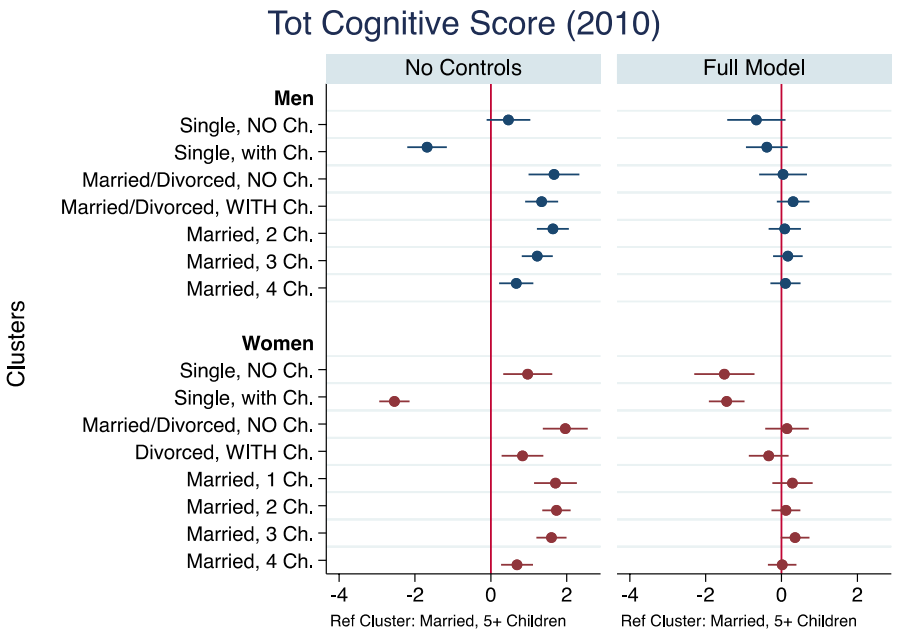


Fig. 6 Total Cognition Score

reports the regression results for the word recall score with and without the controls. The reference cluster is '*Married, 5 + children,*' as it is the most prevalent cluster among both men and women. When the controls are included, all of the coefficients become non-significant for men, showing that the relationship between this cognitive score and the fertility-partnership history is explained by socio-economic and background factors. Among women instead, being in the clusters '*Single, No children*' (b = -1.06, $p < 0.001$) or '*Single, with children*' (b = -0.97, $p < 0.001$) is still associated with a lower word recall score than for the reference cluster *'Married, 5 + children.'* Looking at the mental status index score (Fig. 5), it is possible to see that including the confounders in the model brings the coefficient to non-significant for all clusters, except '*Single, No children*' (b = -0.53, $p < 0.01$) for men, and '*Single, No children*' (b = -0.45, $p < 0.05$) and '*Single, with children*' (b = -0.48, $p < 0.001$) for women. Finally, running the models for the combined total cognition score (Fig. 6), there is no significant relationship between cognition and fertility-partnership trajectory among men, but it is still relevant among women: those in the clusters '*Single, No children*', and '*Single, with children*' report a significantly lower cognition score (i.e. b = -1.5, $p < 0.001$ and b = -1.45, $p < 0.001$, respectively).

These results argue that the groups that have a lower cognition score are those who never got married (*'Single, No children'*), and even more so those who never got married but had children (*'Single, with children'*), especially among women.

Discussion and Conclusion

Given the increasing prevalence of age-associated neurodegenerative dementias and the importance to understand the drivers of cognitive aging, this article investigated the relationship between family histories and cognitive functioning among people aged 50 years old or older in the United States, using data from the Health and Retirement Study. Drawing on the theoretical foundation that health at any point in time is the result of a continuous and cumulative process that develops during the life course, and that it is determined by all the events happened in the past and by the dynamic interaction between these events, this work focused on marital and fertility trajectories as key determinants of cognitive functioning later in life. This research extends previous literature by utilizing a sequence analysis approach to take into account that marital and fertility histories are entwined and create interdependent effects on long-term health, by simultaneously influencing roles, activities, and socioeconomic resources—all of which can influence cognition throughout adulthood.

