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Religiosity does not prevent cognitive declines: Cross-sectional and longitudinal evidence from the Survey of Health, Aging and Retirement in Europe

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ABSTRACT

Over the past hundred years, a plethora of studies on intelligence and religiosity associations predominantly yielded evidence for a meaningful negative relation between these two variables. However, effect strengths varied substantially between primary studies and it has been suggested that religiosity and intelligence associations change as people age, because religiosity may play a protective role for cognitive abilities in elderly individuals. Consequently, it has been suggested that negative intelligence and religiosity associations may decline in strength or even reverse signs as people age. Therefore, we examine here cross-sectional associations of self-reported religious behaviors and several measures of cognitive function (numeracy, verbal fluency, memory and a proxy of psychometric *g*) as well as their cross-temporal changes in respondents from 11 European countries and Israel aged 50+ years ($N = 30{,}424$) in three waves of the Survey of Health, Aging, and Retirement in Europe (SHARE). As expected, cognitive function scores were meaningfully negatively related to praying whilst associations with participation in religious services were trivial. Cross-lagged panel analyses yielded consistently negative, albeit small, effects of both intelligence on praying and of praying on intelligence. Multilevel random-intercept regressions showed tentative evidence for faster cognitive declines in more religious people for numeracy and *g*, but not for verbal fluency and memory. No conclusive evidence for a moderation by societal values of religiosity could be found. In all, our evidence shows a negative, non-trivial association between intelligence and religiosity in elderly participants which remains longitudinally robust. These findings corroborate the generality of the small negative intelligence and religiosity association.

1. Introduction

Associations of intelligence and religiosity have been a subject of research for almost a century by now. So far, a predominant part of studies indicated a negative correlation between cognitive abilities and religious beliefs as well as – to a somewhat lesser extent – behaviors. Meta-analytical examinations of this association have repeatedly demonstrated a remarkably robust negative link (e.g., Zuckerman, Li, Lin, & Hall, 2020; Zuckerman, Silberman, & Hall, 2013) that generalizes in terms of its direction across moderating variables and analytical approaches (Dürlinger & Pietschnig, 2022).

Although the negative intelligence and religiosity link appears to be remarkably robust, the strength of this association seems to be substantially differentiated according to moderators. For instance, associations with intelligence are less pronounced in studies assessing religious behaviors like going to church in contrast to those directly assessing religious beliefs. This is likely due to religious behaviors such as attendance, defined as someone's personal attendance at a religious event or institution, constituting a weaker indicator for the actual beliefs of a person than self-reported beliefs, because behaviors might be motivated extrinsically by social involvement or other factors (Allport & Ross, 1967).

Although the typically correlative nature of intelligence and religiosity association studies does not allow drawing causal inferences, some researchers have argued that religiosity can have an impact on intelligence. For instance, sectarian affiliations and fundamental beliefs in the inerrancy of the bible were found to limit the development of verbal abilities (Sherkat, 2010). To date, most empirical accounts, however, support the interpretation that intelligence affects religious beliefs because intelligence can be measured reliably at an earlier age than

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religiosity (Kanazawa, 2010) and remains stable in adulthood (Larsen, Hartmann, & Nyborg, 2008) in contrast to religious involvement, which is more malleable (O'Connor, Hoge, & Alexander, 2002). This observation suggests a higher predictive value of intelligence compared to religiosity. Developmentally later consolidations of religious worldviews within individuals compared to intelligence may also contribute to explaining varying strengths of the intelligence and religiosity link over different sample types. Observations of stronger associations in samples from the general population and college compared to precollege samples support this idea (e.g., Dürlinger & Pietschnig, 2022).

So far, the intelligence and religiosity link has been predominantly examined in comparatively young samples. Because both religiosity (Bengston, Silverstein, Putney, & Harris, 2015) and cognitive abilities (Harada, Natelson Love, & Triebel, 2013) are prone to change in an older age, it seems plausible that intelligence and religiosity associations in these age groups may change as well.

In the past years, a growing body of research concerning the relationship of religious involvement (participation in or adherence to beliefs or practices of an organized religion) and cognitive declines emerged. There is some support for religiosity acting as a protective factor against cognitive declines (e.g., Hill, Burdette, Angel, & Angel, 2006) which seems paradoxical in the light of the well-established negative link of the two variables (Ritchie, Gow, & Deary, 2014). Thus, despite intelligence having a negative impact on religiosity, religiosity might benefit cognitive functioning in an older age.

Understanding which aspects of religiosity, if any, may have the potential to prevent or at least slow down cognitive declines is a matter of public concern and is growing in relevance with increasing life expectancies in most societies. While the number of people suffering from dementia (i.e., which can be seen as the ultimate result of declining cognitive abilities) globally was estimated to be about 46.8 million in 2015, this number is expected to reach 74.7 million in 2030 and 131.5 million in 2050. In other words, the number of dementia cases will almost double every 20 years (Prince et al., 2015). Dementia and other forms of cognitive impairment are the biggest drivers of disability in elderly people and consequently affect the number of people in need for care (Sousa et al., 2009). Even when leaving the suffering of individuals that are directly and indirectly affected by such conditions aside (e.g., caregivers, relatives), such disease patterns have a substantial economic impact due to the resource-intensive care that is required and which warrants an associated infrastructure, qualified personnel, and funds. In Europe, for instance, it is estimated that dementia-related costs will surpass 250 billion Euros (~257 billion USD) by the year 2030 (Wimo, Jönsson, Bond, Prince, & Winblad, 2013). Protective effects of religious attendance against cognitive declines have been shown in Mexican-American (Hill et al., 2006; Reyes-Ortiz et al., 2008), Taiwanese (Yeager et al., 2006), Korean (Choi, Park, Cho, Chun, & Park, 2016), and US-American samples (Corsentino, Collins, Sachs-Ericsson, & Blazer, 2009; Van Ness & Kasl, 2003). In a narrative review about the effect of religion and spirituality on cognitive function, 82% of the included studies reported positive associations (Hosseini, Chaurasia, & Oremus, 2019).

Conceptually, the underlying protective mechanism could be attributed to an activating role of religion. Religious attendance might lead to an increase of activities which are likely to stimulate cognitive functions, such as praying, singing, studying scriptural texts, or mere general socializing (Hill, 2008). A lifestyle characterized by such (social) engagements has been shown to be conducive to healthy cognitive aging (e.g., Newson & Kemps, 2005; Zunzunegui, Alvarado, Del Ser, & Otero, 2003).

Moreover, religiosity promotes behaviors that may protect against cognitive declines. For instance, abuse of alcohol or other substances has been shown to be less prevalent in religious people (Allport & Ross, 1967; McCullough & Willoughby, 2009), who also tend to smoke less cigarettes (Koenig et al., 1998), and report greater use of preventive healthcare services (Benjamin & Brown, 2004) compared to less religious individuals. Moreover, there is some evidence suggesting that religious people tend to live significantly longer than their non-religious peers (e.g., McCullough, Hoyt, Larson, Koenig, & Thoresen, 2000; Powell, Shahabi, & Thoresen, 2003).

Candidate causes that conceivably may explain the beneficial effects of religiosity for health have been extensively discussed in the literature (Idler et al., 2003). For instance, religiosity may help in reducing stress, anxiety, or feelings of depression and is generally associated with a greater sense of hope, meaning, and purpose in life. This, in turn, could lower the risk for hippocampal atrophy (Koenig, 2012). Furthermore, religious involvement might even have a direct stimulating effect on higher cortical functions which are associated with abstract thinking by causing to reflect on philosophical topics and consequently boost the cognitive reserve (Koenig, 2012).

