Social Network Characteristics Moderate Associations between Cortical Thickness and Cognitive Functioning in Older Adults

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Abstract

INTRODUCTION: Prior research suggests that the strength of association between Alzheimer's disease pathology and lower cognitive performance is influenced by modifiable psychosocial factors, such as social network size. However, little is known about distinct social relationship types.

METHODS: The current cross-sectional study used data from the Washington Heights-Inwood Columbia Aging Project to examine whether social network characteristics (i.e., total size, spouse/partner, number of children, other relatives, friends) moderate associations between cortical thickness in regions implicated in Alzheimer's disease and cognitive performance.

RESULTS: Lower cortical thickness was associated with worse global cognition among individuals with smaller friend networks, but not among individuals with larger friend networks. This pattern of results was most prominent for language and speed/executive functioning.

DISCUSSION: Longitudinal and intervention studies are needed to determine whether these cross-sectional findings reflect a protective effect of later-life friendships for maintaining cognitive performance in the context of poorer brain health.

Keywords: Social Relations, Cognitive Aging, Cognitive Reserve, Psychosocial

Although prior research showed that various structural magnetic resonance imaging (MRI) indicators of brain health are associated with cognitive functioning in later life (1-2), the strength of brain-cognition associations varies. Clinicopathologic studies confirm that some individuals with poor brain health at autopsy did not show cognitive impairment in life, while others exhibited poor cognition commensurate with poor brain health (3-4). Lifestyle factors (e.g., social network, loneliness) may alter the associations between brain and cognition, either increasing or decreasing the probability of exhibiting cognitive symptoms for any given level of brain pathology (5).

One lifestyle factor that may influence the association between brain health and cognition is social networks (5), which are a protective factor for cognitive functioning and dementia risk (6-7). For example, in a clinicopathologic study, older adults who had larger social networks showed a weaker negative correlation between global Alzheimer's disease (AD) pathology at autopsy and cognitive performance during life compared with those with smaller social networks (8). These findings suggest that social relationships may be a modifiable psychosocial factor that helps to maintain cognitive functioning in older adulthood in spite of poorer brain health (9). However, it is not known whether social networks similarly attenuate associations between brain health measured *in vivo* and concomitant cognitive performance.

Recent evidence further suggests that relationship type may be an important factor when examining links between social networks and cognition in older adults. Specifically, some empirical studies showed that larger friend networks (10-12) and being married (11-12) were the strongest social predictors of better cognitive functioning. For example, in a cross-sectional study of Chinese nonagenarians and centenarians, the number of friends and being married, but not the number of children or ties with neighbors, were independently associated with better cognition (11). Consistent with these cross-sectional findings, in a longitudinal study of U.S. older adults, higher contact frequency with friends and being married were independently associated with less decline in episodic memory above and beyond other social network characteristics (12). This specificity regarding the potential "active ingredients" of social networks has the potential to guide more targeted intervention and prevention efforts related to the risk of AD, but prior research incorporating brain variables into the study of social networks and cognition has not disaggregated social networks by relationship types (8).

This cross-sectional study sought to address these gaps in the literature through two main research aims. First, we aimed to expand prior research by examining whether social network characteristics moderate the association between brain health measured *in vivo* and cognition. Compared to the clinicopathologic approach in which brain health is measured post-mortem, the use of structural MRI allows for the examination of brain health measured concomitantly with cognitive performance. To maximize comparability with the previous clinicopathologic study of social networks that focused on global AD-type neuropathology in multiple brain regions vulnerable to early AD (8), we operationalized brain health as average cortical thickness across nine "AD signature" regions (1, 13). We hypothesized that social network size would moderate the association between cortical thickness and cognitive performance. Specifically, in line with prior research (8), we hypothesized that individuals with smaller social networks would show a stronger association between cortical thickness and cognitive performance than individuals with larger social networks. Second, we aimed to examine whether marital status and/or the number of children, other relatives, and/or friends uniquely moderate brain-cognition associations in later life. Based on prior research (10-12), we hypothesized that having more friends and being married, but not the number of children or other relatives, would attenuate associations between cortical thickness and cognitive performance.

