

Social Relationships, Cognition, and Well-Being in Very Old Age



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I conceptualized, analyzed, and wrote all three studies. I developed the research questions and hypotheses, designed the methodological framework, conducted the data analyses, interpreted the results, and took primary responsibility for writing all three manuscripts. Dr. Andrés Oliva y Hausmann supported me in designing the statistical analysis plan of the first study and he revised the manuscript drafts of this study. He also provided feedback on the manuscript for the second study. Prof. Dr. Susanne Zank supervised the research process of all three studies and provided valuable feedback throughout the writing process for each study.

Declaration of AI-Assisted Technologies

The AI-assisted tool Grammarly was used to improve grammar, spelling, and overall writing quality. The manuscript was carefully reviewed afterward. Therefore, I take full responsibility for the content of this dissertation.

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Zusammenfassung

Die Dissertation untersuchte die bidirektionalen Zusammenhänge zwischen Kognition und sozialen Beziehungen im sehr hohen Alter. Die Hochaltrigkeit, definiert als Alter ab 80 Jahren, ist eine Lebensphase mit besonderen Stärken und Vulnerabilitäten. Kognitive Beeinträchtigungen stellen in dieser Altersgruppe ein häufiges Gesundheitsrisiko dar. Bei der Prävention kognitiver Beeinträchtigungen spielen Lebensstilfaktoren eine wichtige Rolle. Insbesondere soziale Beziehungen werden als ein zentraler veränderbarer Lebensstilfaktor betrachtet. Studien haben gezeigt, dass verschiedene soziale Aspekte mit besserer kognitiver Leistungsfähigkeit und einem geringeren Risiko für kognitive Beeinträchtigungen im Alter assoziiert sind. Allerdings stammen die meisten Ergebnisse aus Studien mit Teilnehmenden unter 80 Jahren, wenngleich anzunehmen ist, dass die Zusammenhänge altersabhängig sind. Zudem wurde in der Forschung häufig vernachlässigt, dass die Assoziationen zwischen sozialen Beziehungen und Kognition bidirektional sind, denn auch kognitive Beeinträchtigungen können soziale Beziehungen beeinflussen.

Auf Basis dieses theoretischen Hintergrunds beantwortete die Dissertation zwei Forschungsfragen in drei wissenschaftlichen Artikeln. Die erste Frage untersuchte, ob und welche sozialen Aspekte mit der Kognition im sehr hohen Alter zusammenhängen und somit zur Reduktion des Risikos kognitiver Beeinträchtigungen beitragen könnten. Die zweite Forschungsfrage beleuchtete, wie sich kognitive Beeinträchtigungen auf soziale Beziehungen auswirken und wie diese Zusammenhänge mit dem Wohlbefinden verbunden sind. Beide Forschungsfragen wurden auf Basis der Studie zur Lebensqualität und zum Wohlbefinden hochaltriger Menschen in NRW (NRW80+ Studie) beantwortet.

In der ersten Studie ($n = 518$) waren strukturelle soziale Aspekte als Maß für „social bridging“ positiv mit der globalen Kognition über das sehr hohe Alter assoziiert. Es zeigten sich keine Zusammenhänge mit funktionalen und qualitativen Aspekten als Maß für „social bonding“. Die zweite Studie zeigte ebenfalls positive querschnittliche Assoziationen zwischen strukturellen Aspekten, globaler Kognition und episodischem Gedächtnis ($n = 1207$),

allerdings sagten soziale Aspekte nicht die kognitive Leistungsfähigkeit zwei Jahre später vorher ($n = 639$). Die dritte Studie ($n = 1516$) zeigte, dass Personen mit kognitiven Beeinträchtigungen, insbesondere mit schweren Formen, ein hohes Risiko für eine reduzierte soziale und psychische Gesundheit aufwiesen. Zudem waren niedrige Werte in sozialen Aspekten bei Teilnehmenden mit schweren kognitiven Beeinträchtigungen stärker mit einem geringen Wohlbefinden verbunden als bei Teilnehmenden ohne kognitive Beeinträchtigung.

Zusammenfassend unterstreicht die Dissertation, dass soziale Aspekte im Rahmen von „social bridging“ positiv mit der kognitiven Leistungsfähigkeit im sehr hohen Alter assoziiert sind. Dass die Zusammenhänge ausschließlich querschnittlich beobachtet wurden, deutet darauf hin, dass soziale Beziehungen eher als lebenslange Ressource statt als kurzfristiges Interventionsziel für die Kognition im sehr hohen Alter zu verstehen sind. Darüber hinaus verdeutlichen die Ergebnisse nicht nur die Bedeutung sozialer Beziehungen für die Prävention kognitiver Beeinträchtigungen, sondern auch für das Wohlbefinden von Betroffenen. Personen mit kognitiven Beeinträchtigungen, die einen großen Anteil der hochaltrigen Bevölkerung ausmachen, sollten daher stärker in zukünftige Forschungsprojekte eingeschlossen werden. Abschließend empfiehlt die Dissertation, soziale Teilhabe über die Lebensspanne hinweg zu fördern. Besonders im sehr hohen Alter kommt es aus mehreren Gründen zu einer Verkleinerung des peripheren Netzwerks, während enge Beziehungen häufig gut aufrechterhalten werden. Die Förderung sozialer Partizipation unterstützt den Erhalt dieser breiteren Netzwerke, was sowohl der kognitiven Leistungsfähigkeit als auch dem Wohlbefinden zugutekommt. Gezielte Maßnahmen sollten vor allem altersbedingte Barrieren für soziale Teilhabe abbauen, die durch sensorische, körperliche oder kognitive Beeinträchtigungen entstehen können.

Schlagwörter: Sehr hohes Alter; Hochaltrigkeit; soziale Beziehungen; kognitiver Abbau; kognitive Beeinträchtigung; Demenz; Wohlbefinden

Abstract

The dissertation examined the bidirectional associations between cognition and social relationships in very old age. Very old age, defined as 80 years and older, represents a life phase with unique strengths and vulnerabilities. In this age group, cognitive impairment is a common health risk. Lifestyle factors have been shown to play an important role in preventing cognitive impairment. In particular, social relationships have been identified as a key modifiable lifestyle factor. Prior studies have shown that multiple social aspects are associated with higher cognitive functioning and a lower risk of cognitive impairment in old age. Meanwhile, most findings stem from research on adults younger than 80 years, while there is reason to assume that the associations are age-dependent. Furthermore, research has often overlooked the bidirectional nature of the associations between social relationships and cognition, as cognitive impairment also affects social relationships.

Based on this theoretical framework, the dissertation addressed two main research questions within three scientific articles. The first question investigated whether and which social aspects are associated with cognition in very old age and may thus help reduce the risk of cognitive impairment in this age group. The second research question examined how cognitive impairment is linked to social relationships and how these associations are connected to well-being. Both research questions were answered using data from the Study on Quality of Life and Well-Being of the Very Old in North Rhine-Westphalia (NRW80+ Study).

In the first study ($n = 518$), structural social aspects, as measures of social bridging, were positively associated with global cognition throughout very old age. Functional/qualitative aspects, as measures of social bonding, showed no significant associations. The second study also observed positive cross-sectional associations between structural social aspects, global cognition, and episodic memory ($n = 1207$), but no associations between social aspects and cognition 2 years later ($n = 639$). The third study ($n = 1516$) found that individuals with cognitive impairment, particularly with severe forms,

showed a high risk of poor social and mental health. Moreover, lower social outcomes were more strongly associated with reduced well-being among participants with severe cognitive impairment compared to those without cognitive impairment.

In summary, the dissertation revealed that social aspects, as related to social bridging, are positively associated with cognitive functioning in very old age. The fact that the associations were only cross-sectional suggests that social relationships serve as a life course resource rather than a short-term intervention target for cognition in very old age. Moreover, the findings highlight the importance of social relationships not only in preventing cognitive impairment but also in supporting the well-being of those affected. Individuals with cognitive impairment, who represent a large proportion of the very old population, should be included more in future research projects. Finally, the dissertation recommends promoting social participation throughout the lifespan. Particularly in very old age, peripheral social networks tend to shrink for several reasons, while close relationships are often strengthened. Encouraging social participation supports the maintenance of these broader ties, benefiting both cognitive functioning and well-being in very old age. Targeted measures should include reducing age-related barriers to social participation, such as those due to sensory, physical, and cognitive impairment.