Some recent findings contrast these results by showing a negative relation of religiosity and cognitive functioning in later life (Hill, Carr, Burdette, & Dowd-Arrow, 2020). By controlling for other, more secular forms of social engagement and by assessing the effects of religious involvement as a cumulative life-course exposure on cognitive functions, protective effects of religiosity have been called into question. For instance, elderly participants who attended religious services more often than others over their life-span exhibited poorer working-memory and mental status (Hill et al., 2020). Moreover, in female participants religious attendance was linked negatively to global cognitive functions (Das, 2022).

In the neural resource depletion model, faster cognitive declines in religious people have been hypothesized (Hill et al., 2020). According to this line of argumentation, people who have been religious for a major part of their life tend to experience less cognitive stimulation. This can be attributed to a preference for an intuitive cognitive style in contrast to a more cognitively demanding analytic style (Gervais & Norenzayan, 2012; Pennycook, Ross, Koehler, & Fugelsang, 2016; see Shenav, Rand, & Greene, 2012, for empirical evidence of differences in cognitive demands between intuitive and analytic styles).

In a UK-based sample, no effects on cognitive aging of religious beliefs or involvement were observed (Ritchie et al., 2014). This has been attributed to generally lower importance of religion in the United Kingdom compared to other countries where contrasting findings were observed, such as the US (Norris & Inglehart, 2004). If more people engage in religious activities in a given environment, religious gatherings, events, and memberships may be expected to become more stimulating to the individual. This may mean that religiosity has smaller beneficial effects on health in more secularized countries compared to societies with a larger impact of religion on everyday life.

Here, we aim at examining potential beneficial effects of religiosity on cognitive aging based on large-scale panel data across a substantial number of mostly European countries. International comparisons allow for evaluating the impact of societal values towards religiosity within countries.

1.1. Hypotheses

First, we hypothesized that better performance in numeracy, verbal fluency, and memory tasks, as well as a composite value of these three (i.e., akin to psychometric *g*) will be negatively associated with praying and participation in religious services in cross-sectional assessments.

Second, we hypothesized protective influences of religiosity on cognitive abilities in older ages. Therefore, we expected a decreasing strength of the negative intelligence and religiosity association over time, as participants age. This decreasing strength of intelligence and religiosity correlations could indicate a protective effect of religiosity on cognitive declines. However, it cannot be ruled out that this may be a consequence of systematic attrition and therefore decreased variance. Due to the virtually ubiquitously documented negative relationship between religiosity and intelligence, we did not expect to observe a change in sign but a significant decrease of the strength of the observed

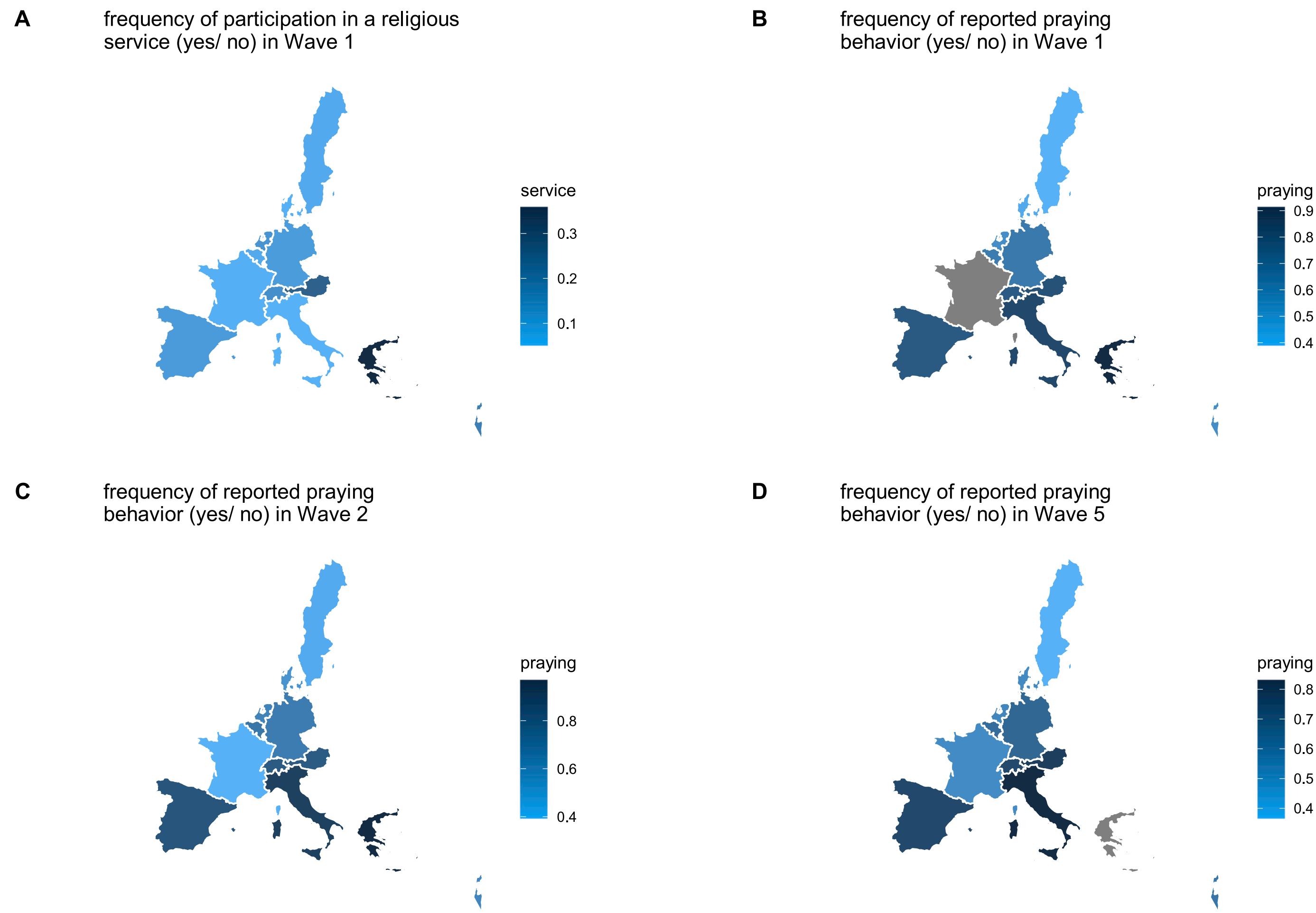

Fig. 1. Heatmaps depicting frequency of participation in religious services (A), as well as praying behaviors (yes/no) in Wave 1 (B), Wave 2 (C) and Wave 5 (D). Colors correspond to the percentage of participants who reported to have taken part in a religious service or to have prayed in the past month relative to population size.

correlation as participants age.

1.2. *The present study*

Here, we examine the associations of different religiosity assessments and measures of cognitive abilities in a large panel survey of European and Israeli citizens in retirement age. We assess different potential causal pathways between intelligence and religiosity. We do so because we consider intelligence to be a potential predictor of religious beliefs, but also take possible effects of religiosity on intelligence into account. Longitudinal data allow us to assess cross-temporal within-individuals changes in the strengths and directions of these associations.

Consequently, we examine (i) whether there are associations between intelligence and religiosity and if so, how strong they are, (ii) what inferences can be drawn about possible causal pathways, and (iii) if correlations between religiosity and intelligence change over time.

The study protocol including our hypotheses and planned confirmatory analyses have been preregistered prior to all data analyses at https://osf.io/ku3mg (see Supplement S1 at https://osf.io/2h6j4tt for deviations from the preregistered protocol).

