Intersectional inequalities in the transition to grandparenthood and cognitive functioning: A longitudinal Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy (MAIHDA)

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Abstract

Objectives: In aging societies, more people become vulnerable to experiencing cognitive decline. Simultaneously, the role of grandparenthood is central for older adults and their families. Our study investigates inequalities in the level and trajectories of cognitive functioning among older adults, focusing on possible intersectional effects of social determinants and grandparenthood as a life course transition that may contribute to delaying cognitive decline.

Methods: Using longitudinal data from the Survey of Health, Ageing and Retirement in Europe, we analyzed a sample of 19,953 individuals aged 50-85 without grandchildren at baseline. We applied Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy to investigate variation in cognitive functioning across 48 intersectional strata, defined by sex/gender, migration, education, and occupation. We allowed the impact of becoming a grandparent on cognitive functioning trajectories to vary across strata by including random slopes.

Results: Intersectional strata accounted for 17.43% of the overall variance in cognitive functioning, with most of the stratum-level variation explained by additive effects of the stratum-defining characteristics. Transition to grandparenthood was associated with higher cognitive functioning, showing a stronger effect for women. Stratum-level variation in the grandparenthood effect was modest, especially after accounting for interactions between grandparenthood and the stratum-defining variables.

Discussion: This study highlights the importance of social determinants for understanding heterogeneities in older adults' level of cognitive functioning and its association with the transition to grandparenthood. Cumulative disadvantages negatively affect cognitive functioning, hence adopting an intersectional lens is useful to decompose inequalities and derive tailored interventions to promote equal healthy aging.

Keywords: Intersectionality; Healthy aging; Cognition; Grandparents; Intergenerational ties

Introduction

Growing longevity and extended lives entail an increased proportion of people at risk of late-life cognitive decline (United Nations, 2015). While cognitive functioning has a genetic component, cognitive differences are strongly affected by environmental exposures accumulated throughout the life course (Deary et al., 2022). Social determinants such as sex/gender, ethnicity and socioeconomic status (SES) combine to shape cognitive functioning, with some suggesting strong intersectional effects (Forrester et al., 2019).

Recent demographic changes have also raised interest in how life course transitions shape cognitive functioning and healthy aging (Chang et al., 2019). The transition to grandparenthood is an increasingly common and important event in the life course of older adults and their families (Skopek, 2021). This transition has been linked to health and well-being, although the direction of the effect remains unclear: Becoming a grandparent can generate psychological benefits through social interaction or positive emotions (Taubman – Ben-Ari et al., 2018) but also threaten mental health due to increased stress or by reinforcing feelings of 'being old' (Tanskanen et al., 2019).

Like overall levels of health and functioning, the nature, direction and strength of grandparenthood effects may be stratified by social position, including the intersectional interplay of multiple social determinants (Dolbin-MacNab & Few-Demo, 2018). While evidence suggests that grandparenthood health benefits are stronger for individuals in more privileged social positions (Di Gessa et al., 2022; Sheppard & Monden, 2019), investigations of the moderating role of social position in such relation remain scarce.

In the present study, we extend research on older adults' cognitive functioning and potential impacts of the transition to grandparenthood by adopting an intersectional perspective that focuses on the interplay of sex/gender, migration background, education, and occupation. According to the intersectional perspective individuals occupy unique social positions that entail particular lived experiences and exposures to (dis)advantages (Crenshaw, 1990). Following standard practice in quantitative intersectionality research (Bauer, 2014), we proxy these positions as the intersections of categorical variables (e.g., sex/gender, migration or education). However, we emphasize that, from an intersectional perspective, it is not these positions themselves that lead to (cognitive) inequalities but rather the interlocking systems of oppression and discrimination (sexism, racism, classism) that shape the experiences associated with them. Despite growing interest in intersectional inequalities, practically no quantitative research has investigated their potential role in shaping cognitive functioning (Hale et al. (2022) for an exception).

Background

Healthy aging and cognitive functioning

Cognitive functioning, understood as a person's abilities for acquiring and processing information, reasoning and decision-making, is key for daily functioning (Jeon et al., 2022). Cognitive decline can negatively impact the ability to perform everyday tasks, implying a loss of independence and quality of life (Thorvaldsson et al., 2016). Lower levels of cognitive functioning are closely linked to deteriorated mental health and well-being, making it a fundamental part of healthy aging (Martinussen et al., 2019).

While normal aging comes with a decline in cognitive functioning due to natural brain changes, social disparities in cognitive functioning cannot be explained by these biological processes alone (Bishop et al., 2010). Higher mental complexity of the main lifetime occupation is predictive of the level and trajectory of change in cognitive functioning (Finkel et al., 2009). Cognitive enrichment theory posits that intellectual and social activities improve cognition, meaning that inactive lifestyles can accelerate decline in cognitive functioning, whereas exposure to stimuli can prevent or delay it (Hertzog et al., 2008). Further, there are indications of substantial cognitive inequalities according to the diverse socio-environmental contexts experienced by older adults (Forrester et al., 2019). For example, individuals from non-majority ethnicities and migration background may be systematically exposed to adverse conditions, living in segregated and disadvantaged neighborhoods or under stressful working conditions, which may prompt the adoption of risky health behaviors that undermine cognitive functioning (Hill et al., 2012). Notably, sex/gender, migration background, and SES are key determinants of disparities in trajectories of cognitive functioning (Walsemann et al., 2022), but few studies have studied their interplay from an intersectional perspective.

Transition to grandparenthood and healthy aging

In addition to overall levels of cognitive functioning, research has increasingly focused on the life course processes and events that may accelerate or delay its decline. One event of major interest is the transition to grandparenthood, due in part to the increasing generational overlap brought about by increasing life expectancy (Taubman – Ben-Ari et al., 2018). The event of becoming a grandparent itself, together with the practices that follow with this new status, can be vital sources of support and social integration. Such a transition can increase social interaction, help maintain positive emotions like sense of purpose, as well as strengthen intergenerational ties (Arpino & Bordone, 2014; Bordone et al., 2023). On the other hand, becoming a grandparent may foster negative self-perceptions such as feeling older, as well as increasing stress levels due to caregiving burdens or reduced resources, which could be directed away to the grandchildren (Bordone et al., 2023; Tanskanen et al., 2019). Likewise, growing residential mobility could diminish the benefits of becoming a grandparent, as grandchildren may live further away (Hank et al., 2018).