Keywords: Very old age; social relationships; cognitive decline; cognitive impairment; dementia; well-being

List of Articles

Article 1

Vogel, S., Oliva y Hausmann, A., & Zank, S. (2024). Exploring the associations between structural and functional aspects of social relationships and cognition in very old age. *Aging & Mental Health*, 28(12), 1642–1649.
<https://doi.org/10.1080/13607863.2024.2348616>

Article 2

Vogel, S., Oliva y Hausmann, A., & Zank, S. (2024). Does the positive association between social relationships and cognition continue until very old age? *European Journal of Ageing*, 21(1), 39. <https://doi.org/10.1007/s10433-024-00835-9>

Article 3

Vogel, S., & Zank, S. (2026). Important for preventing but also living well with cognitive impairment – The associations between social relationships, well-being, and cognition in very old adults. *International Psychogeriatrics*, 38(1), 100109.
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Abbreviations

AD	Alzheimer's Disease
Ceres	Cologne Center for Ethics, Rights, Economics, and Social Sciences of Health
DemTect	Dementia Detection Test
DIA-S4	Depression in Old Age Short Scale
DLB	Dementia with Lewy Bodies
BvFTD	Behavioral-variant Frontotemporal Dementia
FTD	Frontotemporal Dementia
FTLD	Frontotemporal Lobar Degeneration
GDS	Global Deterioration Scale
ICD	International Statistical Classification of Diseases and Related Health Problems
LBD	Lewy Body Dementia
MCI	Mild Cognitive Impairment
MMSE	Mini-Mental State Examination
NRW80+ Study	Study on Quality of Life and Well-Being in North Rhine-Westphalia
PANAS	Positive and Negative Affect Schedule
PD	Parkinson's Disease
PDD	Parkinson's Disease Dementia
PPA	Primary Progressive Aphasia
SAVI	Strengths and Vulnerability Integration
SD	Standard Deviation
SOC Model	Selection, Optimization, and Compensation Model
SST	Socioemotional Selectivity Theory
VaD	Vascular Dementia
W_1	First Measurement Wave
W_2	Second Measurement Wave

Introduction

The demographic change is an ongoing, well-known trend. One of its main mechanisms is the increase in life expectancy. Humans have never lived longer than they do today. In Germany, a person born in 1950 has an average life expectancy of around 70 years, while their great-grandchild born in 2020 is already expected to live around 81 years (United Nations Department of Economic and Social Affairs, 2024). The trend underscores the plasticity of the aging process and the ability to positively modify one's development over the lifespan (Staudinger, 2020). It also reflects historical advances in societal and health care systems that enable us to reach such an old age. At the same time, the increasing life expectancy brings challenges. While we tend to live longer, our healthy life years are not rising at the same pace, which is associated with greater care and medical needs in older age (Choi et al., 2024). Furthermore, increasing life expectancy extends the period after retirement, creating individual and societal challenges (Albertini & Vignoli, 2025).

Another main mechanism of the demographic change is the decline in birth rates. Along with the increase in life expectancy, it substantially changes the age distribution in our society. The process is intensified by the aging of the baby boomers, a proportionally large cohort born in a period of high birth rates. In particular, the group of very old adults (80+ years) is growing faster than any other group in many countries (United Nations Department of Economic and Social Affairs, 2023). To illustrate, around 1% of the German population in 1950 was 80 years or older (Statistisches Bundesamt, 2022). Today, very old adults account for around 7% of the population and are expected to reach 12% by 2050. These shifts in age distribution place increasing pressure on labor, pension, and healthcare systems, as the ratio of employees to retirees declines and the care needs of older adults rise. At the same time, they reshape family roles and structures, for example, by increasing expectations for children to provide care for their aging parents.

In a nutshell, people are living longer while birth rates are declining in many countries. Although these trends represent human achievements and successes, they also pose new

challenges on the individual and societal levels. On the individual level, challenges include changing family structures, extended post-retirement lifespans, and prolonged periods of medical and care needs. At the societal level, the trends put pressure on pension systems, healthcare services, and labor markets.

Very Old Age

Since very old adults historically represented a small fraction of the population, they received limited attention in research so far. With their numbers increasing due to the rising life expectancy, it is crucial to study them more closely, as they tend to differ from younger age groups in their attributes and life circumstances (Malik & Lyketsos, 2020).

It is helpful to start with two perspectives that have shaped research on aging and human development: the lifespan approach and the life course approach. The lifespan approach, rooted in psychology, focuses on individual development from birth to death. It examines changes in biological, cognitive, and psychosocial functioning over the lifetime, with particular attention to adaptation and plasticity (Mayer, 2003). For instance, lifespan researchers may examine how older adults adapt to declines in memory or attention. In contrast, the life course approach, grounded in sociology, views aging as a dynamic process shaped by cumulative social and environmental exposures such as culture or education (Mayer, 2003). Using the same example, a life course researcher would rather address how life experiences, such as occupation or education, affect memory in older age. In their original form, the two perspectives therefore differ in their focus. Today, the concepts tend to overlap more and complement each other, offering a more holistic understanding of aging. Hence, very old age should be understood as the outcome of both internal adaptation and accumulating external exposures.

An influential framework that defines very old age as a unique life phase is the approach of the third and fourth age (Baltes & Smith, 2003). It primarily reflects a lifespan perspective and extends the concept of “successful aging” (Rowe & Kahn, 1997). Successful

aging was one of the first concepts that defined aging not only in terms of decline but also by its potential for growth. It depicts an ideal that goes beyond the absence of disease.

Successful aging is characterized by high physical and mental functioning, an active engagement with life, and a low risk of illness. Baltes and Smith use these initial criteria to distinguish “third agers” from “fourth agers”, therefore, implying that the groups have differing potential to age successfully. The third age, from approximately 60 to 80 years, is generally depicted as a phase of good physical health and active engagement with life, aligning with the definition of successful aging. Recent studies even report further health improvements in this age group across cohorts (Gerstorf et al., 2023; Halloran, 2024). The fourth age, from around 80 years onwards, is characterized as a more vulnerable phase with a higher risk for health and functional declines due to chronic diseases, multimorbidity, frailty, and cognitive impairment (Brijoux et al., 2021; Jaul & Barron, 2017). These risks are associated with higher care needs and a less independent lifestyle, limiting the potential of successful aging. From this perspective, very old adults have often been depicted as a particularly vulnerable group in research on healthy aging.

Meanwhile, critics have highlighted the deficit-oriented and negative connotations inherent in these theories (Wahl & Ehni, 2020). Firstly, they argue that the concept of successful aging creates unrealistic standards, implying that individuals with illnesses or disabilities can only be “unsuccessful agers”. This overlooks other relevant factors, such as individual and environmental aspects, as well as subjective characteristics that shape aging (Plugge, 2021; Tesch-Römer & Wahl, 2016). Secondly, critics have pointed out the substantial within-group differences of very old adults (Curtis et al., 2017). In other words, aging is not uniform and people vary heavily in their aging trajectories. To illustrate, Lowsky et al. (2014) found that 37% of adults aged 60 to 64 scored the maximum on the EQ-5D, a measure of health-related quality of life. The proportion declined to 20% among those aged 80 to 84 and 16% among adults aged 85 and older. At the same time, however, the gap between the healthiest and least healthy individuals increased with age and reached its maximum in the 85+ group. These results highlight the considerable within-age-group

variation among very old adults, which should not be overlooked when interpreting between-age-group differences.

Furthermore, even in the presence of health declines, the outcomes on daily life vary per person due to personal adaptation and plasticity. This is also described by the Selection, Optimization, and Compensation (SOC) model (Baltes & Baltes, 1989). The model encompasses three main adaptive strategies to cope with age-related declines: Selection, Optimization, and Compensation. Selection involves prioritizing and focusing on important goals, optimization involves enhancing resources to achieve these goals, and compensation involves finding alternative ways to compensate for losses. For example, an older person who enjoys gardening but shows arthritis may select fewer plants, optimize their efforts by practicing motor skills, and compensate for limitations by using efficient tools. Similarly, someone with mobility limitations but a desire to stay socially active may select the most meaningful social events to attend, optimize their energy and time to get there, and compensate for fewer outside activities by regularly calling social ties. These processes are examples of how individual adaptation helps people to maintain daily functioning and well-being, even when facing health challenges. It may also explain why very old adults typically report better subjective health than objective health measures suggest (Plugge, 2021; Wettstein et al., 2016), or why older adults maintain emotional well-being despite the experiences of meaningful losses in their social surroundings (Rook & Charles, 2017).

Overall, the section underscores that older people, regardless of whether they are “third agers” or “fourth agers”, can retain independence, agency, and well-being. On that account, the present dissertation uses the distinction between “young old adults” and “very old adults” only to emphasize the average between-group risks, while acknowledging the substantial within-group differences and individual trajectories.