2. Methods

2.1. *Sample*

We tested our hypotheses using data from the Survey of Health, Aging and Retirement in Europe (SHARE). By including information of individuals aged 50 years or older from 28 European nations and Israel, it represents the largest European social science panel study to date. Due to an excess of missing values in the remaining waves (see below), data were extracted from only 3 Waves (1, 2, and 5) covering a timespan of 10 years (2004, 2007, and 2013). Only persons that had at the very minimum participated in Wave 1 were included in our analyses. Participants of Wave 1 ($N = 30{,}424$) averaged 63.87 years ($SD = 10.58$) and were almost balanced regarding sex (16,906 women; 56%; for demographic information of the remaining Waves see Supplement S2 https://osf.io/mg4sr). Respondents in our data resided in 11 European countries: Austria: 1563 (5%), Germany: 2995 (10%), Sweden: 3049 (10%), Netherlands: 2968 (10%), Spain: 2316 (8%), Italy: 2552 (8%), France: 3122 (10%), Denmark: 1706 (6%), Greece: 2897 (9%), Switzerland: 997 (3%), Belgium: 3810 (13%) and Israel: 2449 (8%). Across the three waves, we observed a total of 64,139 data points.

3. Measures

3.1. *Cognitive abilities assessments*

The SHARE data set provides measurements of cognitive functioning which can be used as a proxy for intelligence. Here, we use values of the three assessments numeracy, verbal fluency, and memory.

In the numeracy task, the ability to perform basic numerical operations is assessed by means of four items. Participants were asked to (1) calculate 10% of a certain number; (2) find half of a number; (3) compute a number based on two thirds of its value; (4) successively add

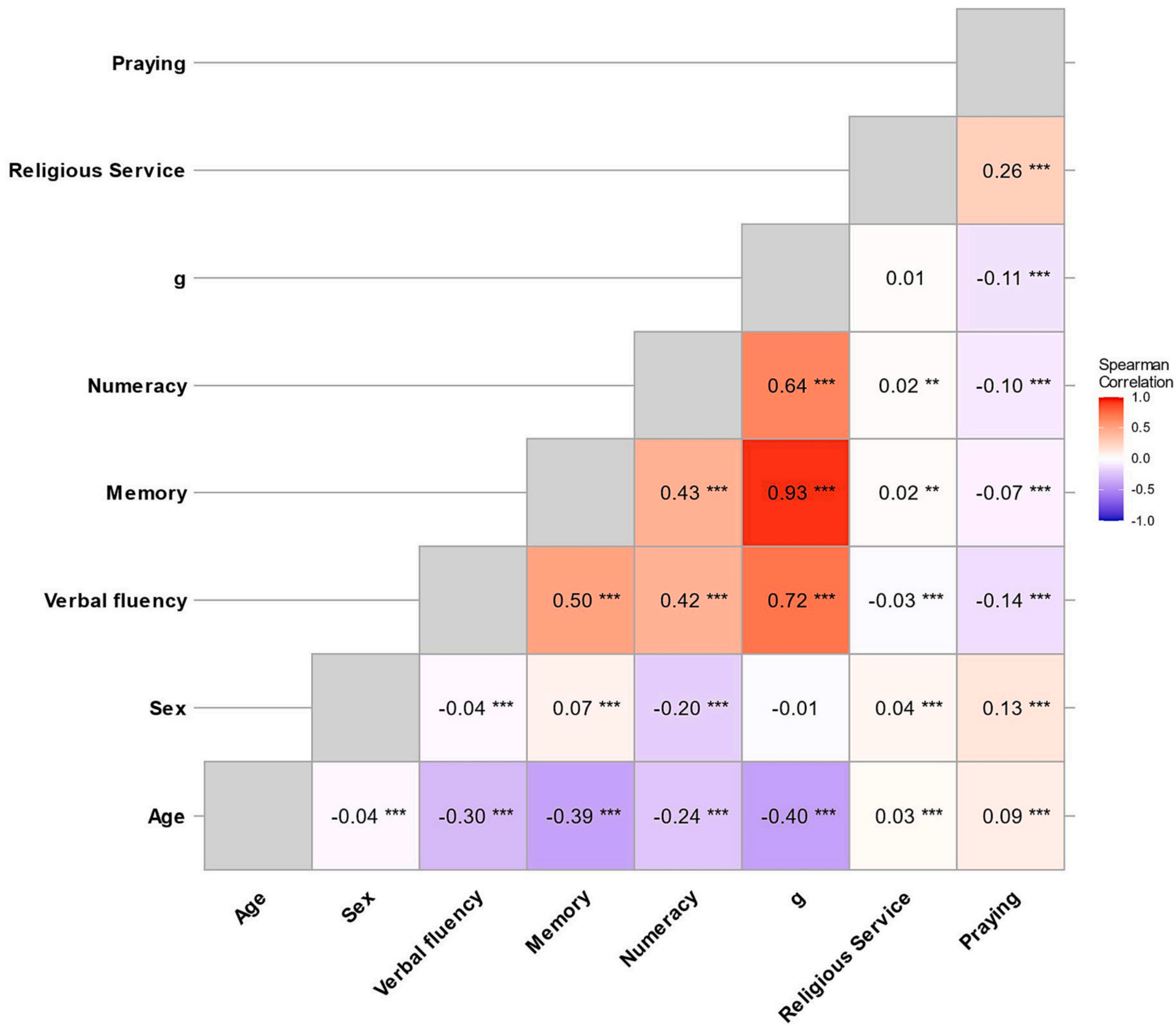

Fig. 2. Correlation heatmap of associations among indicators of intelligence and religiosity and subject-level characteristics. Praying as dichotomous variable (yes/no); Religious Service = participation in a religious service in the past month.

Table 1
Standardized mean differences between complete vs. incomplete data.

Domain	Age	Praying			Numeracy		Verbal fluency			Memory		*g*-factor	
Wave		1	2	3	1	2	1	2	3	1	2	1	3
Complete vs. incomplete data	0.28	−0.06	−0.10	−0.00	−0.18	−0.19	−0.34	−0.38	−0.15	−0.27	−0.29	−0.31	−0.33

Note. Cohen's *d* for mean differences in numeracy, verbal fluency, memory, and *g*-factor depending on the missing data group 0 = complete data, 1 = incomplete data.

10% of its own value twice to a certain number. We calculated an indicator for numeracy, which ranges from one to five (see Dewey & Prince, 2005). Higher values indicate better performance. Due to strong associations of mathematical reasoning and fluid intelligence (e.g., Green, Bunge, Chiongbian, Barrow, & Ferrer, 2017) the numeracy task performance can be expected to exhibit the strongest *g*-loadings.

In the fluency task, participants were asked to name as many animals as they could in exactly one minute. The number of different animals that were named was used as a measure of verbal fluency. Executive functions such as verbal fluency (Aita et al., 2018) have been suggested to be based on similar processes as general intelligence (Barbey et al., 2012).

In the memory task, participants were given a list of 10 words, and were immediately afterwards asked to recall any words they remembered. The number of words recalled equals the resulting score, ranging from 0 to 10. Moreover, delayed recall is assessed by asking participants to recall any of these words after some time had elapsed in which they had completed distractor tasks (i.e., the numeracy and verbal fluency tasks). We averaged both indicator scores (i.e., immediate and delayed recall) for all analyses into one single indicator of memory (except for our principal components and *g*-based analyses). Working memory represents another executive function which has been shown to be substantially *g*-loaded (e.g., Unsworth, 2010).

In addition to individual cognition variable scores, we calculated a composite value akin to a *g*-factor following the approach by Revelle and Wilt (2013). We subjected the four indices of cognitive function (verbal fluency, numeracy, immediate recall, and delayed recall) to a single-factor principal component analysis (PCA). Then, relative frequencies of correct answers were obtained for each participant in each cognition variable by computing the relative numbers of correct solutions within

Table 2
Unstandardized and standardized estimates for (random intercept) cross-lagged panel models.