The results of this study show that among both men and women, those who got married and had children report higher levels of cognitive functioning, both in terms of the word recall and mental status index. Among those who got married, there is a decline in cognition as parity increases, but there is no 'penalty' for those who remained childless. Moreover, disruptions in marital trajectories, such as widowhood or divorce, were not associated with lower cognitive scores. The typology that reported the lowest scores was the one of single parents. Finally, once the confounders were taken into account (i.e. sociodemographic characteristics, childhood health, childhood socioeconomic conditions, and social capital), the differences in cognitive functioning across different groups disappeared among men, with the exception of the mental status index that was lower for men in the 'Single, No Children' group. Women in the 'Single, No Children' and 'Single, with Children' groups still retained lower cognitive functioning than other women, even after including the cofounders in the analysis.

These findings partially confirm Hypothesis 1, which proposed that those who experienced smooth marital and fertility trajectories, i.e. get married and have children, had better cognitive functioning later in life than those who remain single and childless or experience disruptions, e.g. divorce or widowhood. However, experiencing divorce was not associated with lower cognition scores. This is consistent with the theory that social interactions, strong social networks, and social support are protective of cognitive functioning in old age for both men and women (Seeman et al., 2001; Zunzunegui et al., 2003). Getting married and experiencing parenthood enhance these social connections through active social stimulation and involvement with a wider range of activities, which are likely to have a protective effect against cognitive impairment later in life (Håkansson et al., 2009; Karlamangla et al., 2009;). According to the reported analysis, divorce does not disrupt the social connections built over time, or not enough to have a significant effect on cognitive abilities.

Hypothesis 2a was partially confirmed among men, given that the positive association between smooth marital and fertility histories and cognitive functioning was weaker for married high-parity men. However, there was no penalty

associated with being childless. Hypothesis 2b was confirmed among women, as the same trend of weaker positive associations between smooth family trajectories and cognitive functioning was observed among married high-parity women, but not among childless married women, which is consistent with the estrogen exposure hypothesis. The weaker positive associations among high-parity fathers and mothers could be explained by the stress that is introduced with parenthood, especially in large families. Among women, sources of stress can be introduced by both physiological (due to pregnancy and childbearing) and social factors, such as considerable economic costs and disruption of career trajectories (Grundy & Read, 2015). These non-physiological stresses that are involved with parenthood have an effect on men as well, and the negative consequences are more likely to be seen among young parents, among those with short birth intervals, and those with a higher number of children (D'Elio et al., 1997; Falci et al., 2010; Grundy & Kravdal, 2010). The cumulative effect of stress might result in lower cognitive functioning in older age.

Finally, the third hypothesis was partially confirmed, which proposed that the associations between family trajectories and cognition would be mostly explained by early life socioeconomic background, childhood health, and current sociodemographic characteristics and levels of social capital. Confounders could not explain lower cognitive functioning scores among single childless women and among single mothers. A possible explanation for this result is that single women and single mothers were not exposed to social and cognitive challenges or stimulations associated with marriage throughout their life course, and that the positive social interactions offered by motherhood would not offset the disadvantages of being a single parent. Hence, the findings of this study seem to suggest that it is the cumulative effect of social interactions over time, rather than a negative event like a divorce, that matter.

This work is not free of limitations. The Health and Retirement Study does not collect data on cohabitation history; hence, those who are recorded as single might actually be cohabiting or might have cohabited at some point in their partnership trajectory. Given the age span of individuals included in the sample, and the fact that cohabitation became increasingly prevalent only towards the end of the twentieth century, the proportion of men and women in the analysis who would have cohabited is assumedly not very large. However, it is necessary to interpret the results on single men and women with caution. Moreover, sequence and cluster analysis—despite being powerful tools for descriptive analyses—do present their own problems. The within cluster variation is lost in the analysis: not everyone in each cluster has exactly the same marital and fertility trajectory. Also, there is some arbitrariness in the choice of number of clusters[6] and neither sequence, nor cluster analyses, address causality, prompting to interpret the results as associations and not as causal effects.

The main finding of this study is that there is a relationship between marital and fertility histories and cognition later in life, and that the use of sequence analysis

[6] Sensitivity analyses to understand how the findings would change with different numbers of clusters were performed, and the solution presented in the main text remained the optimal solution.

allows us to take into account the interrelation among the events in the family trajectory, and to identify groups at risk. In particular, single women and single mothers do report lower cognitive scores later in life, and these scores cannot be explained by socioeconomic and demographic factors or by social capital. Therefore, it is necessary to think about measures to protect these groups—especially women -, and to offset the negative cumulative effects of remaining single throughout the life course or of experiencing single motherhood.