Cognitive Decline, Cognitive Impairment, and Dementia

Cognitive functioning is essential for maintaining an independent and active lifestyle, as defined by the concept of successful aging. Meanwhile, cognitive impairment is linked to an increased need for care, assistance, and support (Hussenoeder et al., 2020). Due to the detrimental effects on autonomy and daily living functioning, cognitive impairment represents one of the costliest and most time-intensive health conditions (Jönsson et al., 2023). It places a substantial burden on affected individuals, their families and caregivers, and healthcare systems. Burdens reach from economic and financial costs to emotional challenges and strain related to the high care needs.

Age represents one of the strongest predictors of cognitive impairment and related disorders such as dementia (Murman, 2015). When we age, the brain undergoes structural and functional changes. Structural changes refer to physical alterations, such as the loss of neurons, whereas functional changes address modifications in how signals are transmitted throughout the brain, such as decreased neuronal firing (Murman, 2015). These age-associated changes increase the vulnerability of older adults to experience cognitive decline and cognitive impairment. It explains why cognitive impairment becomes particularly prevalent in very old age and represents one of the most common health concerns among older adults (Maust et al., 2020). In Europe, approximately 12% of individuals aged 80 to 84 years and about 40% of those aged 90 years and older are estimated to show cognitive impairment (Georges et al., 2020).

The causes for such an impairment are diverse. There are multiple conditions and diseases that can underlie it. In very old age, the presence of multimorbidity often complicates the identification of the exact underlying conditions. Furthermore, experiencing other health disorders can aggravate cognitive impairment and increase its negative impact on daily life (Neubert et al., 2021).

Cognitive Decline Versus Cognitive Impairment

The terms cognitive decline, cognitive impairment, and dementia are often used interchangeably, although they refer to slightly different constructs. Cognitive decline simply describes a decrease in cognitive abilities. This process also occurs in normal brain aging and begins as early as young adulthood (Murman, 2015). Normal brain aging is associated with several structural and functional brain changes, such as synaptic loss and altered connectivity (Murman, 2015). Importantly, it is not characterized by widespread neuronal death, which makes it different from pathological brain aging. To illustrate, a somewhat older but influential study by Hedman et al. (2012) reports an annual loss of 0.2% in brain volume from 35 years onwards. At age 60, the loss slightly accelerates to approximately 0.5% per year. Roughly estimated, this means that a person aged 80 years old shows around 15% less brain volume compared to when they were 35 years old. However, the brain can partly compensate for this gradual tissue loss by reorganizing and optimizing its neural networks. As a result, cognitive changes in normal brain aging are generally subtle and do not substantially interfere with daily functioning.

Normal brain aging can affect all cognitive domains, including complex attention, memory and learning, executive functions, language, perceptual–motor functions, and social cognition (Sachdev et al., 2014). However, the type and extent of change vary across the domains. While some cognitive abilities decline noticeably with increasing age, others remain stable or even increase. Specifically, in normal brain aging, cognitive decline is more pronounced in the so-called fluid cognitive abilities. These are abilities that largely depend on information processing speed, such as working memory and attention. Especially, episodic memory tends to be affected by aging. It shows a modest decline until around 65 years, after which the decline accelerates (Salthouse, 2019). In contrast, the so-called crystallized skills tend to increase across the lifespan, often reaching a plateau in very old age (Murman, 2015). They refer to all knowledge and experience-based abilities, such as semantic and factual knowledge. Therefore, normal brain aging is associated with subtle declines in some

cognitive skills, while others remain intact and can even be used to compensate for losses in the other domains.

In contrast, cognitive impairment is not a part of normal brain aging and goes beyond normal age-related cognitive decline. It refers to a decline that significantly deviates from age-, education-, and sex-adjusted norms. Depending on its severity, it can be classified as mild or major/severe. In clinical practice, cognitive performances deviating by -1.0 to -2.0 standard deviations (SD) from the normative mean are typically interpreted as mild cognitive impairment (MCI) (Sachdev et al., 2014; Salardini, 2019). Performances deviating more than -2.0 SD from the normative mean are generally considered a major impairment. It means that the performance is in the bottom 2.5% of the normal distribution for people of the same age, sex, and education. This is an exceptionally low performance, too rare to be expected in healthy individuals with these demographics. In most cases, major cognitive impairment occurs in the context of dementia and is often due to pathological brain aging (Sachdev et al., 2014). Although MCI is also considered a risk factor for dementia, it does not always represent an early stage of it. Studies show that MCI does not always progress and can remain stable over time or sometimes even revert to a norm-appropriate level (Oltra-Cucarella et al., 2018). Hence, in clinical practice, MCI is usually classified based on the affected cognitive domain. When memory impairment is involved, it is referred to as amnesic MCI. Amnesic MCI is more strongly linked to the development of dementia compared to non-amnesic MCI, in which memory is not involved (Jessen et al., 2014).

Finally, it is important to note that in both non-pathological and pathological brain aging, there is a high variability in the individual trajectories (Salthouse, 2019). It underscores that although age is a very strong predictor of cognitive impairment, it is not the only factor related to its development.

Dementia: Clinical Definition and Underlying Etiologies

Dementia is a clinical syndrome characterized by a set of cognitive and psychiatric symptoms. It is also defined in the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), which is currently used as the diagnostic manual in Germany (World Health Organization, 2016). While cognitive impairment is an essential criterion, the diagnosis includes other criteria, such as symptoms persisting for at least 6 months and significant impairments in daily functioning. Importantly, the 11th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-11) has replaced the term "dementia" with "neurocognitive disorders", reflecting a shift toward a more symptom-based and less etiological classification (World Health Organization, 2019). In fact, dementia arises from various underlying etiologies. The vast majority of dementia cases are primary dementias. It means their origin lies within the brain, mostly characterized by irreversible neurodegenerative or vascular processes (Salardini, 2019). In contrast, secondary dementias result from potentially reversible causes outside the brain, such as major depression, thyroid dysfunction, or vitamin deficiencies (Sachdev et al., 2014).

For this dissertation, it is important to distinguish between cognitive impairment and dementia, because our data captures cognitive impairment through neuropsychological testing but does not include information on underlying etiologies. Nonetheless, most severe forms of cognitive impairment in older age are part of dementia and caused by pathological brain processes (Sachdev et al., 2014). Therefore, the following sections discuss the most frequent forms and pathologies of dementia and cognitive impairment.

The most common neurodegenerative cause of dementia is Alzheimer's Disease (AD). It accounts for approximately 55% to 70% of all primary dementia cases, although estimates vary widely across studies (Jellinger & Attems, 2015; Salardini, 2019). The symptoms usually start after 65 years. An exception is early-onset AD, accounting for a small fraction of AD cases, as it is defined by a symptom onset before the age of 65 years (Salardini, 2019). In the brain, AD is associated with two main pathological features. Outside

the nerve cells, abnormal accumulations of the protein beta-amyloid are found, which are called amyloid plaques. Inside the nerve cells, neurofibrillary tangles occur, which are abnormal accumulations of the tau protein (Du et al., 2018). Together, they disrupt neuronal communication and eventually cause cell death. The process mostly begins in the temporal lobe, a brain region important for learning and memory, and later spreads to other brain areas. It clarifies why symptoms of AD often start with episodic memory decline. Although beta-amyloid and tau are important markers of AD, they are not considered the origin of the disease. Several hypotheses attempt to explain why they occur, including the inflammation hypothesis and the oxidative stress hypothesis (Du et al., 2018). So far, none of the hypotheses has been confirmed as the definitive explanation. An exception is early-onset AD, where the disease is frequently familial, meaning that it tends to occur more within families. These forms have been linked to specific genetic mutations (Salardini, 2019).

The second most common neurodegenerative dementia is Lewy Body Dementia (LBD). As the name implies, it is characterized by Lewy bodies, abnormal accumulations of the protein alpha-synuclein inside the nerve cell (Salardini, 2019). These accumulations are also found in Parkinson's Disease (PD), which links the two conditions pathologically. However, PD primarily impairs motor function as Lewy bodies are concentrated in the motor regions of the brain, like the substantia nigra. LBD typically produces both cognitive and motor symptoms, reflecting the more widespread distribution of Lewy bodies throughout the brain. Individuals often exhibit early deficits in attention, visuospatial abilities, and motor control, as well as sleep-related problems. Some authors further distinguish LBD into Dementia with Lewy bodies (DLB) and Parkinson's Disease Dementia (PDD). This classification is based on the timing of symptoms. In DLB, cognitive impairment precedes or arises within one year of Parkinsonism, whereas in PDD, cognitive symptoms develop more than one year after Parkinsonism (Salardini, 2019).