	Estimate	*SE*	Standardized estimate
Numeracy			
Autoregressive Path			
Praying Wave 1 → Praying Wave 2	0.56*	0.01	0.58
Numeracy Wave 1 → Numeracy Wave 2	0.57*	0.01	0.56
Cross-Lagged Path			
Praying Wave 1 → Numeracy Wave 2	−0.06*	0.02	−0.02
Numeracy Wave 1 → Praying Wave 2	−0.02*	<0.01	−0.04
Control Variables			
Participant Age → Praying Wave 2	<0.01*	<0.01	0.02
Participant Sex → Praying Wave 2	0.08*	0.01	0.08
Participant Age → Numeracy Wave 2	−0.02*	<0.01	−0.16
Participant Sex → Numeracy Wave 2	−0.20*	0.01	−0.09
Verbal Fluency, $\chi^2(5) = 86.92$, CFI = 1.00, TLI = 0.98, RMSEA = 0.02, SRMR = 0.02			
Autoregressive Path			
Praying Wave 1 → Praying Wave 2	0.04*	0.03	0.05
Praying Wave 2 → Praying Wave 3	0.11*	0.03	0.10
Verbal Fluency Wave 1 → Verbal Fluency Wave 2	0.26*	0.02	0.26
Verbal Fluency Wave 2 → Verbal Fluency Wave 3	0.15*	0.03	0.15
Cross-Lagged Path			
Praying Wave 1 → Verbal Fluency Wave 2	−0.40	0.29	−0.03
Praying Wave 2 → Verbal Fluency Wave 3	−0.54	0.31	−0.03
Verbal Fluency Wave 1 → Praying Wave 2	<0.01*	<0.01	−0.06
Verbal Fluency Wave 2 → Praying Wave 3	<0.01	<0.01	−0.03
Control Variables			
Participant Age → Random Intercept Praying	0.01*	<0.01	0.14
Participant Sex → Random Intercept Praying	0.17*	0.01	0.23
Participant Age → Random Intercept Verbal Fluency	−0.28*	0.01	−0.51
Participant Sex → Random Intercept Verbal Fluency	−0.67*	0.10	−0.06
Memory, $\chi^2(5) = 180.16$, CFI = 0.99, TLI = 0.97, RMSEA = 0.03, SRMR = 0.03			
Autoregressive Path			
Praying Wave 1 → Praying Wave 2	0.04	0.03	0.05
Praying Wave 2 → Praying Wave 3	0.11*	0.03	0.10
Memory Wave 1 → Memory Wave 2	0.25*	0.02	0.24
Memory Wave 2 → Memory Wave 3	0.09*	0.02	0.08
Cross-Lagged Path			
Praying Wave 1 → Memory Wave 2	0.06	0.07	0.02
Praying Wave 2 → Memory Wave 3	−0.06	0.08	−0.01
Memory Wave 1 → Praying Wave 2	−0.01	<0.01	−0.03
Memory Wave 2 → Praying Wave 3	<0.01	0.01	0.00
Control Variables			
Participant Age → Random Intercept Praying	<0.01*	<0.01	0.13
Participant Sex → Random Intercept Praying	0.17*	0.01	0.23
Participant Age → Random Intercept Verbal Fluency	−0.09*	<0.01	−0.65
Participant Sex → Random Intercept Verbal Fluency	0.22*	0.02	0.08
g-factor			
Autoregressive Path			
Praying Wave 1 → Praying Wave 2	0.56*	0.01	0.58
g-factor Wave 1 → *g*-factor Wave 2	−0.07*	0.01	0.68
Cross-Lagged Path			
Praying Wave 1 → *g*-factor Wave 2	−0.03*	0.01	−0.03
g-factor Wave 1 → Praying Wave 2	−0.07*	0.01	−0.08
Control Variables			
Participant Age → Praying Wave 2	<0.01	<0.01	<0.01
Participant Sex → Praying Wave 2	0.09*	0.01	0.09
Participant Age → *g*-factor Wave 2	−0.01*	<0.01	−0.17
Participant Sex → *g*-factor Wave 2	0.01	0.01	0.01

Note. $N = 30{,}424$ participants; *SE* = Standard error. * = $p < .05$.

scales, respectively. These four scores were then multiplied with their respective factor loadings and subsequently averaged. Finally, this score was *z*-standardized, thus resulting in a numerical *g* score for each participant.

3.2. Religiosity assessments

Religiosity was assessed via one question in Waves 1, 2, and 5: "Thinking about the present, about how often do you pray?" (more than once a day/ once daily/ a couple of times a week/ once a week/ less than once a week/ never) and religious behaviors via another one in Waves 1 and 2 (i.e., "Have you done any of these activities in the last month: Taken part in a religious organization (church, synagogue, mosque etc.)" (yes/no). Despite representing a religious behavior, praying can be considered as a better proxy for the actual beliefs of a person than religious attendance, because it can be assumed to represent a consequence of an intrinsic motivation. Therefore, we treat praying as a measure of religious beliefs here whilst we consider attendance in a religious service as a measure of religious behavior.

For our main analyses, we dichotomized the variable praying into the

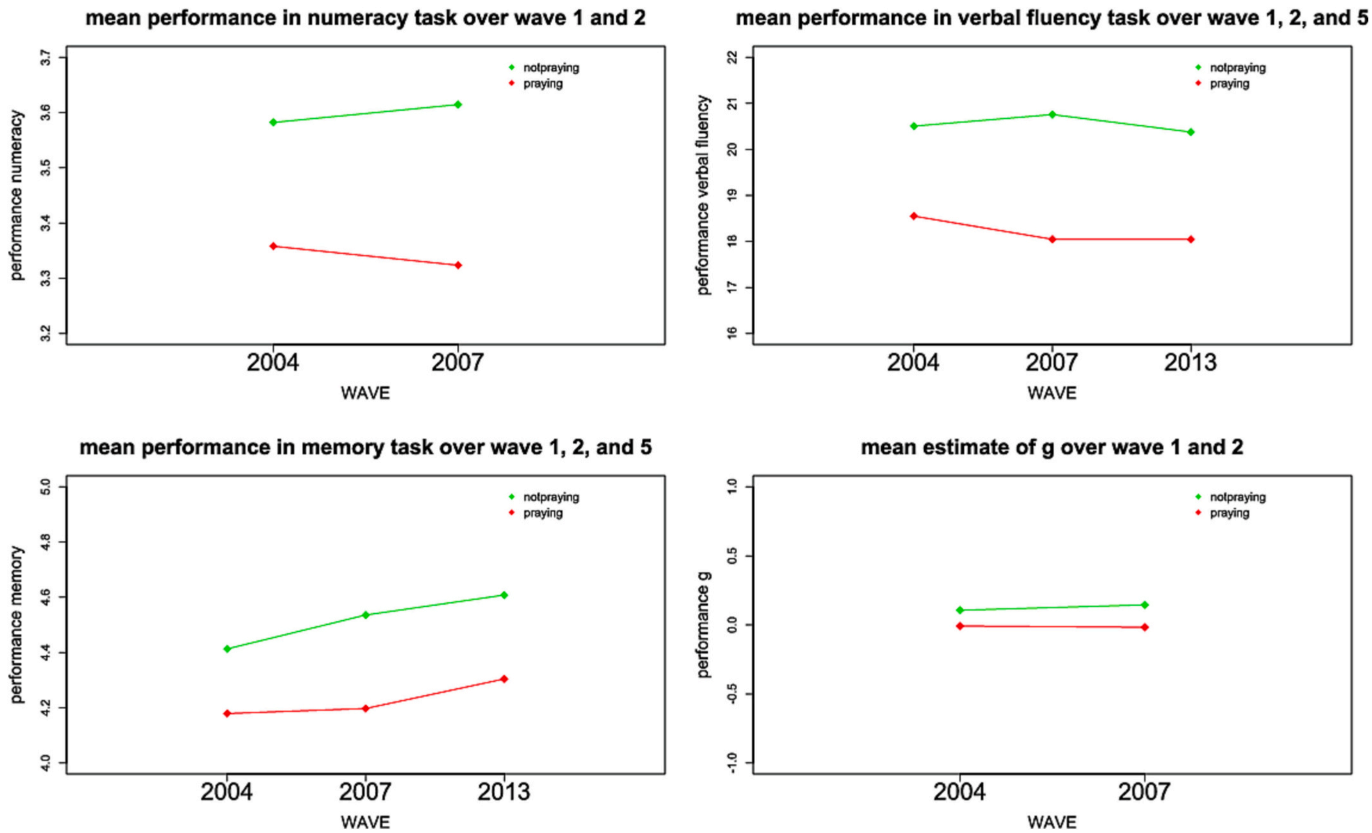

Fig. 3. Mean scores of numeracy, verbal fluency, memory, and *g* for participants who reported praying vs. those who did not across Waves 1 (2004), 2 (2007), and 5 (2013). *Note.* Mean ability changes are irrelevant for changes in correlations as long as the within-variable order of values remains boradly identical.