While early work investigating the impact of transition to grandparenthood on healthy aging was generally cross-sectional and produced mixed findings (Cunningham-Burley, 1986), recent years have seen the emergence of longitudinal studies in the literature that we contribute to in this paper. Overall, longitudinal studies of the transition to grandparenthood with large-scale European data provide evidence of modest mental health and well-being benefits (Bordone & Arpino, 2019; Di Gessa et al., 2020; Sheppard & Monden, 2019; Tanskanen et al., 2019), and a slightly positive effect on cognitive health (Leimer & van Ewijk, 2022). In line with cross-sectional results (Arpino & Bordone, 2014), these studies suggest heterogenous effects based on social determinants, such as more pronounced benefits for women. Even if several investigations highlighted the importance of social determinants and critical events for late-life cognitive functioning, most of them analyzed social determinants separately rather than in combination

(Cicero et al. (2023) for an exception). This leads to an incomplete understanding of the complex ways in which life-course cumulative exposures may impact cognitive functioning.

Although becoming a grandparent may promote healthy aging in many older adults, how the effects of transitioning to grandparenthood might be shaped by the more complex interplay of multiple social categories has, to our knowledge, not been studied so far. The intersectional nature of cultural background, sex/gender and social class may well place some people at greater risks of marginalization, which could lead to lower health benefits of the grandparent status (Dolbin-MacNab & Few-Demo, 2018). Therefore, considering multiple axes of interaction between social determinants can help us address critical knowledge gaps related to cognitive functioning disparities in older adults (Hale et al., 2022). Since intersectionality has rarely been applied to explore healthy aging in quantitative studies, and as advocated by Hale et al. (2022), an intersectional approach is fundamental to understand heterogeneity in cognitive aging inequalities.

Intersectionality framework

Intersectionality theory emphasizes how multiple social characteristics intersect to create unique social positions with particular exposures to oppression and privilege (Crenshaw, 1990). This framework posits that various interlocking systems of power and privilege influence one another, leading to the perpetuation of structural inequalities that define individuals' experiences within social hierarchies. Intersections of characteristics like sex/gender, race, class and age constitute social positions that relate to social and health inequalities through underlying complex processes, such as systems of oppression and social discrimination (e.g., sexism, racism, ageism). Analyzing how several social determinants interact and act simultaneously to shape health outcomes is crucial to gaining a more nuanced understanding of healthy aging inequalities. Likewise, it is important to understand late life by situating it within the socially constructed nature of the life course, where privileges and resources are unequally distributed (Holman & Walker, 2021). Continuous exposure to social determinants that dynamically interact throughout the life course generate cumulative (dis)advantages and greater disparities in late-life cognition (Crimmins, 2020).

Thus, the social context is required to fully comprehend processes of healthy aging, by considering both accumulation of (dis)advantages over time and through multiple intersecting social determinants. Regarding how social position relates to grandparenthood effects on cognitive functioning, neither studies on grandparental childcare (Ahn & Choi, 2019; Arpino & Bordone, 2014; Sneed & Schulz, 2019; Xu, 2022) nor the only study assessing the transition to grandparenthood (Leimer & van Ewijk, 2022) adopted an intersectional perspective.

The present study: A longitudinal, intersectional study of grandparenthood and cognitive functioning using MAIHDA

Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy (MAIHDA), first proposed by Clare Evans et al. (2018), is an analytical approach with great potential for understanding how multiple dimensions of social inequality influence health outcomes across intersectional strata. Its methodological advantages relate to improved scalability, model parsimony and ability to deal with small subgroup samples (Merlo, 2018). An essential characteristic of MAIHDA is the capability to provide precision-weighted predictions of outcome levels and associations for each intersectional stratum, while alleviating multiple testing problems by 'shrinking' group-specific estimates toward the corresponding means (Bell et al., 2019). To the best of our knowledge, only one study has applied the MAIHDA method to investigate biomarkers of healthy aging, drawing on a cross-sectional sample of older English adults (Holman et al., 2020).

Against this background, the present study applies the MAIHDA method in the context of a longitudinal analysis of cognitive functioning as one key aspect of healthy aging. We aim to integrate an intersectional analysis of inequalities in the level of cognitive functioning with an assessment of how potential effects of becoming a grandparent might vary across intersectional strata. Using data from the Survey of Health, Aging and Retirement in Europe (SHARE), we combine MAIHDA with a multilevel longitudinal framework. We investigate whether intersecting social inequalities explain the variance in late-life cognitive functioning (Aim 1), we measure the influence becoming a grandparent on cognitive functioning (Aim 2), and we examine how the impact of transition to grandparenthood on cognitive functioning varies across intersectional strata (Aim 3).

Methods

Data and Sample

We used data from 19 European countries in regular Waves 1, 2, 4, 5, 6 and 8 of SHARE (Supplementary Table S1). SHARE is the largest European social science panel study, with face-to-face interviews on respondents aged 50 or older and their co-residential partners (Börsch-Supan et al., 2013). We selected individuals aged 50 to 85 years with more than two observations and with adult children but no grandchildren at the first observation, meaning they could become grandparents in follow-up waves. Each individual had a different baseline wave depending on their first observation, with an unbalanced panel data structure. Application of the sample restriction and listwise deletion of 970 (4.86%) incomplete cases yielded a study sample of 19,953 and 62,386 person-years (see Supplementary Figure S1).