Another neurodegenerative form of dementia is frontotemporal dementia (FTD). It is caused by frontotemporal lobar degeneration (FTLD), which usually starts in the frontal and temporal lobes (Urso et al., 2025). Unlike AD and LBD, the protein pathology of FTD remains

less well-defined. FTD manifests in two clinical variants: Behavioral-variant FTD (bvFTD) and Primary Progressive Aphasia (PPA). BvFTD predominantly involves degeneration in the frontal lobe, thereby causing early impairments in “frontal” cognitive abilities such as attention and executive functions. They often go along with behavioral changes such as impulsivity or apathy. In PPA, affected brain areas are more centered in the temporal lobe. This yields various speech deficits, including speech production, comprehension, or word retrieval. PPA subdivides into three subtypes depending on the dominant speech deficit (nonfluent/agrammatic, semantic, or logopenic variants). Overall, FTD is less common in older adults and often begins before the age of 65. However, in the group of adults younger than 65 years, it represents a leading form of dementia (Urso et al., 2025). Due to its young age of onset, its consequences are often more profound because individuals tend to be working or have parenting responsibilities. Moreover, symptoms tend to mimic psychiatric disorders, which often delays diagnosis and appropriate treatment (Urso et al., 2025).

Besides neurodegeneration, vascular processes can also lead to dementia. Vascular forms of dementia are summarized under the umbrella term vascular dementia (VaD). VaD encompasses a range of vascular events that disrupt the blood flow in the brain. It can include multiple small infarcts, large or strategic infarcts, and various forms of vessel disease (Salardini, 2019). As a result, the symptoms of VaD vary widely depending on the location and extent of the brain lesions. Symptoms often cover broader deficits in attention, executive functions, and visuospatial abilities (Jekel & Wagner, 2020). Many individuals show a general slowing of cognitive processes and demonstrate more motor symptoms compared to those with neurodegenerative forms of dementia, including gait apraxia or incontinence (Salardini, 2019). Furthermore, the progression of VaD is generally less predictable and less continuous than that of neurodegenerative dementias. It often involves rather abrupt and sudden declines, when new lesions and damage occur.

With advancing age, multiple pathological processes can also occur simultaneously and become intertwined. Estimates of “mixed dementia” differ widely among studies, ranging from 10 % to 93 % (Jellinger & Attems, 2015). In fact, many cases of mixed dementia remain

undiagnosed as the identification is resource-intensive and current diagnostic tools lack sensitivity. Still, it is crucial to acknowledge mixed dementia forms, as they explain atypical symptoms, unexpected progressions, or poor responses to treatments.

Diagnosing dementia represents a mix of neuropsychological and medical testing (Jessen et al., 2014). In its early stages, dementia forms can often be distinguished clinically by their symptoms (Jekel & Wagner, 2020). However, it becomes more difficult in later stages when the pathology becomes more widespread or when pathologies get mixed. Therefore, medical examinations are needed to support the process. Most importantly, this includes the examination of biomarkers, which are measurable indicators of pathological processes, e.g., amyloid and tau in AD (Jessen et al., 2014). It further involves brain imaging to detect structural or functional changes, and the use of differential diagnostic procedures to exclude other potential causes of cognitive impairment like thyroid dysfunctions. This combination of neuropsychological testing and medical examination is crucial, as also medical findings alone are insufficient for the diagnosis of dementia. As shown in the Nun Studies (Riley et al., 2005), many aging individuals show pathological brain processes without developing cognitive symptoms. This occurs due to the brain's ability to buffer pathological effects, a phenomenon commonly known as cognitive reserve (Livingston et al., 2024). Cognitive reserve can be thought of as a resource that the brain can use to maintain cognitive functioning despite damage. This works by improving signal transmission in the brain or building compensating brain networks (Leuner & Gould, 2010), and the process is fueled by healthy lifestyle exposures (Livingston et al., 2024). In summary, combining results from multiple disciplines is essential for accurately diagnosing dementia and identifying its underlying causes.

Dementia: Course and Progression

The progression of dementia can be described along seven stages according to the Global Deterioration Scale (GDS) (Reisberg et al., 1982). In stage one, the affected person shows no cognitive deficits yet, although biomarkers may already be measurable and indicate the presence of pathological brain changes. In stage two, the person shows a very mild cognitive decline, which is often only noticed subjectively or by close others. In stage three, cognitive impairment becomes detectable through neuropsychological testing in the form of MCI. However, daily functioning remains largely intact, although compensatory strategies may already be needed in some activities. Stage four is associated with moderate deficits that interfere with daily life functioning. It typically represents the stage at which a diagnosis of dementia is given. In stage five, cognitive decline intensifies, including an increased need for daily living assistance. Stage six is characterized by severe cognitive impairment, with phases of confusion as well as behavioral and personality changes. The affected person shows total dependence in daily life. Stage seven demonstrates the end stage of the continuum. It includes such severe cognitive impairment that communication is almost impossible, as well as the decline of basic motor functions, impairing walking, toileting, and swallowing.

The average life expectancy after the diagnosis of dementia ranges from 3 to 8 years, often ending in death due to complications related to dementia, such as infections and falls (Wolters et al., 2019). Importantly, the course of dementia varies by age, co-existing health conditions, and underlying pathology. Progression speed and severity are also heavily influenced by strategies to delay or prevent dementia (Wolters et al., 2019). It implies that not every person necessarily goes through all the GDS stages, nor does everyone spend the same amount of time in each stage.

Preventing Cognitive Impairment and Dementia

As stated, cognitive impairment in older age often occurs as part of dementia and arises from pathological brain processes (Sachdev, 2022). Although most forms of dementia remain incurable, research like the Nun Study (Riley et al., 2005) shows that not all individuals with brain pathology develop clinical symptoms. Consequently, current health strategies not only aim to prevent the development of pathology but also to prolong symptom onset. For this, they target modifiable lifestyle risk factors, as current research indicates that around 45% of dementia cases could be prevented by addressing risks such as low education, hearing loss, and social isolation (Livingston et al., 2024). For example, encouraging regular physical activity not only helps slow the progression of brain pathology but also strengthens cognitive reserve.

Furthermore, current health strategies rely on early detection and early intervention. The combination of lifestyle risk profiles, biomarkers, and cognitive testing can support detection by identifying at-risk individuals. Early diagnosis enables timely interventions that can slow progression and improve quality of life. Especially considering recent advances in disease-modifying therapies, such as Lecanemab. Here, early diagnosis is valuable because these treatments are most effective in the early stages of dementia. Overall, effective management of dementia and cognitive impairment requires an integrated approach combining prevention and early detection. Modifiable lifestyle risk factors play an essential role in these approaches.

Social Relationships

Social relationships are important throughout the entire lifespan, and humans are often described as the “social species”. Historically, social relationships have been crucial because group membership supported our survival. Being part of a group protected against environmental threats and improved access to essential resources like food and water. Compared to other species, humans are highly dependent on others at birth and require

constant support to survive. The importance of social relationships from early on has been highlighted in several influential studies and theories. It starts with the disturbing studies on emotional deprivation in orphaned babies by René Spitz (1945) or the attachment theory by John Bowlby (1978). They have shown that early secure bonds are fundamental for health and well-being, while absent or insufficient bonds can have long-lasting negative consequences.