categories "praying" (more than once a day/ once daily/ a couple of times a week/ once a week/ less than once a week) vs. "not praying" (never) because the frequency of praying plays a subordinate role in our examination. Instead, we were mainly interested in whether participants prayed at all, because this can be seen as an expression of being religious as opposed to not being religious. However, in supplementary analyses, we repeated these calculations using ordinal logistic regression models where we maintained the original responses of our dependent variable (i.e., praying: more than once a day/ once daily/ a couple of times a week/ once a week/ less than once a week/ never).

3.3. Analyses

Cross-sectional analyses were performed for Wave 1 data to obtain the largest possible sample size (i.e., because we only considered participants that had participated in Wave 1 for inclusion in any further analysis, Wave 1 data yielded necessarily the largest sample size).

Age is well-known to be correlated with cognitive abilities. Similarly, women have been shown to differ from men in terms of religiosity (higher values for women than men; Stark, 2000) as well as specific cognitive abilities such as semantic fluency (e.g., naming animals; Acevedo et al., 2000) or verbal memory (Hirnstein, Stuebs, Moé, & Hausmann, 2022). Consequently, in all our analyses we control for age and sex unless stated otherwise. We initially calculated partial correlation coefficients by controlling for age and sex in our cross-sectional data of Wave 1.

As a next step, we ran cross-lagged panel models (Little, 2013), which allowed us to evaluate the directionality of otherwise merely conceptually assumed causal relations. Within this approach, standardized path coefficients between variables of interest ("cross") measured at different times ("lagged") are analyzed. Cross-lagged panel modeling based on two waves (numeracy and *g*-factor) and three waves of measurement (verbal fluency and memory) was conducted in Mplus 8.6 (Muthén & Muthén, 1998–2017) to investigate the cross-temporal relationship between praying behavior and cognitive functions. Random intercept cross-lagged panel models (RI-CLPM, Hamaker, Kuiper, & Grasman, 2015) were estimated for verbal fluency and memory, whereas traditional cross-lagged panel models (CLPM) were estimated for numeracy and the *g*-factor. Note, that it was not possible to estimate a RI-CLPM for numeracy and the *g*-factor because the RI-CLPM requires at least three waves of measurement. Consequently, it should be noted that the within- and between-person variance is confounded in the CLPM, whereas the RI-CLPM includes a stable-trait variance component (Lucas, 2023).

To assess potential within-individual changes over time in terms of the cognitive abilities and religiosity link, we fitted growth curve models in a multilevel modeling framework to our data, using a random intercept approach (i.e., allowing for the intercepts to vary). The multilevel approach was necessary because cognitive task performance of an individual at different times (level 1) represents dependent observations that are nested in the respondents (level 2; i.e., our clustering variable).

We ran four multilevel growth curve analyses for the three scale scores as well as for *g* as the outcome variables. We included the data collection wave as a covariate and calculated its interaction with praying to model cross-temporal changes in associations. Here, we used the dichotomous variable praying vs. not praying as predictor of cognitive task performance and subsequently supplemented these analyses by regression models with dummy-coding of the original ordinal scaling of the response variable "praying".

Missingness of data from individual waves did not preclude inclusion for calculations in other waves. This approach was reasonable because the multilevel framework can be considered to be robust against resulting unequal group sizes (Maas & Hox, 2005). Protective effects of religiosity on cognitive declines have been reported to be differentiated

Table 3
Multilevel regression analyses of praying and Wave on cognition variables.

	β	*SE*	η_p^2	*p*	ICC
Numeracy					
Praying	−0.043	0.032	< 0.0001	0.177	
Wave	0.040	0.015	0.0005	0.007	
Sex	−0.454	0.013	0.0500	< 0.001	
Age	−0.029	0.001	0.0800	< 0.001	
Praying*Wave	−0.040	0.019	0.0002	0.040	
					0.551
Verbal fluency					
Praying	−0.889	0.146	0.0010	< 0.001	
Wave	−0.303	0.050	0.0013	< 0.001	
Sex	−0.489	0.082	0.0014	< 0.001	
Age	−0.232	0.004	0.1100	< 0.001	
Praying*Wave	−0.099	0.066	< 0.0001	0.135	
					0.574
Memory					
Praying	−0.083	0.037	0.0001	0.024	
Wave	0.022	0.013	< 0.0001	0.082	
Sex	0.239	0.019	0.0066	< 0.001	
Age	−0.076	0.001	0.2100	< 0.001	
Praying*Wave	−0.022	0.017	< 0.0001	0.187	
					0.489
g					
Praying	−0.029	0.013	0.0003	0.026	
Wave	0.029	0.006	0.0017	< 0.001	
Sex	−0.012	0.006	0.0002	0.052	
Age	−0.022	<0.001	0.1900	< 0.001	
Praying*Wave	−0.022	0.008	0.0006	0.004	
					0.684

Note: Rows correspond to predictors (praying: no = 0, yes = 1; sex: men = 0, women = 1) of 4 separate univariate multilevel random-intercept regression models with the respective cognition variable as the outcome. ICC = Intraclass Correlation Coefficient, representing the amount of variance on level 1 (= Wave) which is explained by the clustering variable (level 2 = participants).

according to the societal value that is ascribed to a given religion according to a given country (e.g., Norris & Inglehart, 2004, for international comparisons). Therefore, we exploratorily used the national religiosity-index for European countries, which is a function of the population percentage in a given country that self-reports to be religious[1] (Austria: 0.14; Belgium: 0.10; Denmark: 0.08; France: 0.12; Germany: 0.12; Greece: 0.49; Italy: 0.27; Netherlands: 0.18; Spain: 0.21; Sweden: 0.10; Switzerland: 0.12.) to predict correlations based on multilevel modeling (Hox, Moerbeek, & van de Schoot, 2018): Three-level modeling was used (Level 1: Measurement, Level 2: Participants, and Level 3: Country) in R 4.3.1 (R Core Team, 2023) by means of the lme4 package version 1.1–34 (Bates, Mächler, Bolker, & Walker, 2015) for numeracy, verbal fluency, memory, and the *g*-factor using the predictors wave, participant age, sex, and the religiosity index. An interaction term reflecting wave * religiosity index was included to evaluate if declines in cognitive functions are depending on national religiosity.

Group-mean centering was used for all predictors at the participant level, while grand-mean centering was used for all predictor variables at the country level (Enders & Tofighi, 2007). As recommended, cluster means of the participant level predictors participant age and sex were included as control variables at the country level (Rights, Preacher, & Cole, 2020).