Appendix

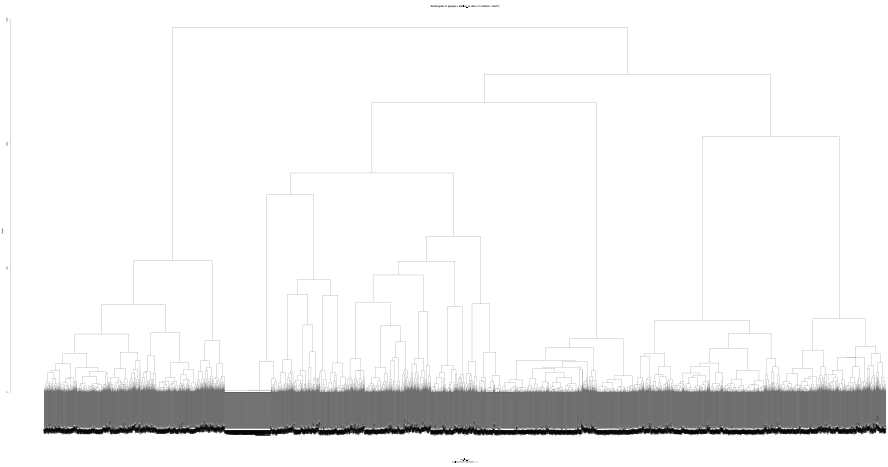


Fig. 7 Dendogram, Men

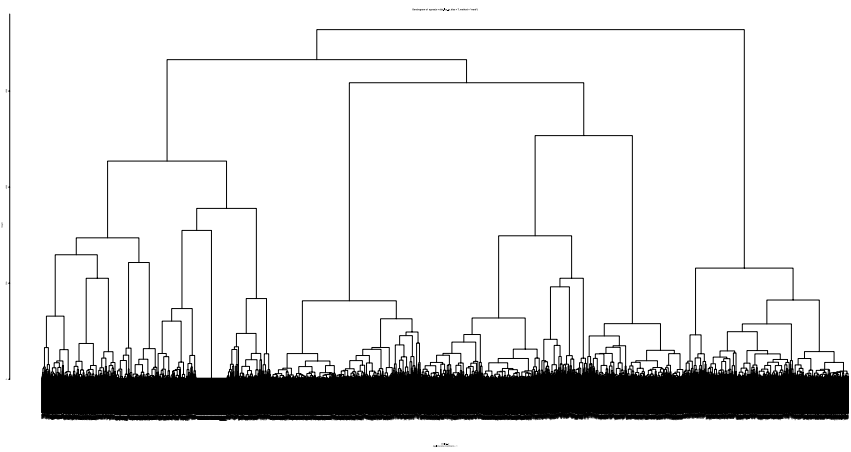


Fig. 8 Dendogram, Women

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Declarations

Conflicts of Interest The Author declares that there is no conflict of interest.

Informed Consent None.

Ethical Treatment of Experimental Subjects (Animal and Human) No experimental treatment was conducted on either human or animal subjects in this study.

References

Abbott, A. (1995). Sequence analysis: New methods for old ideas. *Annual Review of Sociology*, *21*(1), 93–113.

Abbott, A., & Tsay, A. (2000). Sequence analysis and optimal matching methods in sociology: Review and prospect. *Sociological Methods & Research*, *29*(1), 3–33.

Agrigoroaei, S., & Lachman, M. E. (2011). Cognitive Functioning in Midlife and Old Age: Combined Effects of Psychosocial and Behavioral Factors. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 66*(1), i130–140.

Aisenbrey, S., & Fasang, A. E. (2010). New life for old ideas: The" second wave" of sequence analysis bringing the" course" back into the life course. *Sociological Methods & Research*, *38*(3), 420–462.

Alzheimer Association. (2019). 2019 Alzheimer's Disease Facts and Figures. *Alzheimer's & Dementia 2019, 15*(3), 321–87.

Arpino, B., & Bordone, V. (2014). Does Grandparenting Pay off? The Effect of Child Care on Grandparents' Cognitive Functioning. *Journal of Marriage and Family*.

Baker, L. A., & Silverstein, M. (2008). Preventive Health Behaviors among Grandmothers Raising Grandchildren. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*.

Barban, N. (2013). Family Trajectories and Health: A Life Course Perspective. *European Journal of Population / Revue européenne de Démographie, 29*(4), 357–85. http://link.springer.com.skaitykla.mruni.eu/article/https://doi.org/10.1007/s10680-013-9296-3

Barban, N., & Sironi, M. (2019). *Sequence Analysis as a Tool for Family Demography* (pp. 101–123). Springer.