Methods

Participants. Data for this study stem from the Washington Heights-Inwood Columbia Aging Project (WHICAP; 14-15), a longitudinal, community-based study of aging and dementia in northern Manhattan. The current sample included only participants who received a set of psychosocial measures, including items related to social relationships, that was added to the WHICAP battery in 2017. Thus, while WHICAP is a longitudinal study, only cross-sectional data were available for the current analyses. In the current study, 740 participants who received the psychosocial battery also had available structural MRI data. Of those, 56 participants were excluded who had a consensus diagnosis of dementia (*n*=45) or lack of diagnostic information (*n*=11). An additional thirty participants were excluded who did not complete the social network size items (*n*=13) and/or who were missing covariates (*n*=17). Therefore, our final analytic sample included 654 participants (see descriptive sample characteristics in Table 1).

Measures

Social Network Characteristics. Three items asked participants how many children, other relatives, and friends they talk to at least once a month (8, 16). Marital status was measured with a single item asking participants if they were married or living with a partner (unmarried as the reference category). Total network size was calculated by summing these four items, and higher scores represented a larger social network size.

Cortical Thickness. Structural MRI was obtained on a 3.0T Philips Achieva scanner at Columbia University Medical Center. T1-weighted (repetition time =6.6 ms, echo time= 3.0 ms, field of view 256 cm, 256×256 matrix, 1.0 mm slice thickness) images were acquired in the axial orientation. Regional cortical thickness was quantified using FreeSurfer (version 6.0; http://surfer.nmr.mgh.harvard.edu/) using T1-weighted images.

A cortical thickness composite score was calculated by averaging cortical thickness across hemisphere in nine regions that, together, have previously been shown to best reflect early Alzheimer's neurodegeneration (13). These regions, named by Dickerson and colleagues and represented by specific FreeSurfer regions of interest (in parentheses) were the following: rostral medial temporal lobe (entorhinal cortex and parahippocampus), angular gyrus (inferior parietal lobe), inferior frontal lobe (pars opercularis, pars orbitalis, and pars triangularis), inferior temporal lobe (inferior temporal lobe), temporal pole (temporal pole), precuneus (precuneus), supramarginal gyrus (supramarginal gyrus), superior parietal lobe (superior parietal lobe), and superior frontal lobe (superior frontal lobe).

Cognitive Outcomes. Cognition in WHICAP is assessed with a comprehensive neuropsychological battery (17) that assesses four cognitive domains: episodic memory, language, speed/executive functioning, and visuospatial functioning. The factor structure of the neuropsychological battery used in WHICAP has been demonstrated to be invariant across race, ethnicity, sex/gender (18) and language (19). Cognitive composites in WHICAP are derived by converting all cognitive test scores to z-scores using means and standard deviations from the overall sample at baseline and averaging them within each domain. Episodic memory composite scores include immediate, delayed, and recognition trials from the Selective Reminding Test (20). Language scores include measures of naming, letter and category fluency, verbal abstract reasoning, repetition, and comprehension. Speed/Executive Functioning scores include Color Trails I and II (21). Visuospatial scores include recognition and matching trials from the Benton Visual Retention Test (22), the Rosen Drawing Test (23), and the Identities and Oddities subtest of the Dementia Rating Scale (24). Prior research in WHICAP has linked the cortical thickness composite score to all four of these cognitive domains (25), and all four cognitive domains were moderately correlated ($.49 < r < .67$). Therefore, composite scores for the four domains were averaged, and global cognition used as our primary outcome variable. Secondary analyses examined the four cognitive domains separately.

Covariates. All analyses controlled for age, sex/gender, education, race, ethnicity, chronic disease burden, depressive symptoms, and total intracranial volume. Age was self-reported and continuous. Sex/gender was represented by a binary variable (males as the reference group). Race and ethnicity were represented by four mutually exclusive groups: non-Hispanic White, non-Hispanic Black, non-Hispanic Other and Hispanic (any race), with non-Hispanic White as the reference group. Education (0–20 years) was measured via self-report. Chronic disease burden was represented by the sum of 15 self-reported chronic conditions, such as diabetes, stroke and, heart disease. Depressive symptoms were quantified with a 10-item dichotomous version of the Center for Epidemiologic Studies Depression Scale (CES-D; 26). Total intracranial volume was derived from T1-weighted images using FreeSurfer version 6.0.