Model parameters were estimated using the restricted maximum likelihood (REML) method and Satterthwaite's degrees of freedom method implemented in the lmerTest package version 3.1–3 (Kuznetsova, Brockhoff, & Christensen, 2017) was used to test parameters for statistical significance. Our entire analytic code is available at https://osf.io/u46w3.

In our results, we interpret effect sizes according to Cohen's well-established classifications (Cohen, 1988) where absolute $r = 0.10$, 0.30, and, 0.50 values are considered to represent lower thresholds of small, medium, and large effects, respectively(i.e., absolute $r = 0.1$ represents the upper threshold of non-triviality).

4. Results

In the beginning of the results section, frequencies of religious engagements and zero-order correlations with measures of cognitive abilities are presented. Subsequently, we detail missing data diagnostics which revealed a missing at random pattern (missing values because of participant's age). Afterwards, we provide results of cross-lagged panel models which showed path coefficients that were trivial to small in magnitude. Then, we present confirmatory multilevel models which showed no evidence for a protective effect of religiosity on cognitive decline. Finally, we show that exploratory moderation analyses by societal religiosity revealed indications for a faster cognitive decline in certain domains.

4.1. Descriptive statistics

In Wave 1, 3504 (12%) participants reported to have taken part in religious services in the past month, whereas 26,377 (88%) did not. A total of 5977 respondents had not prayed at all in 2004, whilst 9069 had reported at least some praying behavior within the past month (see Supplement S3 for descriptives https://osf.io/5vz3w). Fig. 1 shows a heat map of religious behavior frequencies in Europe and Israel. Zero-order correlations among indicators of intelligence, religiosity and subject-level characteristics are provided in Fig. 2.

Note that age and sex were both positively related to praying, whereas praying was negatively associated with cognitive abilities. Furthermore, age showed strong negative associations with intelligence. These cross-sectional patterns indicate a necessity to control for age and sex in cross-sectional as well as cross-temporal examinations.

4.2. Missing data

In total, 27.15% of data from 24,689 cases were either missing or incomplete, mainly due to non-participation in individual Waves: (i) participants who dropped out of the study after Wave 1 ($n = 8033$), (ii) participants who dropped out after Wave 2 ($n = 9791$), and (iii) participants who missed Wave 2, but participated in Waves 1 and 3 ($n = 1543$). The remaining 5322 participants had missing values on single variables. Attrition analyses were conducted by comparing characteristics of participants who provided complete data with those that had dropped out of the study (Nicholson, Deboeck, & Howard, 2017). Moderate differences between participants with missing vs. complete cases emerged for age ($d = -0.28$), verbal fluency at Wave 1 ($d = 0.34$) and Wave 2 ($d = 0.38$), and the *g*-factor at Wave 1 ($d = 0.31$) and Wave 2 ($d = 0.33$). Trivial-to-moderate effects were observed for praying, numeracy, verbal fluency at Wave 3, and memory (see Table 1). These results indicate a missing at random pattern where missingness can be attributed to the age of the participant; i.e., older participants are more likely to drop out of the study.

Moreover, age is known to be related to cognitive abilities so that participants with higher cognitive abilities are less likely to drop out of the study. Note that the median age of the participants was 63 years and the third quartile was 71 years at Wave 1. This means that roughly half of the sample were older than 63 years and roughly 25% of the sample were older than 71 years at the initial assessment. Given the 10 years

[1] Religiosity index from the PEW Research Center: https://www.pewresearch.org/interactives/how-religious-is-your-country/. Israel was excluded from these analyses due to unavailability of this index.

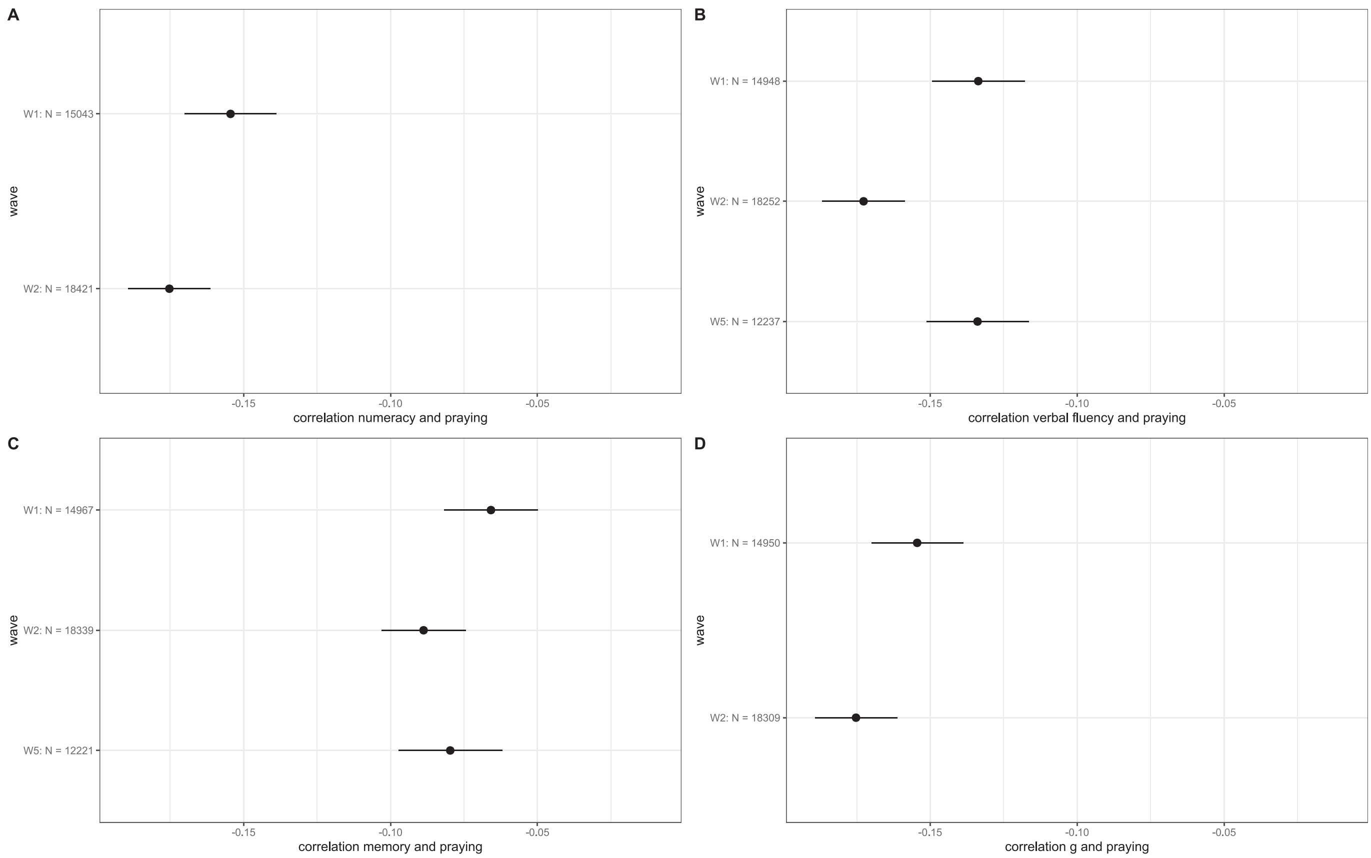

Fig. 4. Forest plots of intelligence religiosity associations over Wave 1, 2, and 5. No Wave 5 associations were available for numeracy and *g* due to a data missingness. Correlations of numeracy (A), verbal fluency (B), memory (C), and *g* (D) with praying are displayed on the x-axis.

that had elapsed between Wave 1 and Wave 3, the observed dropout is unsurprising.