Barrett-Connor, E., & Kritz-Silverstein, D. (1999). Gender differences in cognitive function with age: The Rancho Bernardo study. *Journal of the American Geriatrics Society*.

Behl, C. (2002). Estrogen Can Protect Neurons: Modes of Action. *In Journal of Steroid Biochemistry and Molecular Biology*.

Cherlin, A. J. (2005). American Marriage in the Early Twenty-First Century. *Future of Children, 15*(2), 33–55.

Cigolle, C. T., et al. (2007). Geriatric Conditions and Disability: The Health and Retirement Study. *Annals of Internal Medicine, 147*(3), 156–164.

D'Elio, M. A., Ness, R. B., Matthews, K. A., & Kuller, L. H. (1997). Are Life Stress and Social Support Related to Parity in Women? *Behavioral Medicine, 23*(2), 87–94.

Deary, I., et al. (2007). The Lothian Birth Cohort 1936: A Study to Examine Influences on Cognitive Ageing from Age 11 to Age 70 and Beyond. *BMC Geriatrics, 7*(1), 28.

Deary, I. J., et al. (2009). Age-associated cognitive decline. *British Medical Bulletin*.

Elder, G. H. (1985). Perspectives on the Life Course. *Life Course Dynamics: Trajectories and Transitions, 1*(2007), 23–49.

Elzinga, C. H. (2010). Complexity of Categorical Time Series. *Sociological Methods & Research, 38*(3), 463–481.

Falci, C. D., Mortimer, J. T., & Noel, HarmoniJoie. (2010). Parental Timing and Depressive Symptoms in Early Adulthood. *Advances in Life Course Research, 15*(1), 1–10.

Fingerman, K. L., & Charles, S. T. (2010). It Takes Two to Tango: Why Older People Have the Best Relationships. *Current Directions in Psychological Science, 19*(3), 172–176.

Van G., Boukje M., et al. (2006). Marital Status and Living Situation during a 5-Year Period Are Associated with a Subsequent 10-Year Cognitive Decline in Older Men: The FINE Study. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*.

Geronimus, A. T., & Korenman, S. (1992). The Socioeconomic Consequences of Teen Childbearing Reconsidered. *The Quarterly Journal of Economics, 107*(4), 1187–1214. papers://e09fda77–1450–4449–8ecf-5a9bb72f5b0a/Paper/p367.

Grundy, E., & Kravdal, Ø. (2010). Fertility History and Cause-Specific Mortality: A Register-Based Analysis of Complete Cohorts of Norwegian Women and Men. *Social Science & Medicine,* 70(11), 1847–57. papers://e09fda77–1450–4449–8ecf-5a9bb72f5b0a/Paper/p5311.

Grundy, E., & Read, S. (2015). Pathways from Fertility History to Later Life Health: Results from Analyses of the English Longitudinal Study of Ageing. *Demographic Research, 32*(4), 107–146.

Haas, S. (2008). Trajectories of functional health: The 'Long Arm' of childhood health and socioeconomic factors. *Social Science & Medicine,* 66(4), 849–61. papers://e09fda77–1450–4449–8ecf-5a9bb72f5b0a/Paper/p64.

Haas, S. A. (2007). The Long-Term Effects of Poor Childhood Health: An Assessment and Application of Retrospective Reports. *Demography, 44*(1), 113–135. https://doi.org/10.1353/dem.2007.0003

Håkansson, K., et al. (2009). Association between Mid-Life Marital Status and Cognitive Function in Later Life: Population Based Cohort Study. *BMJ (clinical Research Ed.), 339*, b2462.

Halfon, N., & Hochstein, M. (2002). Life Course Health Development: An Integrated Framework for Developing Health, Policy, and Research. *The Milbank Quarterly, 80*(3), 433–79, iii.

Hansen, T., Britt, S., & Moum, T. (2009). Childlessness and psychological well-being in midlife and old age: An examination of parental status effects across a range of outcomes. *Social Indicators Research, 94*(2), 343–62.

Helmer, C., et al. (1999). Marital status and risk of Alzheimer's disease: A french population-based cohort study. *Neurology*.

Hesson, J. (2012). Cumulative estrogen exposure and prospective memory in older women. *Brain and Cognition*.