Analytic Strategy. In order to address Aim 1 (i.e., total network size), we initially conducted a multiple linear regression model to examine the main effects of total network size, cortical thickness and their interaction on global cognitive performance, controlling for covariates. Subsequent to this omnibus test of main effects and interactions, separate regressions were conducted for each of the four cognitive domains. To address Aim 2 (i.e., distinct social relationships), we ran a multiple linear regression model examining the unique effects of marital status, number of children, number of other relatives, number of friends, cortical thickness, and their corresponding interactions on global cognition, controlling for covariates. Following this omnibus test, we conducted separate regressions across each of the four cognitive domains. All analyses were conducted in SPSS (Version 27). All binary variables were contrast coded in all analyses. Continuous independent variables were standardized before computing interaction terms. Interactions of interest were subsequently graphed using the PROCESS Macro (27) after excluding other, nonsignificant interactions.

Results

Descriptive statistics of all variables of interest are reported in Table 1. Total social network size was not associated with cortical thickness (β= .05, *p*= .194), controlling for age, sex/gender, ethnicity, race and education. Similarly, marital status (β= .03, *p*= .405), number of children (β= -.01, *p*= .828), number of other relatives (β= -.03, *p*= .505), and number of friends (β= .07, *p*= .073) were not associated with cortical thickness, controlling for age, sex/gender, ethnicity, race and education.

Total Social Network Size. As shown in Table 2, individuals with lower cortical thickness had lower global cognitive scores. The interaction between cortical thickness and total network size was not significant (*p* = .073). To facilitate comparison with prior research (8), this interaction was dissected by graphing one standard deviation above and below the mean of our predictors variables (see Supplemental Figure 1). Simple slopes revealed that for individuals with a smaller social network size, lower cortical thickness was associated with worse global cognition (*t*= 2.73, *p*= .007). For individuals with a larger social network, there was no association between cortical thickness and global cognition (*t*= 0.22, *p*= .826).

Following this omnibus test for main effects and interactions, we ran analyses for each cognitive domain, and results are displayed in Table 3. For language, lower cortical thickness was significantly associated with lower performance. Neither social network size nor the interaction between cortical thickness and total network size was associated with language performance. For speed/executive functioning, larger total network size was associated with better performance. Neither cortical thickness nor the interaction between cortical thickness and total network size was associated with speed/executive function.

Neither social network size, cortical thickness, nor their interaction were associated with episodic memory or visuospatial functioning.

Individual Relationship Types. As shown in Table 4, a two-way interaction between number of friends and cortical thickness was found for global cognition. Simple slope analyses revealed that for individuals with fewer friends, lower cortical thickness was associated with worse global cognition (t= 2.43, p= .015), whereas no association between cortical thickness and global cognition was found for individuals with more friends (t= -.57, p= .565). No other main or interaction effects on global cognition emerged for number of children, number of relatives, or marital status.

Next, we ran analyses testing these associations for each cognitive domain, and these results are described in Table 5. A two-way interaction between number of friends and cortical thickness was found for language. Among individuals with fewer friends, lower cortical thickness was associated with worse language (t= 2.41, p= .017), whereas no association was found for those with more friends (t= -.59, p= .558). A similar two-way interaction between number of friends and cortical thickness was found for speed/executive functioning. Among individuals with fewer friends, lower cortical thickness was associated with worse speed/executive functioning (t= 2.08, p= .038), whereas no association was found for those with more friends (t= -1.46, p= .145). No significant main effects or interaction effects of cortical thickness and social network characteristics were found for episodic memory or visuospatial function.

Exploratory Analyses. As race and ethnicity may influence associations between social resources and cognitive functioning, race and ethnicity stratified models were conducted to assess whether the main finding (i.e., two-way interaction between friend networks and cortical thickness on cognition) was evident across groups. Friend networks moderated the effects of cortical thickness on global cognition for Non-Hispanic White participants (β = -.19, *p* = .045), but not Hispanic (β = -.10, *p* = .135) or non-Hispanic Black participants (β = -.10, *p* = .227). Similarly, friend networks moderated the effects of cortical thickness on language for Non-Hispanic White participants (β = -.23, *p* = .050), but not Hispanic (β = -.10, *p* = .149) or non-Hispanic Black participants (β = -.11, *p* = .207). In contrast, friend networks moderated the effect of cortical thickness on speed/executive function for Hispanic participants (β = -.17, *p* = .040), but not non-Hispanic White (β = -.18, *p* = .100) or non-Hispanic Black participants (β = -.15, *p* = .069).