Measures

Outcome: cognitive functioning

Cognitive functioning was assessed with four tests: two of memory, one of verbal fluency and one of numeracy. The memory tests measured immediate and delayed recall of 10 words. Verbal fluency was measured by the maximum animals named in one minute. The numeracy test comprised basic arithmetical calculations on everyday life situations. We summarized these tests into a one-dimensional cognitive measurement using Principal Component Analysis (PCA), a common approach for its efficiency in reducing dimensionality without assuming a theoretical model while retaining maximum variance (Mazzonna & Peracchi, 2017). PCA revealed one component with eigenvalue > 1, explaining over 60% of the total variance and with a positive sign for all observed variables (Supplementary Table S2). A Kaiser–Meyer–Olkin (KMO) value of 0.73 confirmed the adequacy of a single index. Higher scores indicated higher levels of cognitive functioning.

Intersectional Strata dimensions

We selected four socio-demographic variables to define intersectional strata, using the PROGRESS-Plus framework to identify social characteristics that create axes of potential (dis)advantages and stratify health outcomes (O'Neill et al., 2014). *Sex/gender* was categorized as women or men, and we use the term sex/gender to encompass the conflation of sex and gender in the survey item. *Migration background* was a binary variable (yes/no) after the question "Were you born in the country of interview?" *Education* was based on ISCED 1997 categories, grouped into low (0-2), medium (3-4) and high (5-6). *Occupation* was the present or latest-held work position, categorized according to ISCO-88: white-collar high-skill (WCHS; ISCO-88 major group 1-3), white-collar low-skill (WCLS; ISCO-88 major group 4-5), blue-collar high-skill (BCHS; ISCO-88 major group 6-7), and blue-collar low-skill (BCLS; ISCO-88 major group 8-9). Given the longitudinal design, we chose four variables that remained unchanged across waves, positioning individuals in the same intersectional strata over time. The combination of all possible categories resulted in 48 unique intersectional strata based on sex/gender (2 categories), migration background (2 categories), education (3 categories) and occupation (4 categories) (Evans et al., 2018).

Grandparenthood

Grandparenthood was the main predictor, captured with a binary variable indicating whether the respondent reported having at least one grandchild at each wave (yes/no). Additionally, we created a variable for the "time relative to transition" (t = 0 at the first wave reporting grandchildren), which took values between t = -4 and t = 4 for grandparents, and values fixed at 0 for all person-years of non-grandparents. We truncated the data at four waves before and after the event because case numbers become quite small beyond these points. The time variable captures (linear) differences in cognitive functioning trajectories of individuals becoming grandparents and those who did not. It controls for some forms of selection into grandparenthood, which might be more likely when (potential) grandparents experience more favorable cognitive aging trajectories and can provide greater support to their children (Di Gessa et al., 2020; Leimer & van Ewijk, 2022). As a sensitivity check, we conducted separate sub-analyses including only individuals who became grandparents. This involved dropping non-grandparents who were included in the main analysis and contributed to the estimation of age profiles in cognitive functioning. We also conducted a sensitivity analysis without the time variable.

Covariates

Because cognitive functioning is curvilinear over the life-course (Hale et al., 2022), we adjusted for mean-centered age and a quadratic age term.

Statistical Analyses

MAIHDA analyses are based on multilevel models where individuals are nested within intersectional strata (Evans et al., 2018). In our case, time-varying observations were placed at level 1, nested within individuals at level 2, nested within intersectional strata at level 3. We used Restricted Maximum Likelihood (REML) estimation to fit linear multilevel models taking the form:

$$Y_{ijk} = \beta_0 + \beta_1 x_{jk} + \beta_2 z_{ijk} + \upsilon_{0k} + \mu_{0jk} + \varepsilon_{0ijk} \quad (1)$$

Level 3: $\upsilon_{0k} \sim N(0, \sigma_\upsilon^2)$

Level 2: $\mu_{0jk} \sim N(0, \sigma_\mu^2)$

Level 1: $\varepsilon_{0ijk} \sim N(0, \sigma_\varepsilon^2)$

where Y_{ijk} is the cognitive functioning of observation i for individual j in intersectional stratum k, β_0 is the intercept, x_{jk} is a transposed vector of stratum-defining individual-level variables, β_1 is the transposed vector of the corresponding parameter values, z_{ijk} is a transposed vector of the observation-level variables including grandparenthood status, and β_2 is the transposed vector of the corresponding parameter values. υ_{0k}, μ_{0jk}, and ε_{0ijk} are stratum-level, individual-level, and observation-level random effects with means of zero and variances σ_υ^2, σ_μ^2, and σ_ε^2. The random effects were assumed to be uncorrelated with the predictors and all other random effects.

We first fitted an unadjusted null model (Model 1) to decompose the variance and calculate the Variance Partition Coefficient (VPC). This measure captured the percentage of the outcome variance that is attributable to differences between intersectional strata (Axelsson Fisk et al., 2018). The stratum-level VPC was calculated as:

$$VPC = \frac{\sigma_{\upsilon}^2}{\sigma_{\upsilon}^2 + \sigma_{\mu}^2 + \sigma_{\varepsilon}^2} \tag{2}$$

We added the stratum-defining variables as main effects in Model 2. To quantify the between-stratum variance attributable to the *additive* main effects, we calculated the Proportional Change in Variance (PCV). A PCV value < 100% indicates that additive effects of strata-defining variables cannot fully explain the stratum-level variation, thus denoting the presence of *multiplicative* interactions (Axelsson Fisk et al., 2018). The PCV was calculated as:

$$PCV = \frac{\sigma_{\upsilon,\ Null\ model}^2 - \sigma_{\upsilon,\ Main\ effects\ model}^2}{\sigma_{\upsilon,\ Null\ model}^2} \tag{3}$$

Model 3 incorporated the grandparenthood indicator and covariates as fixed effects. Stratum-level residuals (υ_{0k}) in Model 3 captured the difference between the stratum-specific means and the value expected based on *additive* effects. We used these residuals to isolate the *multiplicative* effects due to intersectional interactions. Specifically, we obtained so-called best linear unbiased predictions (or empirical Bayes estimates) of the stratum-specific residuals, with 95% confidence intervals based on standard errors obtained with the Stata command *reses*.