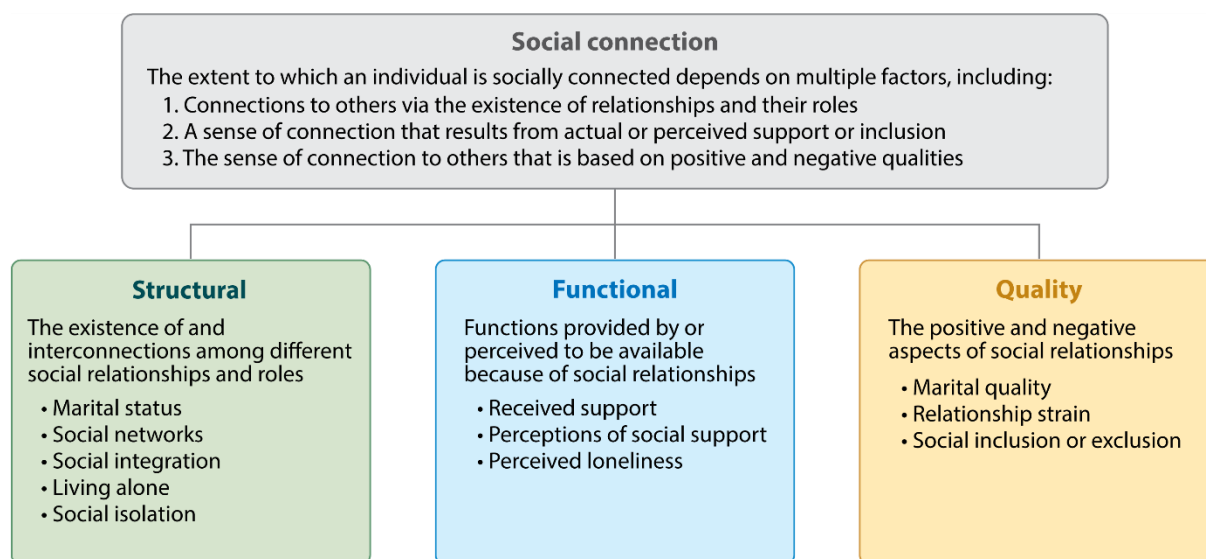
But social relationships are not only important in the early stages of life. They remain meaningful for health and well-being until oldest age (Holt-Lunstad, 2018). One of the most prominent studies illustrating their beneficial influence is the Harvard Study of Adult Development. It is one of the longest-running studies of human life. It followed participants for more than 75 years to examine predictors of health and well-being in older age. In the study, good social relationships were the strongest predictors of long-term health, cognitive functioning, and overall well-being, compared to all other measured factors (Waldinger & Schulz, 2023). Other studies further report that social relationships predict not only health but also morbidity and life expectancy, highlighting their meaning for the whole life course (Holt-Lunstad et al., 2015).

Theoretical Definitions of Social Relationships

But what is meant by “good” social relationships? Social relationships are complex, which makes them difficult to capture and define in research. As shown in Figure 1, there are many different social aspects. These can be categorized into three dimensions, namely structure, function, and quality. The structure refers to rather objective aspects such as the number of network members, contact frequency, or regular engagement in social activities. It addresses how many people someone interacts with and how often these interactions occur. The function describes the mechanisms within these social structures, such as the different kinds of support that we receive. Emotional support involves showing care, offering comfort and consolation, and fostering a sense of worth. Instrumental support refers to tangible

assistance, such as practical advice or guidance. Support not only addresses how much we receive but also how much we provide, and the balance between them. Research has shown that a disbalance between giving and receiving support, including both giving too much and receiving too much, is negatively associated with our health and well-being (Sims et al., 2014). Some literature also classifies loneliness as a functional social measure, emphasizing that it reflects unmet social needs and, therefore, the absence of sufficient functional aspects (Holt-Lunstad, 2018). Lastly, the dimension of quality summarizes the positive and negative aspects of our relationships, such as levels of satisfaction and strain. While a relationship can be close and trusting, it may still involve stress or conflict.

So, to answer the question of what “good” social relationships mean, determining what counts as “good” is difficult. Having many social contacts does not guarantee a close bond with others or much emotional support. Likewise, high emotional support does not always come with low relationship strain. In other words, all dimensions together determine the extent to which social relationships are beneficial for health and well-being, and each contributes in different ways. This often challenges researchers to measure social relationships in ecologically valid ways.

Figure 1*Dimensions of Social Relationships*

 Holt-Lunstad J. 2018.
Annu. Rev. Psychol. 69:437–58

Note. Reprinted from Holt-Lunstad J. (2018). Why social relationships are important for physical health: A systems approach to understanding and modifying risk and protection. *Annual Review of Psychology*, 69(1), 437–458. <https://doi.org/10.1146/annurev-psych-122216-011902>. Copyright 2018 by Annual Reviews. Reprinted with permission.

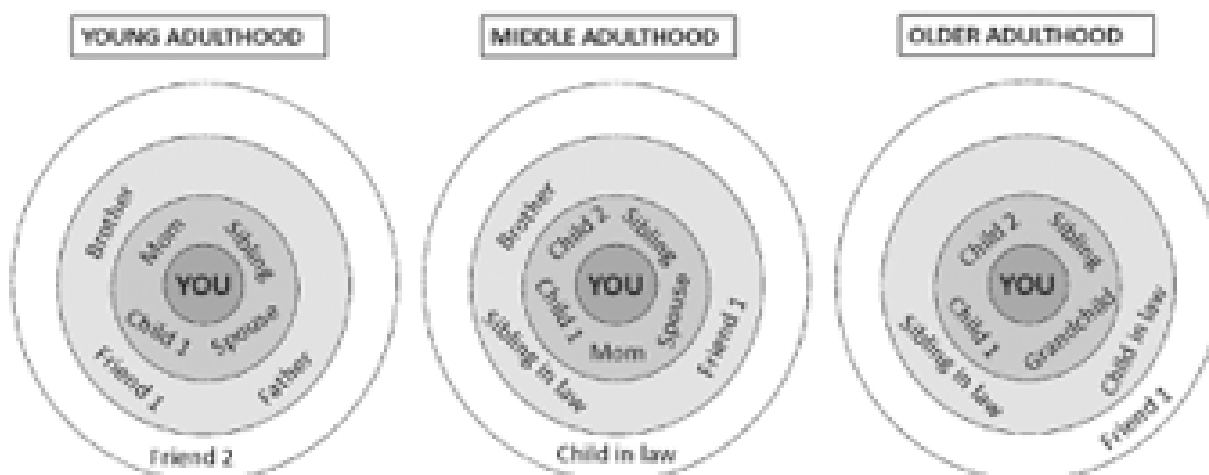
Social Relationships Throughout the Life Course

Another challenge for research is that social relationships are not static but evolve over the life course. The Social Convoy Model, introduced by Kahn and Antonucci (1980), illustrates these dynamics by organizing social networks into concentric circles around us. These are defined based on their varying levels of intimacy (see Figure 2). The inner circle represents our closest ties, such as spouses, children, parents, or siblings, who provide the primary support. The middle circle summarizes our moderately close relationships, like close friends or other important family members. They are important and supportive ties, but less central than the inner circle. The outer circle consists of more distant connections, such as

colleagues, acquaintances, or neighbors. While these are less intimate, they still play a relevant role for us, by providing support or access to information. The model highlights that social convoys are multidimensional and each one is shaped by different structural, functional, and qualitative characteristics. These are influenced by both personal and situational factors. Personal factors encompass individual aspects such as age, gender, and race, while situational factors refer to the wider context and environment in which a person lives, such as the geographic location and cultural norms.

Importantly, the Convoy Model adopts a life course perspective, describing how social relationships gradually change in response to age-related life events (Antonucci et al., 2014). These changes are not only driven by the external event itself but also by our reaction to it. Hence, it proposes that due to external and internal changes, some social ties may strengthen, and others may weaken with increasing age. Overall, the inner circle tends to remain more stable throughout life, while the outer circle is more vulnerable to change (Antonucci et al., 2019; Fuller et al., 2020).

In older age, retirement often marks a critical life transition that reduces peripheral, work-related contacts (Halloran, 2024). Furthermore, health declines, chronic illnesses, mobility issues, or frailty can restrict broader social participation, particularly leading to changes in the outer circle (Escourrou et al., 2022; Rodrigues et al., 2025). For instance, gait problems may prevent an older person from attending activities at a community center when it is not barrier-free. Similarly, vision loss may make it difficult to leave home alone, limiting opportunities to socially interact. Compared with younger groups, the inner circle also becomes more vulnerable to change. As we get older, the death of a spouse, sibling, or close friend becomes more frequent, which significantly reshapes the inner circle (Brittain et al., 2017). Especially, widowhood displays a critical age-related life event that is difficult to cope with, even in the presence of a strong support system (Freak-Poli et al., 2025). To summarize, social networks tend to shrink with increasing age. It primarily addresses the outer circle, although changes also affect the inner convoy more often than at a younger age.

Figure 2*The Social Convoy Model Over the Life Course*

Note. Reprinted from Fuller, H. R., Ajrouch, K. J., & Antonucci, T. C. (2020). The Convoy Model and later-life family relationships. *Journal of Family Theory & Review*, 12(2), 126–146.

<https://doi.org/10.1111/jftr.12376>. Copyright 2020 by Journal of Family Theory & Review.