4.3. Cross-sectional analyses

Testing of our hypotheses regarding negative cross-sectional associations of intelligence and religiosity was based on Wave 1 data only. We observed negative, albeit small, associations of praying and all indices of cognitive abilities (numeracy: $r = -0.056$, $p < .001$, verbal fluency: $r = -0.110$, $p < .001$, memory: $r = -0.046$, $p < .001$, g: $r = -0.079$, $p < .001$,). Participation in a religious service was positively associated with numeracy ($r = 0.093$, $p < .001$) and only marginally with verbal fluency ($r = -0.005$, $p = .381$), memory ($r = 0.046$, $p < .001$), and g ($r = 0.031$, $p < .001$). Partial correlations of intelligence with praying as an ordinal variable are provided in Supplement S4 (https://osf.io/59zme) and respective country-specific correlations in Supplement S5 (https://osf.io/a8jzs).

In all, results of our cross-sectional analyses were in line with the expectations of negative associations between intelligence and religiosity (indicated by praying behavior). Less pronounced associations with intelligence for religious participation than for praying behavior are consistent with previous findings (e.g., Dürlinger & Pietschnig, 2022).

4.4. Cross-temporal relationships between reported praying behavior and cognitive functions

In our longitudinal analyses, we examined dependent data of Waves 1, 2, and 5 (numeracy and *g*-based analyses were limited to Waves 1 and 2 due to Wave 5 data missingness).

In order to take all potential causal pathways of religiosity and vice versa into account, four separate cross-lagged panel analyses were conducted for relationships of reported praying behavior with numeracy, verbal fluency, memory, and *g*, respectively (see Table 2 for dichotomized praying and Supplements S6 https://osf.io/khxy6 for ordinal scaled praying). According to well-established guidelines (Hu & Bentler, 1999), a comparative fit index (CFI) with a value >0.95 and a standardized root mean square residual (SRMR) of <0.08 were assumed to be indicative of sufficient model fit. Fit index comparisons were only performed for verbal fluency and memory (i.e., assessments in more than two waves). Both fit indices were satisfactory for verbal fluency (CFI = 0.996, SRMR = 0.016) and for memory (CFI = 0.994, SRMR = 0.025). Numeracy and *g* were restricted to Wave 1 and 2. Because these models are merely identified, no fit indices were obtained.

As for numeracy and the *g*-factor, results showed a statistically significant cross-lagged relationship between praying, numeracy, and *g*-factor. More specifically, praying at Wave 1 was associated with a decrease in numeracy (standardized estimate = −0.02, $p = .002$) and *g*-factor (standardized estimate = −0.03, $p < .001$), whereas higher numeracy (standardized estimate = −0.04, p < .001) and *g*-factor (standardized estimate = −0.08, p < .001) at Wave 1 was associated with a decrease in the probability of praying. For memory, results did not show any statistically significant cross-lagged relationship with praying across the three waves of measurement. For verbal fluency, however, results showed that higher verbal fluency scores at Wave 1 were associated with a decrease in the probability of praying between Wave 1 and Wave 2 (standardized estimate = −0.06, p = .002). All other cross-lagged paths between praying and verbal fluency were not statistically significant.

Testing of our hypotheses regarding protective effects of religiosity on cognitive declines was based on fitting a growth curve model in the multilevel-framework. Based on the set of observed repeated-measures

Table 4
Unstandardized and standardized estimates for multilevel modelss.

	Numeracy			Verbal fluency			Memory			*g*-factor		
	Unstandardized estimate	*SE*	Standardized estimate	Unstandardized estimate	*SE*	Standardized estimate	Unstandardized estimate	*SE*	Standardized estimate	Unstandardized estimate	*SE*	Standardized estimate
Fixed Effects												
Intercept	3.32*	0.11		18.89*	0.65*		4.14*	0.18*		−0.02	0.05	
Wave	0.05*	0.01	0.02	−0.22	0.14	−0.02	0.05	0.03	0.02	0.03*	<0.01	0.03
Participant Age	−0.03*	<0.01	−0.27	−0.23*	<0.01	−0.31	−0.07*	<0.01	−0.41	−0.02*	<0.01	−0.43
Sex	−0.45*	0.01	−0.19	−0.60*	0.07	−0.04	0.24*	0.02	0.06	−0.02	0.01	−0.01
Average Participant Age within Country	−0.14	0.17	−0.10	−0.84	0.91	−0.09	−0.45	0.10	−0.21	−0.11	0.06	−0.16
Proportion of Female Participants within Country	−5.29	9.14	−0.07	−20.70	49.56	−0.05	15.95	5.35	0.14	−1.79	3.52	−0.05
Religiosity Index	−0.79	1.18	−0.08	−20.15*	6.65	−0.30	−3.28	1.63	−0.22	−0.91	0.54	−0.22
Wave x Religiosity Index	0.04	0.07	<0.01	0.78	1.26	<0.01	−0.38	0.25	−0.02	−0.12*	0.04	−0.01
Variance Components												
Level 1 – Measurement	0.505			20.415			1.343			0.072		
Level 2 – Participant	0.568			21.23			1.141			0.128		
Level 3 – Country	0.145			4.667			0.354			0.032		
Slope for Wave	<0.001			0.209			0.008			<0.001		

Note. $N = 45{,}987$–$57{,}390$ observations from 27,975 participants in 11 countries; *SE* = *Standard Error*. * = $p < .05$.

within-person trajectories are obtained. In this framework, these trajectories become the unit of analysis.

We observed no decreases of absolute associations with praying for either cognition variable (Fig. 3). Our multilevel regressions indicated that the mean cognitive task performance of people who did not pray exceeded those of participants who did pray (see Table 3). Of note, effect sizes for verbal fluency were somewhat larger than for the other cognition variables. This might be due to fundamental beliefs having a negative influence on the development of verbal abilities (Sherkat, 2010).

We observed significant interactions for numeracy ($\beta = -0.040$, $p = .040$) and *g* ($\beta = -0.022$, $p = .004$), indicating increasing differences in performance between praying and non-praying participants in the second Wave (2007). These results indicate a faster cognitive decline in more religious people. No significant interactions were found for verbal fluency and memory.

Differences in task performance between participants were cross-temporally stable (ICC-range: 0.489 to 0.684). Results from ordinal regression-based supplementary analyses were in line with these findings (Supplement S7 https://osf.io/p598b). Different frequencies of praying showed consistently negative effects on measures of cognitive function.

In order to account for attrition, we conducted three more multilevel models, including only respondents who participated in (i) Wave 1 and 2, (ii) Wave 1 and 3 and (iii) Wave 2 and 3 (see Supplement S8 https://osf.io/2eqyp). Effect sizes were trivial, suggesting that results of the overall-models are not primarily attributable to a loss of data.

Cross-lagged panel models and multilevel regressions for participation in a religious organization are provided in Supplement S9 (https://osf.io/fnqk9). We observed no significant interactions of participation in a religious organization and Wave. We had to reject our hypotheses regarding cross-temporal changes in magnitude of intelligence and religiosity associations. In all, our results do not support the idea of a protective effect of praying on cognitive abilities. Forest plots of zero-order point-biserial correlations of respective cognition variables and praying according to Waves are provided in Fig. 4. All correlation coefficients were significant, non-trivial, and negative.

4.5. *Explorative analyses*

Finally, we exploratively assessed if the effect of cognitive functioning was differentiated according to national religiosity estimates. Results showed a statistically significant interaction of Wave and religiosity index for predicting the *g*-factor (see Table 4). When assuming an average religiosity index, an increase in the *g*-factor between Wave 1 and 2 was observed (standardized estimate = 0.03, $p < .001$). With increasing religiosity, however, this increase turns into a decrease in the *g*-factor across time (standardized estimate = −0.01, $p = .022$). There were no statistically significant interactions for numeracy, verbal fluency, and memory. Analyses were repeated without values for Greece (see Supplements S10 https://osf.io/p69bz), which represented an outlier in terms of inhabitant religiosity with almost twice as many self-reported religious participants compared to the second-largest national value. When omitting this leverage point, the interaction for Wave and religiosity for predicting the *g*-factor was not statistically significant anymore.