Model 3 is a conventional MAIHDA model that explores intersectional effects on the level of cognitive functioning. To explore possible intersectional interactions in the effect of becoming a grandparent, we expanded this model in a stepwise procedure, evaluating the adequacy of including random slopes by comparing the model fit through a likelihood ratio test (LRT), given identical fixed-effects specifications (LaHuis & Ferguson, 2009). First, we fitted Model 4 by adding a stratum-level random slope on the grandparenthood variable (Heisig & Schaeffer, 2019). The aim of this model was to capture possible intersectional variation in the effect of becoming a grandparent on cognitive functioning, after comparing its fit with Model 3. Note that the VPC and PCV no longer retain their straightforward interpretation in the presence of random slopes, hence we did not report them for Model 4 and subsequent specifications (Goldstein et al., 2002).

Model 5 included cross-level interactions of sex/gender, migration background, education and occupation with the transition to grandparenthood, which took the form:

$$Y_{ijk} = \beta_0 + \beta_1 x_{jk} + \beta_2 z_{ijk} + \beta_3 x_{jk} Grand_{ijk} + \upsilon_k + \mu_{jk} + \varepsilon_{0ijk} \quad (4)$$

$$\upsilon_k = \upsilon_{0k} + \upsilon_{1k} Grand_{ijk} \quad (5)$$

$$\mu_{jk} = \mu_{0jk} + \mu_{1jk} Grand_{jk} \quad (6)$$

where notation is equivalent to (1) with the addition of cross-level interactions between $Grand_{ijk}$, the observation-level dummy variable indicating whether the respondent has at least one grandchild, and the vector of respondent-level stratum-defining variables x_{jk} as well as the associated coefficient vector β_3. Stratum-level residuals were composed of a random intercept υ_{0k} and a random slope term $\upsilon_{1k} Grand_{ijk}$, alike individual-level residuals with a random intercept μ_{0jk} and a random slope term $\mu_{1jk} Grand_{jk}$. Similar to Model 3 for intersectional effects on cognitive functioning levels, Model 5 showed the remaining stratum-level random slope variation after adding cross-level interactions as fixed effects. A large remaining slope variance would indicate the importance of interactive intersectional effects for variability in the association between grandparenthood and cognitive functioning. Finally, we compared Model 5 with a simpler Model 6, which omitted the random slope while keeping the cross-level interactions.

All analyses were conducted in Stata 17.0. Statistical significance was based on a two-tailed p-value < 0.05 for regression coefficients and two-sided 95% confidence intervals not including zero for stratum-level residuals. The Stata analytical code file is provided with the Supplementary Materials.

Results

Descriptive Statistics

Table 1 presents descriptive statistics of the study sample by grandparenthood status. Sample sizes of the intersectional strata varied between 16 and 2,536 (Supplementary Tables S4 and S5), with 5 out of the 48 strata (10.42%) having fewer than 25 respondents. The distribution of the strata-defining social determinants was similar between individuals who became grandparents (46.50%) and those who did not (53.50%). Our analysis included a slightly higher proportion of women (52.21%), while 10% of individuals had a migration background. More than 40% achieved medium education, while almost a third were highly educated. Regarding occupation, most respondents reported WCHS (37.60%) or WCLS (32.33%), followed by BCHS (15.14%) and BCLS (14.92%). Individuals who became grandparents were slightly younger at baseline (61.71 years) compared to those who did not (62.07 years). The mean level of cognitive functioning at baseline was very similar for grandparents (27.08) and non-grandparents (26.83).

[INSERT TABLE 1 HERE]

MAIHDA I: Intersectional variation in the level of cognitive functioning

Table 2 displays the results from all MAIHDA models. The VPC in Model 1 indicated that 17.43% of the cognitive functioning variance was attributable to the intersectional strata, revealing a good level of clustering (Axelsson Fisk et al., 2018). This suggested that intersectional strata played a substantial role in explaining cognitive functioning inequalities. When adding the strata-defining variables in Model 2, the VPC decreased to 0.76% and the PCV was 96.39%. Including covariates in Model 3 further reduced the VPC (0.59%) and increased the PCV (97.29%), meaning that 2.71% of variance was unexplained (100% - PCV). Thus, most differences in cognitive functioning across intersectional strata were due to additive effects of sex/gender, migration background, education and occupation.

[INSERT TABLE 2 HERE]

Figure 1 illustrates the heterogeneity in predicted cognitive functioning between intersectional strata, considering both the additive (fixed) effects of the stratum-defining variables and the multiplicative interactive effects captured by the stratum-level residuals. Strata with the highest cognitive functioning comprised individuals with non-migrant background, high education and white-collar occupations, showing a clear social gradient. Conversely, the groups with combinations of migrant background, low education and blue-collar occupations exhibited the lowest cognitive functioning levels.

[INSERT FIGURE 1 HERE]

Figure 2 displays the multiplicative interactive effects separately. Five strata had significantly higher cognitive functioning than expected from the additive main effects (confidence intervals excluding 0), whereas another five strata had significantly lower cognitive functioning than expected. Table 3 contains more detailed information on the residual analysis, displaying the five intersectional strata with highest and lowest interaction effects. We found some intersectional multiplicative effects, but, consistent with the low VPC and high PCV in Model 3, differences between strata were mostly driven by additive effects.

Regarding the transition to grandparenthood, Model 3 revealed that individuals who became grandparents had higher cognitive functioning than those who did not become grandparents (coefficient = 0.94, $p < 0.01$). These differences were averaged over all intersectional strata, and consistently present in longitudinal Models 4-6 (coefficients ranging from 0.94 to 0.91, $p < 0.01$, see Supplementary Table S6). The sensitivity analysis including only grandparents confirmed that higher levels of cognitive functioning were primarily due to the transition itself (Supplementary Table S7). The sensitivity analysis excluding the variable “time relative to transition” resulted in a worse model fit than when it was included. In this specification the grandparenthood effect increased in size (coefficients ranging from 1.43 to 1.35, $p < 0.01$), because the more favorable cognitive aging trajectory of eventual grandparents was no longer modeled. Findings concerning the additive interactions between grandparenthood and the stratum-defining variables as well as intersectional stratum-level variation in the grandparenthood effect were qualitatively similar to the main analysis (full results are available upon request).