Discussion

The current study examined the moderating role of social network size on the association between brain and cognitive health and the unique role of individual network components. We found that the moderating effect of social networks on the association between cortical thickness and global cognition was only significant for friend networks. Specifically, having more friends attenuated the association between lower cortical thickness and worse global cognition. Individuals with fewer friends showed an association between lower cortical thickness and worse global cognition, whereas individuals with more friends showed similar global cognitive performance across levels of cortical thickness. While cross-sectional, our findings are consistent with the hypothesis that social network characteristics, particularly larger friend networks, may contribute to cognitive reserve.

The Importance of Disaggregating Social Network Size

The current study extends the seminal study by Bennett et al (8), which focused on post-mortem Alzheimer's disease (AD) neuropathology, by measuring brain integrity *in vivo*. Our findings are in line with those of Bennett et al (8) in that individuals with smaller social networks showed an association between lower cortical thickness and lower global cognition, while individuals with larger social network showed no association between cortical thickness and global cognition. While this pattern of findings was consistent with Bennett and colleagues (8), it is important to note that the interaction between total social network size and cortical thickness was not statistically significant. The relatively weaker evidence for a moderating effect of total social network size on the brain-cognition relationship in the current study may be due to differences in measurement. Specifically, Bennett and colleagues examined AD neuropathology directly (i.e., a composite of amyloid-beta load and neurofibrillary tangle density; 8, 28). In contrast, the current study used an index of cortical thickness that has been shown to be sensitive to early Alzheimer's neurodegeneration (13). However, this index of cortical thickness conflates AD neurodegeneration with other sources of individual differences (e.g., genetic, developmental, environmental). It may be that social networks offer unique protection against acquired AD pathology in late life.

We found stronger evidence for a moderating effect of a particular component of social networks (i.e., friend networks), highlighting the importance of disaggregating social network size in studies of cognitive aging and considering social network composition. The moderating role of friends as opposed to family on brain-cognition links in the current study may be partly attributed to the distinct roles that family and friends play. Prior research showed that older adults identified friends as a greater source of companionship, whereas family was identified as a greater source of emotional and instrumental social support (29-30). In one experiential sampling study, older adults reported more positive subjective well-being when in the company of friends than when in the company of family (31) which may be attributable to the different types of activities conducted with friends versus family. That is, older adults reported engaging in more active leisure activities (i.e., hobbies, religious/cultural activities) when with friends, whereas they reported engaging in more maintenance (i.e., chores) and passive leisure activities (i.e., watching television) when with family (31). Thus, it may be that friendships confer unique cognitive benefits through companionship and shared activities/hobbies. Consistent with this notion, cross-sectional and longitudinal research has shown that higher activity engagement mediates the positive association between friendship and cognition (10, 32).

Contrary to our predictions, current marital status did not moderate the link between cortical thickness and cognition. Prior research suggested that being partnered may benefit cognitive functioning through increased economic resources, social support, and reduced risky health behaviors through spousal monitoring (see review, 33). As socioeconomic resources and health behavior pathways may also contribute to brain health, it may be that brain health mediates the association between marital status and cognition rather than marital status moderating brain-cognition associations. Of note, the current study did not find an association between marital status and cortical thickness. Future research is necessary to disentangle the links between marital status, brain health and cognition.

The Unique Role of Social Networks for Language and Speed/Executive Functioning

We also extended previous work by testing whether findings persisted across four cognitive domains. Our finding that larger friend networks attenuated the link between lower cortical thickness and worse cognition was evident for language and speed/executive functioning, and not episodic memory or visuospatial functioning. These domain-specific effects may shed light on mechanisms underlying the potential beneficial cognitive effects of larger friend networks.

One potential mechanism may involve cognitive stimulation via verbal interaction. Specifically, greater engagement in conversations may uniquely promote language and speed/executive functioning skills. Prior research has shown that engagement in even in a 10-minute verbal interaction promotes better working memory, processing speed (34) and executive functioning (35). In one experimental study, individuals who engaged in a discussion with another participant for 10-minutes performed better on tasks of working memory and processing speed than those who watched a video clip (see Study 2; 34).