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Besides these negative changes, older adults often maintain close and supportive social relationships (Bruine de Bruin, 2020; Fuller et al., 2020; Paine et al., 2022). This has been shown as early as the 1980s, in studies such as the National Supports of the Elderly Study (Antonucci, 1985). It demonstrated that older adults maintain close, meaningful social ties, challenging the idea that aging necessarily leads to social isolation. Indeed, the Convoy Model acknowledges that older adults are not at the mercy of critical life events. They can actively reshape their social networks, like strengthening existing ties to compensate for losses. The idea aligns with the widely recognized Socioemotional Selectivity Theory (SST) (Carstensen, 2006). SST suggests that aging changes our social goals and motivations. When we perceive our remaining lifetime as long-lasting, such as in young adulthood, our social goals tend to be more knowledge-focused. It means that we view social relationships primarily as sources for learning new information, gaining experiences, and accessing new

opportunities. In contrast, when we perceive our remaining lifetime as limited, such as in very old age, our social goals shift towards emotional satisfaction and fulfillment. Therefore, older adults intentionally focus on close and emotionally rewarding relationships that enhance the feelings of connectedness and belonging, while reducing their investment in peripheral contacts (Carstensen, 2006; Rook & Charles, 2017). Connecting it to the observation that older adults often experience social losses and network shrinkage, these shifts help them to align their networks with goals that sustain emotional well-being.

Indeed, the motivational changes are accompanied by cognitive and behavioral strategies. First, older adults tend to focus on and selectively remember the positive aspects of social situations, even when negative events occur. The process is known as positive reappraisal (Shiota & Levenson, 2009). The strategy serves as an important adaptive mechanism, protecting emotional well-being and satisfaction. Second, older adults are more likely to avoid conflict in their social interactions (Luong et al., 2011), thereby promoting harmony and reducing strain in their relationships. Their prosocial behaviors often elicit positive responses from their social partners, as suggested by the Social Input Model (Fingerman & Charles, 2010). It further fosters positive social interactions and strengthens intimacy. These findings underscore the efforts that older adults make to maintain emotional balance and well-being in their social relationships.

Another important model that explains how emotional well-being is maintained in older age is the Strengths and Vulnerability Integration (SAVI) model (Charles, 2010). It not only acknowledges the differences between young and old adults but also focuses on the within-group heterogeneity among older adults. It postulates that older adults often report higher well-being than younger adults because they avoid and reduce exposure to stressful, high-arousal situations. However, during unavoidable or high-arousal stressors, these age differences decrease, and older adults seem more physiologically vulnerable to these stressors (Charles, 2010). Once the stressor passes, their well-being tends to recover more quickly than that of younger adults. Hence, SAVI provides a final piece of the puzzle in explaining why older adults tend to report higher emotional and social well-being than

younger adults, while also accounting for increases in distress among some older individuals, such as when faced with health declines or meaningful losses, such as widowhood. It underscores that certain age-related social challenges remain particularly difficult to overcome (Freak-Poli et al., 2025).

In a nutshell, the models and frameworks demonstrate that aging involves both social challenges and opportunities. They highlight how older adults can cope with ongoing social changes and maintain emotional well-being by developing strategies that help sustain or rebuild their social connections.

Social Relationships and Cognition

The Harvard Study of Adult Development has highlighted the impact of social relationships on health, well-being, and cognition. Indeed, social relationships are seen as a key factor for maintaining cognitive functioning and for preventing cognitive impairment. The Lancet Commission currently identifies social isolation as the prime risk factor for dementia in older adults, responsible for about 5% of the individual risk (Livingston et al., 2024). Meta-analyses have consistently shown the beneficial effects of social aspects on cognitive performance, cognitive decline, and the risk of developing dementia (Kuiper et al., 2015; Kuiper et al., 2016; Piolatto et al., 2022; Samtani et al., 2022). Particularly, structural social aspects such as a large network and frequent contact have been linked to less cognitive decline and a lower risk of cognitive impairment (Evans et al., 2019; Fan et al., 2021; Rodrigues et al., 2025). Other studies have also found positive effects of functional and qualitative aspects, such as emotional support and closeness (Maddock et al., 2023). The magnitude of the associations is comparable to other lifestyle factors such as physical activity and depression (Bourassa et al., 2017).

Several mechanisms have been found to explain the positive findings between social aspects and cognition in old age. A useful way to contextualize them is by the distinction between social bonding and social bridging, visualized in Figure 3 (Perry et al., 2022;

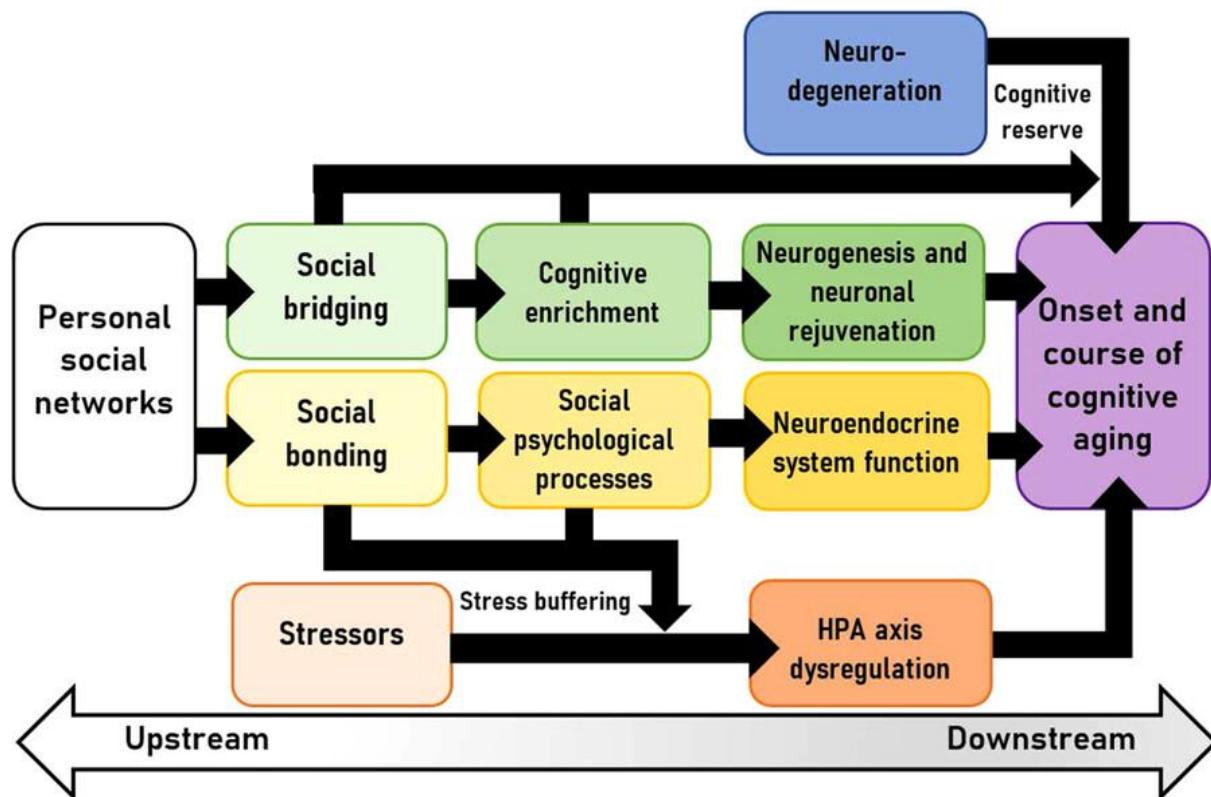
Samtani et al., 2022). Social bonding addresses our close relationships, which are the primary source of emotional support and provide a sense of belonging. Social bonding is, therefore, mainly captured by functional and qualitative social aspects. It is assumed to benefit cognition by reducing stress and promoting well-being. Among others, it helps regulate stress-related physiological processes such as elevated cortisol and inflammation, which negatively impact brain functions and are thereby associated with cognitive decline (Hostinat et al., 2015; Ouanes & Popp, 2019). To illustrate, Hülür et al. (2022) reported that widowhood negatively affects cognitive functioning, likely due to elevated stress and grief. However, for people with strong social support, these negative effects of widowhood on cognition were reduced. Furthermore, supportive social relationships reduce the risk of depressive symptoms, a well-known risk factor for cognitive decline (Wiels et al., 2020). In contrast, social bridging often involves weaker, more diverse ties that provide access to new information and experiences. It is mainly captured by structural measures. Bridging is assumed to enhance cognition because it requires individuals to navigate and adapt to new social situations. This exercises cognitive functions and stimulates the brain. It aligns with the “use-it-or-lose-it” principle, which proposes that cognitive skills are maintained through regular exercise, while abilities decline when they are not regularly used (Sachdev, 2022). Evidence on neuroplasticity further supports the bridging theory. Plasticity is the brain’s ability to form new neural connections and strengthen existing ones. It is a process triggered by mental stimulation and exercise. By frequently engaging in diverse social interactions, individuals can form new neural pathways and strengthen existing ones. In this way, they also build more cognitive reserve, which has previously been introduced as a buffer against neuropathological damage. Plasticity is particularly observed in the hippocampus, a brain region primarily responsible for learning and memory, which is the cognitive domain most affected by aging (Leuner & Gould, 2010). Lastly, bonding and bridging can both support cognition by promoting a healthier lifestyle. Friends and family can motivate and model positive health behaviors, including nutritious meals, physical activity, adherence to medical treatments, quitting smoking, and regular health check-ups (Holt-Lunstad, 2018; Sachdev,

2022). Among others, it helps to reduce the risk of cardiovascular disease and, consequently, vascular damage in the brain (Sommerlad et al., 2023). Moreover, a healthier lifestyle can support better management of visual and hearing impairments, with hearing loss being linked to an increased risk of cognitive decline (Livingstone et al., 2024).