[INSERT FIGURE 2 HERE]

[INSERT TABLE 3 HERE]

MAIHDA II: Intersectional variation in the effect of grandparenthood on cognitive functioning trajectories

The longitudinal MAIHDA in Table 2 displays the connection in the analysis between intersectional inequalities, transition to grandparenthood and cognitive functioning. A significant LRT (χ^2 = 148.8; p = 0.01) confirmed the better fit of Model 4 compared to Model 3, hence allowing the slope of transition to grandparenthood to vary across strata. Model 5 revealed some remaining random slope variance after adding cross-level interactions, suggesting that the impact of transitioning to grandparenthood on cognitive functioning trajectories varied moderately across intersectional strata. The interaction between transition to grandparenthood and sex/gender was significant (0.18, p = 0.03), indicating multiplicatively positive effects on cognitive functioning for women. The comparison between Model 5 and Model 6 (Supplementary Table S6) resulted in a better fit of the latter, with a non-significant LRT ($\chi2$ = 3.81; p = 0.15). Hence, we cannot reject the null hypothesis of no (further) stratum-level variation in the transition to grandparenthood slope after incorporating additive interactive effects (i.e., interactions between the stratum-defining variables and grandparenthood) in the fixed part of the model.

Discussion

Our aim was to investigate how intersectional social positions and the transition to grandparenthood impact late-life cognitive functioning in a European population. Using SHARE longitudinal data, we applied MAIHDA to explore heterogeneities in social determinants of cognitive functioning with an intersectional lens. Moreover, we expanded this methodology in a longitudinal manner to capture changes in cognitive functioning trajectories after the transition to grandparenthood. We found cognitive functioning differences across social positions measured at the intersection of sex/gender, migration background, education and occupation. Most differences were explained by additive rather than multiplicative effects, hence finding only modest intersectional interaction effects. The transition to grandparenthood was associated with higher levels of cognitive functioning. We found some intersectional effects in the association between transition to grandparenthood and cognitive functioning. Results suggested that women becoming grandmothers had larger cognitive functioning benefits than men or women who did not become grandmothers. While becoming a grandparent is an important transition associated with healthy aging, the role of social position in shaping cognitive functioning and health inequalities cannot be overlooked.

There were substantial inequalities in cognitive functioning across intersectional strata, with a clear social gradient. Respondents at the intersections of migration background, low education and blue-collar occupations exhibited lower cognitive functioning. These results are aligned with the scarce literature on intersectionality of cognitive inequalities, which highlights that late-life cognitive decline is particularly concerning for populations experiencing multiple forms of social inequalities (Hale et al., 2022; Walsemann et al., 2022). We found limited indications of multiplicative effects. Nevertheless, the pattern of cognitive inequalities across social positions reflects the consequences of continuous exposure to interlocked systems of power and oppression (Bauer, 2014). This should be seen as a step further in characterizing the heterogeneities created by systemic social processes (i.e., individuals with migrant background and blue-collar occupations suffering interlaced racism and classism, which may result in minor health benefits of grandparenthood), emphasizing the importance of exploring intersectional mechanisms to gain a more nuanced understanding of disparities in healthy aging.

Our results suggested that becoming a grandparent may contribute to successful aging by increasing cognitive functioning or delaying its decline. This broadens previous work that showed cognitive benefits associated with grandparenting (Ahn & Choi, 2019; Arpino & Bordone, 2014; Bordone & Arpino, 2019; Sneed & Schulz, 2019; Xu, 2022) or becoming a grandparent (Leimer & van Ewijk, 2022), especially for women. Grandparenthood often fosters social and emotional connections with younger generations and stronger intergenerational ties, which may benefit cognitive functioning (Krzeczkowska et al., 2021). Our findings support the cognitive enrichment theory (Hertzog et al., 2008), suggesting that the role and feelings gained from intergenerational ties promote intellectual stimulation, maintaining cognitive functioning or preventing its decline.

The effect of becoming a grandparent on cognitive functioning trajectories varied across intersectional strata with significant random slopes (comparison between Models 3-4), indicating that these strata explained some variance in the impact of becoming a grandparent on cognitive functioning. We found that the transition to grandparenthood was particularly beneficial for women. As argued by Sheppard and Monden (2019) and Di Gessa et al. (2020), these sex/gender differences are aligned with the kin-keeper argument, since women traditionally devote more time and effort in maintaining intergenerational relationships. While women typically provide more grandchild care and this may entail cognitive functioning benefits (Arpino & Bordone, 2014), the adoption of the role itself similarly contributes by strengthening grandmothers' binding positions within intergenerational ties (Sieber, 1974).

MAIHDA is proving to be a useful tool to map health inequalities resulting from underlying systems of oppression and privilege, facilitating the design of precise public health actions for groups at greater risks of marginalization. However, there is an ongoing debate about the inference of level-2 empirical Bayes residuals as significant interactions in multilevel models, due to the increased chance of erroneously detecting interactions with multiple testing; some scholars advocate to inflate the confidence intervals with corrections such as Bonferroni (Afshartous & Wolf, 2007); others argue that multilevel models address this problem with the automatic shrinkage from residual estimates (Bell et al., 2019; Jones et al., 2016). Gelman et al. (2012) demonstrated that shrinkage may be more efficient as it leads to more appropriate conservative comparisons without reducing the power to detect true differences. While acknowledging this ambiguity, we opted to rely on the shrinkage to estimate stratum-level residuals. Since our results show low stratum-level variation after adding the main effects, we plausibly are in a high shrinkage and therefore conservative inference setting (Bell et al., 2019).

This study has several strengths. The sample was based on data from a large, multi-national longitudinal survey. We adopted an application of quantitative intersectionality by mapping cognitive functioning inequalities across intersectional strata, which, to our knowledge, had not been yet investigated. Further, we analyzed longitudinal associations between the transition to grandparenthood and cognitive functioning, finding remarkable benefits of intergenerational ties for healthy aging. Additionally, we extended MAIHDA with a longitudinal application, an important step for future research on intersectional trajectories.