Further, the magnitude of this cognitive advantage was comparable to that observed for participants who completed 10 minutes of mentally stimulating activities (e.g., crossword puzzle; 34). In line with these findings, older adults who engaged in a six-week intervention study involving daily, 30-minute web-enabled, face-to-face conversational interactions showed improvements in both letter and semantic fluency, but not in other cognitive domains, compared with older adults in a control group who received a weekly phone call (36). Together, these experimental and intervention studies point to a unique causal association between verbal interaction and cognitive domains of language and speed/executive functioning, which supports the current pattern of domain-specific results.

Having more opportunities to actively engage in verbal communication may also uniquely engage frontal brain regions that support performance on many of the included language and speed/executive functioning tasks, such as verbal fluency, verbal abstraction, and set-shifting. For example, verbal interactions have been linked to stronger neural networks involving the frontal cortex through the demands of perspective taking and planning (37). The finding that both main effects and interactions involving social network variables were unique to those cognitive domains that included frontally-mediated tasks may also support the role of frontal lobe networks in cognitive reserve. Specifically, compensatory frontal lobe networks have been suggested to underlie the maintenance of cognitive performance in the face of AD neuropathology in the temporal lobes (38). Future research is needed to explore whether larger social networks may contribute to cognitive reserve through mechanisms involving frontal lobe networks.

Limitations and Future Directions

There are limitations to the current study. First, the study is cross-sectional, and the potential for reverse causation warrants caution in interpreting the direction of our findings. While recent longitudinal research indicates that larger friend networks predict less subsequent cognitive decline but not vice versa (12), additional longitudinal research is necessary to disentangle the associations between social network characteristics and long-standing versus acquired differences in brain health. Second, although the primary model focused on global cognition showed that friend networks moderated the effect of cortical thickness, caution in interpreting the results of subsequent, domain-specific models is warranted due to the number of models conducted (i.e., spurious findings). Third, the current study was likely under-powered to adequately test for three-way interactions between cortical thickness, friend networks, and race/ethnicity. Exploratory race/ethnicity-stratified models suggested that two-way interactions between cortical thickness and friend networks differed across groups, consistent with prior research suggesting that race and ethnicity moderate the impact of social resources on cognitive function (39). Future research should confirm these racial/ethnic differences and investigate potential mechanisms. Fourth, to maximize comparability with the previous clinicopathologic study of social networks (8), we used a single measure of brain health: average cortical thickness across nine 'AD Signature' regions (1). Future research should further investigate whether these findings are also consistent across other, specific brain regions sensitive to AD pathology such as the hippocampus. Fifth, the current study focused on structural aspects of social network characteristics, and future research should incorporate information on functional (e.g., support) and quality (e.g., relationship satisfaction) aspects of social relations on brain-cognition associations. More detailed data on the nature of individuals' social interactions (e.g., shared activities) is needed to clarify the mechanisms underlying the current pattern of results.

Finally, although only larger friend networks were associated with higher cognition across levels of cortical thickness, these results do not imply that family relationships are not an important resource in later life. Family members provide more long-term care and social support as well as social control to reduce unhealthy/risky behaviors (30). Thus, friends and family may provide distinct resources in contextually different circumstances.

Conclusions

The current study found that larger friend networks attenuated the association between lower cortical thickness in AD-signature regions and worse cognition such that older adults with more friends showed relatively high language and speed/executive performance regardless of cortical thickness. While our study was cross-sectional, this pattern of results is consistent with the notion that friends represent a psychosocial resource that helps to promote cognitive reserve. The specificity of findings with regard to friends versus other network members and cognitive domains of language and speed/executive functioning versus episodic memory and visuospatial functioning may further point to potential mechanisms underlying the potential protective effects of social networks. As total network size, a more general index of social network, was not found to moderate brain-cognition associations, the current study also highlights the importance of examining individual relationships types, which may provide distinct resources that differentially influence cognitive health. Such knowledge can inform future intervention research investigating whether and how social networks could be harnessed to help maintain cognitive health in the face of age-related brain changes.