Together, bridging and bonding form a theoretical framework for understanding how social relationships can support cognitive functioning and prevent cognitive impairment in older age. The processes should not be seen as purely passive, as individuals can actively initiate them. For example, when someone experiences stress and reaches out to friends for emotional support, they are activating bonding mechanisms. From this perspective, it also becomes clear that the use of these mechanisms varies across individuals due to differences in personality and health. For instance, cognitively healthy adults can use these mechanisms effectively, seeking support or engaging with social contacts when needed. In contrast, it becomes more challenging for people with cognitive impairment. They might have difficulty expressing their needs when facing distress or initiating new contacts when feeling lonely. The example highlights a key drawback of the model: It was developed for cognitively healthy individuals. It explains why many studies exclude people with cognitive impairment from this type of research. They aim to ensure that the observed associations reflect the protective effects of social relationships rather than the consequences of cognitive impairment. Indeed, the model of bridging and bonding is vulnerable to reverse causality, as cognitive decline could limit social engagement rather than social ties protecting against cognitive impairment (Piolatto et al., 2022). Therefore, studies must use methodological approaches such as excluding individuals with cognitive impairment or using longitudinal designs to reduce the possibility of reverse causality.

Figure 3

Social Bridging and Social Bonding on the Development of Cognitive Impairment



Note. Reprinted from Perry, B. L., McConnell, W. R., Coleman, M. E., Roth, A. R., Peng, S., & Apostolova, L. G. (2022). Why the cognitive “fountain of youth” may be upstream: Pathways to dementia risk and resilience through social connectedness. *Alzheimer’s & Dementia*, 18(5), 934–941. <https://doi.org/10.1002/alz.12443>. Copyright 2022 by Alzheimer’s & Dementia. Reprinted with permission.

Social Relationships and Cognition in Very Old Age

While much research has investigated social relationships as protective factors against cognitive impairment, little research has examined whether the associations vary by age group. As proposed by Baltes and Smith (2003), young old and very old adults tend to differ in their health and social resources. These differences may influence the extent to which social relationships can protect cognitive functioning, because rising biological

vulnerabilities and reduced social resources in very old age may limit their beneficial effects. Therefore, it is useful to examine the associations between social relationships and cognition among different age groups.

While some studies have found positive associations between social relationships and cognition in very old age (Huang et al., 2023; Röhr et al., 2020), others have questioned these findings. For instance, Vos et al. (2017) found that lifestyle-related risk factors did not predict cognitive impairment in very old adults, unlike in middle-aged and young old adults. Similarly, Grothe et al. (2022) reported that social networks were not predictive of cognitive impairment in very old age after accounting for survival biases. Those findings suggest that the impact of social relationships on cognition becomes more variable in very old age. This could be due to selection and composition processes that occur when survival is not random but is driven by specific, sometimes unknown factors. It can make the absence of protective factors appear less harmful or even neutral. For instance, people who have been socially isolated for years but reach very old age without developing cognitive impairment may possess unmeasured but compensating traits that explain the absence (Vos et al., 2017). Another explanation aligns with the idea that the mechanisms linking social relationships to cognition are not purely passive but depend on an individual's cognitive and physiological capacity. Pathological processes that accumulate with age may limit the impact of lifestyle factors by decreasing the brain's responsiveness to bridging and bonding. In other words, at some point, the “hardware” may not respond to the “software” anymore. The idea is supported by findings demonstrating that while the average cognitive performance of older adults has improved over recent decades, the timing and trajectory of cognitive decline have remained largely unchanged (Gerstorf et al., 2023). Taken together, there is good reason to believe that the positive associations between social relationships and cognition may be weaker among very old adults than young old adults.

Social Relationships, Cognitive Impairment, and Well-Being

Another gap in the research is that, although much has been done on the associations of social relationships and cognition before the onset of cognitive impairment, far less attention has been paid to how cognitive impairment shapes social relationships. Considering the growing number of people affected by cognitive impairment, it is important to understand how these changes influence social networks and participation in later life. In Germany, cognitive impairment is estimated to affect around 43% of very old adults (Brijoux & Zank, 2023). Even if this percentage remains stable over the next few years, the expected growth in absolute numbers of very old adults will result in a substantial increase in the total number of individuals with cognitive impairment. As long as effective treatment is lacking for most causes of cognitive impairment in old age, the focus remains on maintaining quality of life for those affected. This is also a key objective of the “living well with dementia” approach (Kim & Shin, 2023). It aims to find possibilities to support individuals in maintaining quality of life and well-being despite their cognitive impairment. Thereby, it addresses critiques of “successful aging” by shifting the focus toward aging well in individuals with health conditions such as dementia, groups that have traditionally been seen as “unsuccessful agers”. A central element of the approach lies in the promotion of meaningful social relationships, activities, and interactions (Martyr et al., 2018; Tragantzopoulou & Giannouli, 2021). These are vital for well-being because they provide emotional support, reduce stress, and foster a sense of belonging (Holt-Lunstad, 2018), but are also crucial sources for self-worth and identity (Huizenga et al., 2022).

In fact, the occurrence of cognitive impairment fundamentally reshapes a person’s social life. As proposed by the Convoy Model, social relationships change in response to major life events (Antonucci et al., 2014; Kahn & Antonucci, 1980). This includes the experiences of health conditions such as cognitive impairment or dementia. Declines in memory, attention, or language make social interactions more demanding. The affected person may find it harder to follow conversations, recall shared experiences, or express their thoughts clearly. This gradually changes their social interaction patterns and, over time, their

relationship dynamics. For instance, role shifts are common when people become more dependent and need care (Shiff et al., 2025). Most illustrative is the example of spousal care. When one spouse increasingly takes on a caregiving role for the other, support becomes more one-sided, and the reciprocity of the relationship decreases. These kinds of role shifts can be difficult to accept and to adjust to for both social sides. While not the core focus of the dissertation, it is noteworthy that cognitive impairment not only affects the individuals but also imposes a substantial burden on their families, friends, and other caregivers (Shiff et al., 2025). Besides role shifts, cognitive impairment makes misunderstandings and communication difficulties more frequent. This can lead to frustrations on both sides. Social network members may withdraw because of misunderstandings, related insecurities, or underlying stigma. For the person with cognitive impairment, misunderstandings can cause embarrassment, fear, or shame, which may result in further withdrawal from social situations. These examples demonstrate how cognitive impairment can reshape both the composition and the dynamics of the social networks.

Such developments are also captured by the Unmet Needs Model (Cohen-Mansfield et al., 2015). The framework was developed to explain behavioral and psychological symptoms in people with dementia (Cohen-Mansfield & Werner, 1995). The Unmet Needs Model views these symptoms as a consequence of frustrated needs rather than as an inevitable part of dementia. It proposes that cognitive impairment reduces the individual's ability to meet a broad range of basic needs. These include physical, psychological, environmental, and social needs. Hence, people with cognitive impairment increasingly depend on others to fulfill those needs. At the same time, however, communication becomes more challenging for them. They may struggle to take part in conversations and may find it difficult to express and communicate their feelings and needs to others. This again makes it more difficult for caregivers and other social partners to understand and identify the needs of the affected person. As a result, a spiral of frustration can develop. To illustrate, a person with cognitive impairment who feels lonely may struggle to name and express this emotion. Instead, they may scream for help, follow others around, or get angry when someone leaves

the room. The Unmet Needs Model interprets these behaviors as attempts to communicate the unmet needs for companionship and interaction. For others, however, the behavior may seem agitated and difficult to understand. Thus, they may respond with irritation rather than emotional support, further frustrating the person with cognitive impairment. Therefore, the Unmet Needs Model highlights the importance of recognizing and satisfying the underlying needs of people with cognitive impairment and dementia to support their well-being. It also underscores how cognitive impairment reduces opportunities for bridging and bonding and heightens the vulnerability to lower social health.