Limitations and Future Directions

Various limitations must be considered. First, SHARE does not survey the exact date of grandchild birth, so we assumed that people reporting grandchildren had become grandparents between waves. Additionally, we omitted potential mediators such as physical distance to grandchildren or contact frequency, since such data was only available for a small part of our sample. Although these factors probably have a stronger impact on cognitive functioning than the event of transitioning itself, their inclusion would possibly overspecify the model (Bordone et al., 2023). Second, we used an unbalanced longitudinal sample with most observations pooled around the transition. While a balanced longitudinal dataset would facilitate control of outcome trajectories, we prioritized a larger sample size. Third, our sample could be subject to selective panel attrition since older adults with higher cognitive functioning are more likely to participate in follow-up waves. Fourth, we used listwise deletion due to its simplicity and a low rate of incomplete cases (4.86%). While alternative missing data approaches such as multiple imputation might have some potential to improve upon our analysis, their implementation would involve significant practical challenges given the complex nature of our analysis. Nevertheless, we acknowledge that potential biases due non-random missingness cannot be ruled out. Fifth, we only examined short-term effects of grandchild birth on cognitive functioning. The age of grandchildren shapes the nature of relationships and interactions. However, as cognitive functioning benefits were based on the recency of the transition, the effect may differ as grandchildren as age. Relatedly, we assumed linear trends in the time relative to transition. While this simplifying assumption was important in order to contain the methodological complexity of our intersectional analysis, future studies may want to explore more flexible specifications allowing for different (and possibly non-linear) trends before and after the transition to grandparenthood.

Our study makes an important contribution by indicating the importance of adopting an intersectional lens to understand later life and cumulative (dis)advantages of increasingly heterogeneous societies. We provide evidence about the preventive advantages of intergenerational relationships on the healthy aging of grandparents. Based on our findings, future research should investigate more thoroughly the contextual factors influencing the impact of the transition to grandparenthood on cognitive functioning, including effect modifiers or moderators such as age of becoming a grandparent.

Conclusion

Our results revealed substantial cognitive functioning differences across intersectional social positions. These differences were mostly due to additive effects, underlining the important role of social determinants for trajectories of cognitive functioning across the life course. Further, we found evidence that the transition to grandparenthood is positively associated with late-life cognitive functioning. As societies grow older and more people become grandparents, this is paramount for understanding the process of healthy aging. Fostering intergenerational exchange while considering social determinants and intersectionality holds potential as a strategy for preserving late-life cognitive functioning.

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Conflict of Interest

None declared.

Author Contributions

E.A.P., P.G. and J.L.OS. planned the study. E.A.P. and J.L.OS. reviewed the existing literature. E.A.P., J.P.H., P.G. and J.L.OS. designed the methodology. E.A.P. carried out the analyses and was the main contributor in writing the manuscript with substantial input of all authors. E.A.P., J.P.H. and J.L.OS. were involved in interpreting the findings. J.L.OS. supervised the study, M.K. and P.G. were senior advisors. All authors have read and approved the final version.

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Tables

Table 1. Descriptive sample statistics at *t* = -1 for grandparents and all person-years for non-grandparents, N = 19,953.

Variables	Transition to grandparenthood (*n* = 9,279)	No transition to grandparenthood (*n* = 10,674)	Total (*N* = 19,953)
	%	%	N
Dimensions of social position			
Sex/gender			
Men	46.70	48.73	9,535
Women	53.30	51.27	10,418
Migration background			
No migration background	89.98	89.03	17,853
Migration background	10.02	10.97	2,100
Education			
High	29.25	33.02	6,238
Medium	42.80	40.33	8,276
Low	27.95	26.65	5,438
Occupation			
White-collar high-skill (WCHS)	38.01	37.24	7,503
White-collar low-skill (WCLS)	32.77	31.95	6,451
Blue-collar high-skill (BCHS)	14.67	15.56	3,022
Blue-collar low-skill (BCLS)	14.55	15.25	2,978
Covariates			
Age, M (SD)	61.71 (7.10)	61.24 (6.52)	61.52 (6.84)
Outcome			
Cognitive functioning overall level, M (SD)	27.08 (7.50)	26.85 (7.62)	26.97 (7.60)

Note: t = time; M = mean; SD = standard deviation. Unweighted estimates.

Table 2. Results from MAIHDA intersectional models for level of cognitive functioning.

	Model 1 (Null)	Model 2 (Main effects)	Model 3 (Adjusted)	Model 4 (Random Slopes)	Model 5 (Interactions)
Variable	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Fixed Effects					
Intercept	25.34 (24.41, 26.25)	29.75 (29.18, 30.32)	30.24 (29.73, 30.75)	30.28 (29.80, 30.76)	30.27 (29.80, 30.75)
Intersectional strata					
Men		Ref.	Ref.	Ref.	Ref.
Women		1.30* (0.86, 1.74)	1.21* (0.82, 1.61)	1.17* (0.8, 1.55)	1.17* (0.80, 1.54)
No migration background		Ref.	Ref.	Ref.	Ref.
Migration background		-2.12* (-2.59, -1.66)	-2.08* (-2.50, -1.66)	-2.09* (-2.5, -1.68)	-2.10* (-2.51, -1.69)
High education		Ref.	Ref.	Ref.	Ref.
Medium education		-2.07* (-2.62, -1.53)	-2.04* (-2.53, -1.55)	-2.07* (-2.53, -1.6)	-2.07* (-2.53, -1.62)
Low education		-6.16* (-6.73, -5.59)	-5.89* (-6.40, -5.37)	-5.94* (-6.43, -5.45)	-5.94* (-6.42, -5.45)
White-collar high skill		Ref.	Ref.	Ref.	Ref.
White-collar low-skill		-0.41 (-0.99, 0.18)	-0.48 (-1.00, 0.04)	-0.46 (-0.95, 0.03)	-0.45 (-0.93, 0.04)
Blue-collar high-skill		-1.64* (-2.27, -1.01)	-1.68* (-2.25, -1.11)	-1.67* (-2.21, -1.12)	-1.66* (-2.19, -1.12)
Blue-collar low-skill		-3.08* (-3.72, -2.44)	-3.15* (-3.72, -2.57)	-3.09* (-3.64, -2.54)	-3.07* (-3.61, -2.53)
Covariates					
Age			-0.07* (-0.08, -0.06)	-0.07* (-0.08, -0.06)	-0.07* (-0.08, -0.06)
Age quadratic			-0.01* (-0.01, -0.01)	-0.01* (-0.01, -0.01)	-0.01* (-0.01, -0.01)
Time relative to first grandparenthood			0.50* (0.44, 0.55)	0.50* (0.45, 0.55)	0.50* (0.45, 0.55)
Not Grandparent			Ref.	Ref.	Ref.
Grandparent			0.94* (0.82, 1.07)	0.94* (0.81, 1.08)	0.91* (0.79, 1.03)
Interactions					
Grandparent*Female					0.18* (0.03, 0.33)
Grandparent*Migration					0.14 (-0.25, 0.54)
Grandparent*Med. education					0.11 (-0.20, 0.42)
Grandparent*Low education					0.23 (-0.12, 0.59)
Grandparent*WCLS					-0.11 (-0.43, 0.21)
Grandparent*BCHS					-0.09 (-0.48, 0.30)