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Table 1

Sample Characteristics

	M or %	*SD*
Age	76.52	5.77
% Female	62.40	-
Education	12.58	4.56
Chronic disease burden (0-15)	2.69	1.57
Race and ethnicity		
% non-Hispanic White	26.00	
% non-Hispanic Black	33.00	-
% Hispanic	38.10	-
% Other	2.90	-
Total Intracranial Volume (mm^3)	1410120.13	171932.99
Depressive Symptoms (0-10)	1.32	1.70
Cortical Thickness (mm)	2.62	0.11
Number of Children	1.90	1.78
Number of Relatives	2.40	3.04
Number of Friends	3.23	5.77
% Married/partnered	36.30	-
Total Social Network Size	7.84	7.29

Table 2

Regression Coefficients for Total Social Network Size, Cortical Thickness and their Interaction on Global Cognition

	Main Effects					With Interaction Term				
	B	SE	β	*p*	95% CI	B	SE	β	*p*	95% CI
Global Cognition										
Cortical Thickness	.04	.02	.06	.040	.00, .07	.04	.02	.06	.038	.00, .07
Social Network Size	.02	.01	.05	.088	-.00, .05	.03	.01	.07	.027	.00, .06
Size x CT	-	-	-	-	-	-.03	.01	-.05	.073	-.05, .00

Note. CT = Cortical Thickness, Size = Total Social Network Size.

Table 3

Regression Coefficients for Total Social Network Size, Cortical Thickness and their Interaction on Cognitive Domains

	Main Effects					With Interaction Term				
	B	SE	*β*	*p*	95% CI	B	SE	*β*	*p*	95% CI
Model 1: Memory										
Cortical Thickness	.04	.03	.05	.169	-.02, .10	.04	.03	.05	.173	-.02, .10
Social Network Size	.04	.02	.06	.087	-.01, .08	.05	.02	.07	.051	.00, .09
Size x CT	-	-		-	-	-.02	.02	-.04	.312	-.07, .02
Model 2: Language										
Cortical Thickness	.04	.02	.06	.031	.004, .08	.04	.02	.06	.029	.004, .08
Social Network Size	.02	.02	.04	.181	-.01, .05	.03	.02	.06	.058	-.001, .06
Size x CT	-	-	-	-	-	-.03	.02	-.05	.061	-.06, .001
Model 3: Speed/Executive Function										
Cortical Thickness	.04	.03	.04	.234	-.02, .09	.04	.03	.04	.236	-.02, .09
Social Network Size	.05	.02	.07	.025	.01, .09	.06	.02	.10	.007	.02, .11
Size x CT	-	-	-	-	-	-.04	.02	-.06	.108	-.09, .01
Model 4: Visuospatial										
Cortical Thickness	.02	.02	.04	.210	-.01, .06	.02	.02	.04	.205	-.01, .06
Social Network Size	-.02	.02	-.03	.291	-.04, .01	-.01	.02	-.02	.500	-.04, .02
Size x CT	-	-	-	-	-	-.02	.02	-.03	.349	-.05, .02

Note. CT = Cortical Thickness, Size = Total Social Network Size.

Table 4

Regression Coefficients for Social Network Components, Cortical Thickness and their Interactions on Global Cognition

	Main Effects					**With Interaction Terms**				
	B	SE	β	*p*	95% CI	B	SE	β	*p*	95% CI
Global Cognition										
Cortical Thickness	.03	.02	.05	.126	-.01, .06	.03	.02	.05	.142	-.01, .07
Number of Children	-.03	.02	-.04	.204	-.07, .01	-.02	.02	-.03	.293	-.06, .02
Number of Relatives	.01	.02	.01	.700	-.03, .04	.00	.01	.00	.900	-.03, .04
Number of Friends	.02	.01	.05	.074	-.00, .05	.04	.01	.08	.009	.01, .06
Married/Partnered	.03	.02	.06	.066	-.00, .07	.03	.02	.05	.075	-.00, .07
Children x CT	-	-	-	-	-	.01	.02	.01	.793	-.04, .05
Relatives x CT	-	-	-	-	-	-.00	.02	-.01	.841	-.04, .03
Friends x CT	-	-	-	-	-	-.03	.01	-.07	.020	-.06, -.01
Partner x CT	-	-	-	-	-	-.00	.02	-.01	.838	-.04, .03

Note. CT = Cortical Thickness, Children = Number of Children, Relatives = Number of Relatives, Friends = Number of Friends, Partner = Married/Partnered.