Heys, M., et al. (2011). Life long endogenous estrogen exposure and later adulthood cognitive function in a population of naturally postmenopausal women from Southern China: The Guangzhou biobank cohort study. *Psychoneuroendocrinology*.

Hughes, M. E., Waite, L. J., LaPierre, T. A., & Luo, Y. (2007). All in the family: The impact of caring for grandchildren on grandparents' health. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*.

Karlamangla, A. S., et al. (2009). Trajectories of Cognitive Function in Late Life in the United States: Demographic and Socioeconomic Predictors. *American Journal of Epidemiology, 170*(3), 331–342.

Knoester, C., & Eggebeen, D. J. (2006). The Effects of the Transition to Parenthood and Subsequent Children on Men's Well-Being and Social Participation. *Journal of Family Issues, 27*(11), 1532–1560.

Kravdal, Ø., Grundy, E., Lyngstad, T. H., & Wiik, K. A. (2012). Family life history and late mid-life mortality in Norway. *Population and Development Review*.

Laws, K. R., et al. (2016). Sex differences in cognitive impairment in Alzheimer's disease. *World Journal of Psychiatry*.

Low, L. F., et al. (2005). Reproductive period and cognitive function in a representative sample of naturally postmenopausal women aged 60–64 years. *Climacteric*.
MacMillan, R., & Copher, R. (2005). Families in the Life Course: Interdependency of Roles, Role Configurations, and Pathways. *Journal of Marriage and Family, 67*(4), 858–879.
McCarrey, A. C., et al. (2016). Sex differences in cognitive trajectories in clinically normal older adults. *Psychology and Aging*.
Minkler, M., & Fuller-Thomson, E. (1999). The health of grandparents raising grandchildren: Results of a national study. *American Journal of Public Health*.
Murman, D. L. (2015). The Impact of Age on Cognition. *Seminars in Hearing, 36*(3), 111–121.
Peck, N. M. (1994). The Importance of Childhood Socio-Economic Group for Adult Health. *Social Science and Medicine, 39*(4), 553–562.
O'Flaherty, M., Baxter, J., Haynes, M., & Turrell, G. (2016). The family life course and health: Partnership, fertility histories, and later-life physical health trajectories in Australia. *Demography, 53*(777), 1–28. https://doi.org/10.1007/s13524-016-0478-6
Penman-Aguilar, A., Carter, M., Snead, M. C., & Kourtis, A. P. (2013). Socioeconomic disadvantage as a social determinant of teen childbearing in the U.S. *Public Health Reports, 128*(2_suppl1), 5–22. http://www.ncbi.nlm.nih.gov/pubmed/23450881
Rahkonen, O., Lahelma, E., & Huuhka, M. (1997). Past or Present? Childhood Living Conditions and Current Socioeconomic Status as Determinants of Adult Health. *Social Science and Medicine, 44*(3), 327–336.
Read, S. L., & Grundy, E. M. D. (2016). Fertility History and Cognition in Later Life. *The Journals of Gerontology Series b: Psychological Sciences and Social Sciences, 00*(00), 1–11.
Ryan, J., et al. (2009). Life-time estrogen exposure and cognitive functioning in later life. *Psychoneuroendocrinology*.
Ryan, J., Stanczyk, F. Z., Dennerstein, L., Mack, W. J., Clark, M. S., Szoeke, C., ... & Henderson, V. W. (2012). Hormone levels and cognitive function in postmenopausal midlife women. *Neurobiology of Aging*.
Seeman, T. E., et al. (2011). Histories of social engagement and adult cognition: Midlife in the U.S. study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*.
Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology*.
Sironi, M., Barban, N., & Impicciatore, R. (2015). Parental social class and the transition to adulthood in Italy and the United States. *Advances in Life Course Research*, *26*(1).
Sironi, M., Ploubidis, G. B., & Grundy, E. M. (2020). Fertility History and Biomarkers Using Prospective Data: Evidence From the 1958 National Child Development Study. *Demography, 57*(2), 529–558. https://doi.org/10.1007/s13524-020-00855-x
Smith, C. A., et al. (1999). Lifelong estrogen exposure and cognitive performance in elderly women. *Brain and Cognition*.
Tierney, A. T., & Kraus, N. (2013). The ability to tap to a beat relates to cognitive, linguistic, and perceptual skills. *Brain and Language*.
United Nations. (2015). *World Population Ageing 2015*.
Zunzunegui, M. V., Alvarado, B. E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*.

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