Grandparent*BCLS					-0.27 (-0.67, 0.14)
Random Effects					
Between stratum variance	10.046 (6.614, 15.260)	0.362 (0.165, 0.797)	0.272 (0.116, 0.635)	0.233 (0.094, 0.037)	0.224 (0.091, 0.560)
Strata-level grandparenthood slope				0.107 (0.002, 0.197)	0.076 (0.001, 0.149)
VPC (%)	17.43%	0.76%	0.59%	-	-
PCV (%)	-	96.40%	97.29%	-	-

Notes: CI=Confidence Interval; WCHS=white-collar high-skill; WCLS=white-collar low-skill; BCHS=blue-collar high-skill; BCLS=blue-collar low-skill; VPC=Variance Partition Coefficient; PCV=Proportional Change in Variance. Models 3-5 control for country dummies.

*p < .05.

Table 3. Five intersectional strata with the highest and lowest residuals (intersectional interaction effects) in Model 3, with 95% confidence intervals.

	Sex/Gender		Migration Background		Education			Occupation				
Stratum	M	W	No	Yes	Hi	Me	Lo	WCHS	WCLS	BCHS	BCLS	Intersectional interaction effects (95% CI)
	Five Strata with the most positive (protective) Interaction Effects											
2113		X	X		X					X		**0.93 (0.24, 1.62)**
2222		X		X		X			X			**0.61 (0.13, 1.09)**
2122		X	X			X			X			**0.47 (0.21, 0.73)**
2221		X		X		X		X				0.44 (-0.15, 1.03)
1334	X			X			X				X	**0.43 (0.14, 0.73)**
	Five Strata with the most negative (hazardous) Interaction Effects											
1134	X		X				X				X	**-0.51 (-0.90, -0.12)**
1132	X		X				X		X			**-0.58 (-0.96, -0.20)**
2134		X	X				X				X	**-0.68 (-1.22, -0.14)**
1214	X			X	X						X	-0.88 (-1.85, 0.10)
2133		X					X			X		**-1.36 (-2.02, -0.70)**

Notes: M: Men; W: Women; Hi: High; Me: Medium; Lo: Low; WCHS: white-collar high-skill; WCLS: white-collar low-skill; BCHS: blue-collar high-skill; BCLS: blue-collar low-skill; CI: Confidence Interval. Each stratum is labelled with a four-digit code corresponding to the social strata dimensions in the following order: Sex/gender: 1= Men, 2 = Women; Migration Background: 1 = No, 2 = Yes; Education: 1 = High, 2 = Medium, 3 = Low; Occupation: 1 = white-collar high-skill, 2 = white-collar low-skill, 3 = blue-collar high-skill, 4 = blue-collar low-skill.