Table 5

Regression Coefficients for Social Network Components, Cortical Thickness and their Interactions on Cognitive Domains

	Main Effects					With Interaction Terms				
	B	SE	β	*p*	95% CI	B	SE	β	*p*	95% CI
Model 1: Memory										
Cortical Thickness	.04	.03	.05	.214	-.02, .10	.04	.03	.05	.211	-.02, .10
Number of Children	-.03	.03	-.03	.439	-.09, .04	-.03	.03	-.03	.459	-.09, .04
Number of Relatives	.01	.03	.01	.815	-.05, .06	.01	.03	.01	.746	-.05, .06
Number of Friends	.04	.02	.07	.063	-.00, .08	.04	.02	.08	.060	-.00, .09
Married/Partnered	.04	.03	.04	.249	-.02, .09	.03	.03	.04	.269	-.03, .09
Children x CT	-	-	-	-	-	-.02	.03	-.02	.557	-.09, .05
Relatives x CT	-	-	-	-	-	-.04	.03	-.04	.268	-.10, .03
Friends x CT	-	-	-	-	-	-.01	.02	-.02	.567	-.05, .03
Partner x CT	-	-	-	-	-	.02	.03	.02	.569	-.04, .08
Model 2: Language										
Cortical Thickness	.03	.02	.05	.129	-.01, .07	.02	.02	.03	.315	-.02, .06
Number of Children	-.03	.02	-.04	.158	-.08, .01	-.03	.02	-.04	.225	-.07, .02
Number of Relatives	.01	.02	.02	.695	-.02, .05	.01	.02	.01	.670	-.03, .05
Number of Friends	.02	.01	.04	.149	-.01, .05	.04	.02	.07	.019	.01, .07
Married/Partnered	.02	.02	.03	.295	-.02, .06	.02	.02	.03	.269	-.02, .06
Children x CT	-	-	-	-	-	.00	.02	.00	.938	-.04, .05
Relatives x CT	-	-	-	-	-	-.01	.02	-.01	.773	-.05, .04
Friends x CT	-	-	-	-	-	-.03	.01	-.07	.026	-.06, -.00
Partner x CT	-	-	-	-	-	-.03	.02	-.05	.108	-.07, .01

Model 3: Speed/Executive Function										
Cortical Thickness	.03	.03	.03	.382	-.03, .09	.05	.03	.05	.161	-.02, .11
Number of Children	-.01	.03	-.01	.730	-.08, .06	.00	.03	.00	.987	-.07, .07
Number of Relatives	.01	.03	.01	.764	-.04, .06	-.00	.03	-.00	.923	-.06, .05
Number of Friends	.04	.02	.07	.037	.002, .08	.07	.02	.12	.002	.03, .11
Married/Partnered	.05	.03	.07	.078	-.01, .11	.05	.03	.06	.127	-.01, .10
Children x CT	-	-	-	-	-	.05	.04	.05	.171	-.02, .12
Relatives x CT	-	-	-	-	-	.01	.03	.02	.686	-.04, .08
Friends x CT	-	-	-	-	-	-.06	.02	-.12	.002	-.11, -.02
Partner x CT	-	-	-	-	-	.02	.03	.03	.485	-.04, .08
Model 4: Visuospatial										
Cortical Thickness	.02	.02	.03	.385	-.02, .06	.02	.02	.03	.395	-.02, .06
Number of Children	-.02	.02	-.04	.282	-.07, .02	-.02	.02	-.03	.336	-.07, .02
Number of Relatives	-.00	.02	-.01	.888	-.04, .03	-.01	.02	-.01	.706	-.04, .03
Number of Friends	-.01	.01	-.03	.336	-.04, .01	-.00	.02	-.01	.841	-.03, .03
Married/Partnered	.02	.02	.04	.255	-.02, .06	.02	.02	.04	.264	-.02, .06
Children x CT	-	-	-	-	-	.00	.02	.01	.846	-.04, .05
Relatives x CT	-	-	-	-	-	.01	.02	.02	.589	-.03, .05
Friends x CT	-	-	-	-	-	-.02	.01	-.05	.177	-.05, .01
Partner x CT	-	-	-	-	-	-.00	.02	-.00	.901	-.04, .04

Note. CT = Cortical Thickness, Children = Number of Children, Relatives = Number of Relatives, Friends = Number of Friends, Partner = Married/Partnered.