5. Discussion

Here, we show that there is only little evidence for protective effects of religiosity for cognitive abilities in retirement-aged Europeans. Negative non-trivial associations between cognitive abilities and religiosity appear to yield similar strengths as previously shown in younger samples (Dürlinger & Pietschnig, 2022). These associations appear to remain cross-temporally stable and do not show meaningful within-individuals changes over time. These findings present several points of interest, as we discuss below.

First, we observed no conclusive evidence for a protective effect of religiosity on cognitive declines in old ages. Our results suggest that the well-established negative link of cognitive abilities and religiosity seems to generalize to elderly samples and does not diminish in strength as participants age. In other words, religiosity does not affect the cognitive decline of individuals. This is interesting, because many activities that are an integral part of religious attendance have been proposed to stimulate cognitive faculties, including singing, praying, sermons, scriptural studies, theological or philosophical discussions, or socializing in general (Hill, 2008). Beneficial effects of an active and stimulating lifestyle and of engaging in social activities on cognitive functioning in later life are well documented (e.g., Hultsch, Hertzog, Small, & Dixon, 1999; Newson & Kemps, 2005).

As a consequence, a later and slower decline of cognitive abilities could be expected in people engaging in religious behaviors, which has been theorized to be mediated by the preservation of a dense network of neocortical synapses (Hill, 2008). The absence of such protective effects of religion in our data may mean that non-religious elderly participants in the presently investigated countries experience sufficient alternative means of cognitive stimulation in their everyday lives that are unrelated to religious activities. Positive, albeit small, associations of religious attendance and cognitive abilities (excepting verbal fluency) in our cross-sectional analyses could indicate a moderation by measurement modalities. However, we did not observe protective effects of religious behavior on cognitive abilities measured later either, what shows somewhat of an ambiguity of our results.

The presently observed strength of the verbal fluency and praying association in elderly samples appeared to be virtually identical to intelligence and religiosity associations that have been observed in meta-analyses of predominantly younger samples (e.g., Dürlinger & Pietschnig, 2022; Zuckerman et al., 2020).

Second, our path analyses yielded only significant negative effects of praying on cognitive abilities in models without random intercepts (numeracy and *g*). This could be due to a conflation of between- and within-individual changes, which are a common critique of cross-lagged panel models. Results of our path analyses should therefore be interpreted with caution. The bidirectionality of intelligence and religiosity (path coefficients of religiosity on intelligence measured later and of intelligence on religiosity measured later are virtually identical in strength) contrast the idea of intelligence being a stronger predictor for religiosity than vice versa, at least when it comes to older individuals. Conceivably, a further variable, namely the preferred cognitive style, may be responsible for this observation. Specifically, preference for an analytic cognitive style is associated positively with cognitive abilities (Frederick, 2005) and negatively with religiosity (Gervais & Norenzayan, 2012).

It has been demonstrated that cognitive styles partially mediate the effect of intelligence on religiosity (Dürlinger & Pietschnig, 2022; Zuckerman et al., 2013). In a similar vein, preference for an intuitive cognitive style, which has been shown to be more prevalent in religious people, could cause faster cognitive declines due to lower cognitive stimulation. This idea has already been proposed in the framework of the neural resource depletion model (Hill et al., 2020). Both of these ideas pertaining to cognitive styles are consistent with our present observations because the small negative religiosity and intelligence association should persist over increasing participant ages.

In fact, the presently observed significant interactions of Wave with praying when predicting numeracy and *g* yielded unexpected signs, thus further contrasting expectations of protective religiosity effects against cognitive declines. This observation is in line with the above discussed potential causes of the observed negative religiosity and intelligence associations and therefore also appears to be consistent with the neural resource depletion framework. However, due to the very nature of the present study (i.e., precluding assessment of participant religiosity at younger ages), we cannot conclusively rule out alternative explanations. Importantly, examination of direct measures of religious behavior (i.e., taking part in a religious organization) showed virtually identical results to those of praying. This further corroborates the finding that there are no protective effects on cognitive abilities in the presently observed population.

In this vein, contrasting findings that have documented some protective effects of religiosity for cognitive functions (e.g., Hill et al., 2006; Reyes-Ortiz et al., 2008; Van Ness & Kasl, 2003) are suggestive of potential moderating effects of religious denomination. With the exception of Israel, participants of the present study were inhabitants of countries with Catholic majorities. However, religious customs differ between different denominations and, arguably, so may the effects that religious beliefs and behaviors have. Religious beliefs and behaviors might be more clearly distinguishable in American Protestantism than in Catholicism or Judaism, for instance. Religious practices and rituals including other people are characteristic of Catholicism and Judaism and part of the respective religious identity (Cohen, Hall, Koenig, & Meador, 2005). Conceivably, potential protective effects on cognitive abilities might be relevant in varying degrees depending on how much religions lie emphasis on a strong embeddedness of believers in the community. Future research is needed to evaluate potential effects of societal or cultural conditions that may explain why protective effects have been found in America and Asia (for an overview, see Hill, 2008) but not in Western Europe.

Third, moderator analyses of societal values of religiosity revealed that higher national religiosity does not account for potential protective effects of religiosity as people age. In fact, we observed faster declines of *g* in countries that are characterized by higher societal religiosity. This is surprising, because we expected slower declines of cognitive abilities in more religious societies, mainly because in such surroundings, being religious should be more stimulating. Moreover, upholding religious beliefs could be more rewarding if religiosity is associated with a higher societal status. However, the observed negative effect disappeared when we removed a leverage point (i.e., Greece) from our analyses, thus indicating no meaningful role of the societal value of religiosity in our data. We cannot rule out though, that variance restriction in religiosity indices may be responsible for the absence of any meaningful influence of this variable.

In all, our findings corroborate the robustness of the small inverse intelligence and religiosity association.

6. Limitations

Some limitations of this study need to be acknowledged. On the one hand, due to the comparatively old age of participants during the first wave of data collection, we cannot entirely rule out that the subsequent lack of changes in the observed observation may have been due to an uncharacteristically low and age-specific correlation baseline. However, within-Wave correlations yielded largely coefficients that were similar to those that are typically observed in younger cohorts (see Dürlinger & Pietschnig, 2022), thus suggesting that protective effects - if any - may manifest themselves after 62 years (i.e., representing mean ages of participants in Wave 5) of age at best. In a similar vein, we did not observe a consistent pattern of cognitive declines across ages. Conceivably, this may be either due to systematic data attrition or alternatively a possible later onset of cognitive declines and consequently potential protective effects of religiosity.

On the other hand, we did not formally assess cross-temporal measurement invariance within cognitive domains. This was due to an unsuitable response format (i.e., count-data responses for verbal fluency and memory) as well as non-identical between-cohorts numeracy items administrations. However, because of the very nature of these subscales, measurement invariance is unlikely to play a major role for cross-temporal ability changes (i.e., item drift typically affects knowledge-based content whilst the presently assessed abilities are mostly related to fluid abilities).

Finally, our composite measure of *g* is a rather noisy proxy of general intelligence. Tasks measuring cognitive function are meant to detect a potential cognitive decline and can be susceptible to ceiling effects in healthy participants. However, executive functioning assessments may be particularly useful in the present context due to our focus on cognitive declines.

7. Conclusion

The present study investigated potential protective effects of religiosity for cognitive abilities in later life. We failed to show evidence for positive associations of praying or religious participation with healthier cognitive aging. Instead, our results suggest that the often observed small negative association of intelligence and religiosity remains longitudinally robust within participants. Our results suggest that the negative religiosity and intelligence link generalizes over the entire lifespan.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intell.2023.101796.

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