Figures

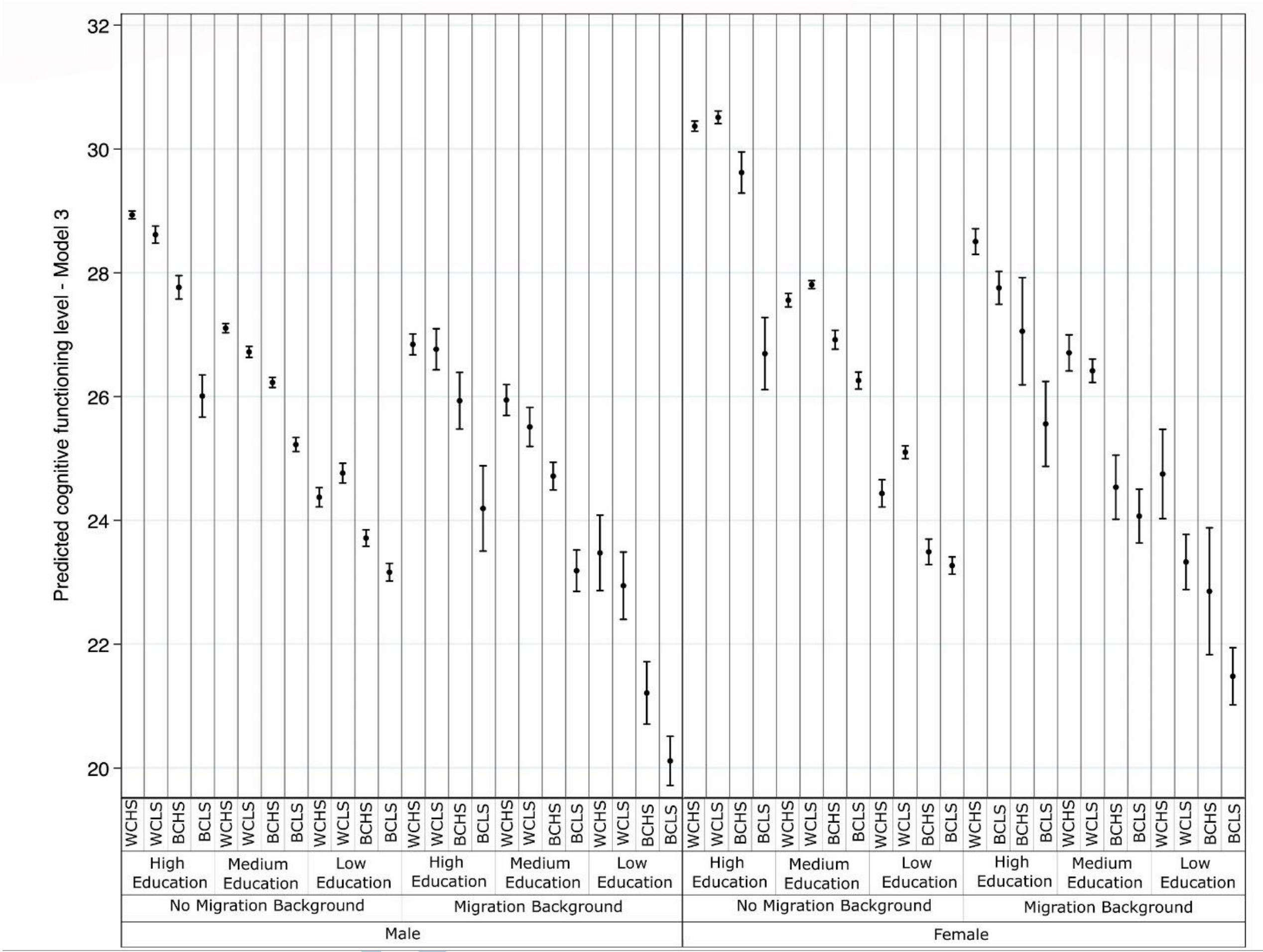
Figure 1. Predicted cognitive functioning level with 95% confidence intervals, by intersectional strata (Model 3). Higher scores indicated higher levels of cognitive functioning. WCHS: white-collar high-skill; WCLS: white-collar low-skill; BCHS: blue-collar high-skill; BCLS: blue-collar low-skill.

Alt Text: Plot where each of the 48 strata are represented in the X-axis, with their corresponding predicted cognitive functioning level in the Y-axis.

Figure 2. Stratum level residuals with 95% confidence intervals from Model 3. Intersectional strata are presented in ascendant ranking of their residual values.

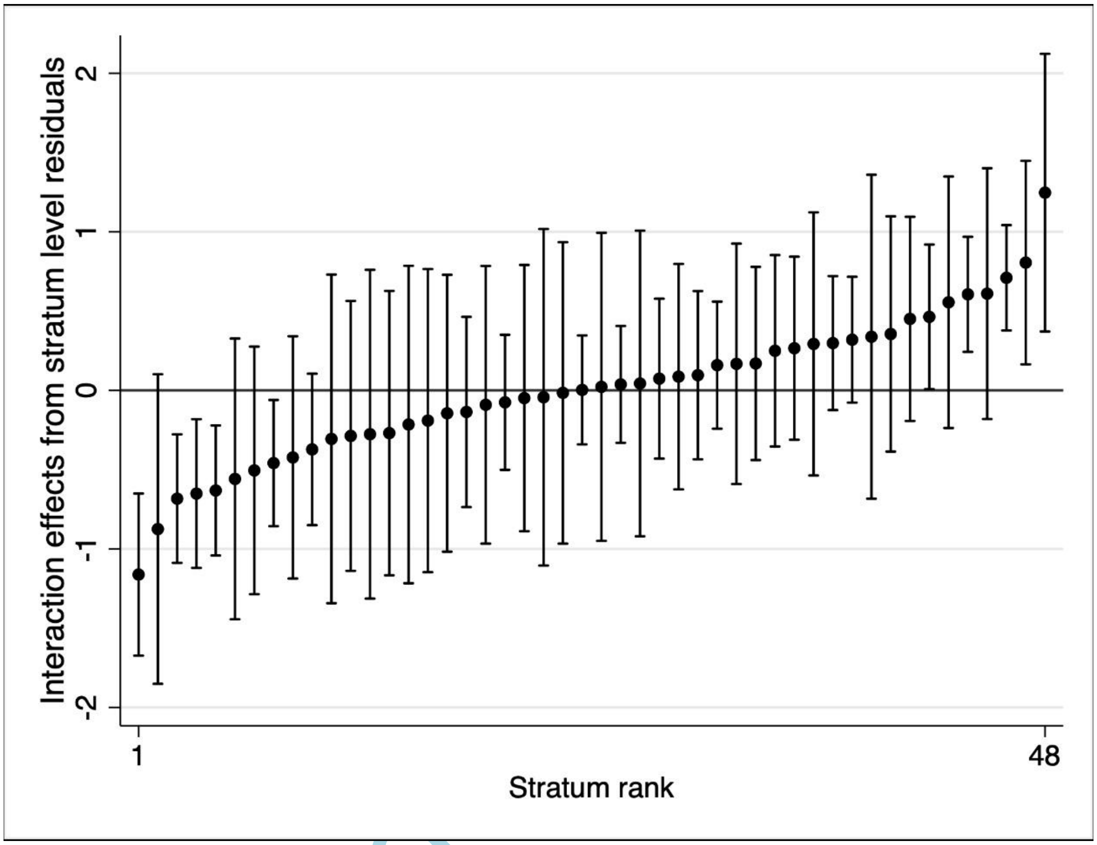
Alt Text: Horizontal caterpillar plot of the strata-level residuals for each stratum, ranked from smallest to largest in the X-axis. The Y-axis corresponds to the calculated residuals and includes a horizontal line representing the 0.

Figure 1



Predicted cognitive functioning level - Model 3
32
30
28
26
24
22
20
WCHS
WCLS
BCHS
BCLS
High Education
Medium Education
Low Education
No Migration Background
Migration Background
Male
Female

Figure 2



Interaction effects from stratum level residuals
2
1
0
-1
-2
1
48
Stratum rank