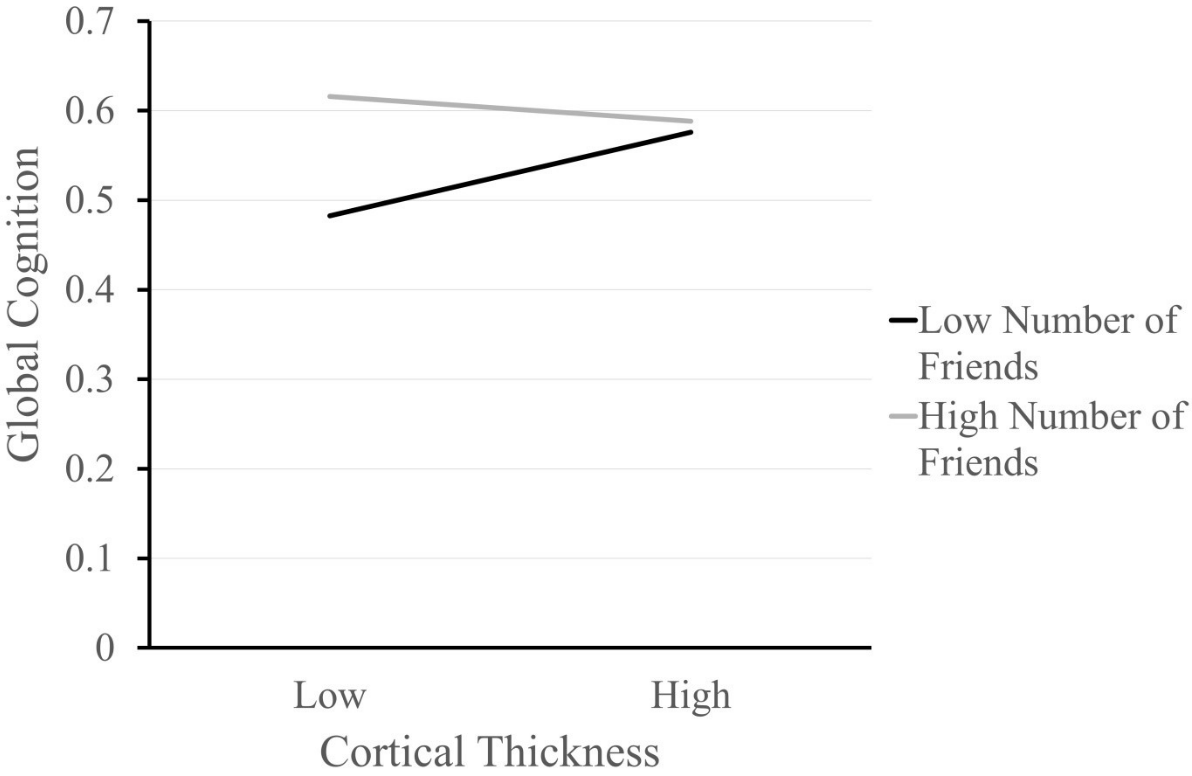

Figure 1. Number of Friends by Cortical Thickness interaction for Global Cognition. One standard deviation above and below the mean were used as points to plot for number of friends and cortical thickness.

RESEARCH IN CONTEXT

Systematic Review: Authors searched the literature for relevant literature using databases (e.g., PsycInfo, Google Scholars) to identify relevant studies focused on the associations between social relations, cognitive functioning, and brain health in older adulthood.

Interpretation: This cross-sectional study clarifies previous research suggesting a potential protective effect social networks by identifying later-life friendships as a particularly important social resource for maintaining cognitive performance in the context of poorer brain health. This is the first study to examine the unique role of individual social relationships (partner, children, friends, relatives) in moderating brain-cognition associations.

Future Directions: Longitudinal and intervention research is necessary to extend these cross-sectional finding. Additionally, future research is needed to investigate the potential mechanisms, such as cognitively stimulating social interactions, that may underlie the potentially protective effects of social networks.