Individuals with cognitive impairment report a strong desire to remain socially active, maintain reciprocal relationships, and preserve their social identity (Huizenga et al., 2022; Patterson et al., 2018). At the same time, research demonstrates that they have smaller social networks, show lower levels of social participation, and report more loneliness than individuals without cognitive impairment (Dyer et al., 2021; El Haj et al., 2016; Hackett et al., 2019). This trend is particularly pronounced in those living in institutional settings (Nikmat et al., 2015). The contrast between their desire to stay socially connected and their limited opportunities to do so may explain why well-being is often lower in people with cognitive impairment than in those without (Mank et al., 2022). For instance, social isolation has been associated with reduced quality of life, lower well-being, and increased neuropsychiatric symptoms in people with cognitive impairment, with effects varying by its severity (Carbone et al., 2022; Rippon et al., 2024; Sun et al., 2020). Even more, individuals with cognitive impairment who lived alone reported lower well-being than those living with others, although they showed better cognitive and functional abilities (Clare et al., 2024). It suggests that the observed reductions in well-being may be driven more by social changes than by the cognitive decline itself. In fact, positive relationships and interactions have been associated with higher well-being and life satisfaction for people with cognitive impairment (Lee et al., 2017). For instance, a high relationship quality with carers has been shown to buffer the negative effects of loneliness and social isolation on well-being in people with dementia

(Rippon et al., 2024). Moreover, regular social interaction and engagement have been shown to improve mood and reduce psychiatric and behavioral symptoms (McDermott et al., 2019).

In summary, this section underscores the heightened risk of people with cognitive impairment experiencing lower social health. It also emphasizes their vulnerability to reduced well-being due to lower social connections. At the same time, it demonstrates how social engagement can actively promote well-being among people with cognitive impairment. In this way, it responds to critiques of successful aging, which primarily address the potential for aging well in the absence of diseases, and stresses the relevance of supporting quality of life in groups facing frequent health issues such as cognitive impairment and dementia.

Aims of the Present Dissertation

In summary, very old adults represent a rapidly growing age group in many countries. Compared to young old adults, they experience distinct social and health challenges (Baltes and Smith, 2003). The risk of cognitive impairment increases significantly in very old age (Georges et al., 2020). Social relationships are associated with a reduced risk of cognitive impairment (Piolatto et al., 2022), but these associations may vary by age group (Vos et al., 2017). Most research has focused on young old adults, with meta-analyses typically reporting an average age of 65 to 75 years (Kuiper et al., 2015; Kuiper et al., 2016; Piolatto et al., 2022). Additionally, while social factors have been widely studied as protective, less attention has been given to how cognitive impairment relates to social relationships.

This dissertation examines the two-way relationship between social relationships and cognition in very old age, guided by two research questions. **First, it examines whether and which social aspects are positively associated with cognitive performance in very old age, cross-sectionally and longitudinally.** The goal is to identify social factors that can reduce the risk of cognitive impairment in very old age. Accordingly, the focus lies on individuals who do not yet show major cognitive impairment. We hypothesize that social aspects, particularly structural aspects, are positively associated with cognition in old age,

cross-sectionally and longitudinally. The hypothesis is grounded in prior findings from young old adults, and some evidence in very old age, in which aspects related to social bridging were particularly strong predictors of cognition (Huang et al., 2023; Piolatto et al., 2022; Röhr et al., 2020). **Second, the dissertation investigates how cognitive impairment is linked to social relationships and if social aspects moderate the associations between cognitive impairment and well-being.** It aims to identify social aspects that are vulnerable to change with cognitive impairment and to explore how these risks relate to well-being, to develop strategies for aging well with cognitive impairment. We hypothesize that cognitive impairment is associated with lower social outcomes, which, in turn, are linked to lower well-being (Martyr et al., 2018; Tragantzopoulou & Giannouli, 2021). Furthermore, we hypothesize that low social resources are more strongly linked to decreased well-being in individuals with cognitive impairment than in those without, as their limited social resources are more often involuntary (Cohen-Mansfield et al., 2015; Huizenga et al., 2022; Patterson et al., 2018).

The first two papers aim to answer the first research question and focus on participants without major cognitive impairment / probable dementia. The first study starts broadly and models the dynamics between social aspects and cognition throughout very old age. It pays specific attention to which social aspects are linked to cognitive performance over very old age. Building on this, the second study addresses the directionality of these associations and combines cross-sectional and longitudinal analyses. Attention is given to structural social aspects because the first study found them to be most strongly related to cognition. The third study takes a different perspective and includes individuals with severe cognitive impairment. It compares social aspects between participants with no, mild, and severe cognitive impairment, and examines how these differences relate to well-being.

Together, the studies aim to shed light on the bidirectional association between social relationships and cognition in very old age. For the fields of rehabilitation and special education, the findings provide valuable insights for developing strategies and interventions that support cognitive health into very old age, as well as for identifying ways to maintain quality of life despite cognitive impairment.

Methods

NRW80+ Database

All presented studies are based on the data from the Study on Quality of Life and Well-Being in North Rhine-Westphalia (NRW80+ Study). Its data is publicly accessible at GESIS – Leibniz Institute for the Social Sciences data repository (Albrecht et al. 2022; Zank et al. 2022). The study investigated health, well-being, and quality of life in very old residents (aged 80+ years) of North Rhine-Westphalia (NRW). While the data is limited to NRW, it can be viewed as a representative depiction of Germany due to its variety of rural and urban areas and its longstanding history of immigration. The NRW80+ Study was approved by the Ethics Committee of the Medical Faculty of the University of Cologne (Protocol No. 17–169).

Recruitment of participants was conducted within a two-step sampling method, in which participants were randomly chosen from 94 pre-selected communities of NRW (Hansen et al. 2022). Participants either resided in private households or in institutional facilities. The assessments were conducted using computer-assisted interviews. They were carried out with target persons but also proxies, in case participants were unable to respond personally. Particularly, when participants were unable to respond personally, they were asked whether they consented to a proxy, which they could choose, who would answer on their behalf.

The study comprised two project waves. Wave 1 (W_1) took place from 2016 to 2018, with data gathering occurring between 2017 and 2018. In total, W_1 includes data from 1.863 very old adults. Wave 2 (W_2) took place from 2019 to 2021, with data collection between 2019 and 2020. It comprised data of 1.862 participants, of whom 912 also took part in W_1 . As the interview materials of W_1 and W_2 largely overlapped, change analyses and longitudinal comparisons were possible for these panel participants.

To address potential biases in the data recruitment, representative weights were calculated. In the cross-sectional sample, they adjusted for selection probability using age, sex, household size, regional area and type, municipality size, housing type, and marital status. Because male sex was intentionally oversampled to enable sex comparisons, it had a

particularly strong influence on the weights. In the panel, the weights also controlled for relevant W_1 risk factors of W_2 dropout. These included age, socioeconomic status, cognition, physical health, household size, and urbanization (Wagner & Zank, 2022). As opinions on representative weights are mixed, especially when based on the main independent variables in the analysis, all analyses were repeated without weights (Winship & Radbill, 1994).

Research Materials

Table 1 provides a comprehensive overview of the measurement instruments employed across the studies presented in this article. Notably, not every study included all variables due to differences in research design and sample characteristics. Additionally, the social variables were often re-coded and transformed among the articles to align with the specific analytic needs of each study. These adaptations also highlight the inherent methodological challenges in operationalizing and quantifying the multidimensional nature of social relationships.

Table 1*Measurement Included in the Presented Studies*

Category	Instrument	Article 1	Article 2	Article 3
Cognition	DemTect (0 to 18)	Included	Included	Included
	DemTect – Wordlist (0 to 10)	Not included	Included	Not included
	GDS (0 to 7)	Not included	Included	Included
Social aspects		Included	Included	Included
<i>Structural</i>	Overall network size (0 to 30)	Included	Included	Included
	Contact frequency – close network (1 to 5)	Not included	Included	Not included
	Contact frequency – overall network (1 to 5)	Included	Not included	Included
	Social activity (0 to 5)	Included	Included	Included
	Marital status (married, widowed, single)	Included	Included	Not included
	Current partnership (single, partnered)	Not included	Included	Included
<i>Qualitative</i>	Close network index (0 to 4)	Included	Included	Included
<i>Functional</i>	Loneliness (1 to 4)	Included	Included	Included
	Social support (1 to 5)	Included	Not included	Included
Well-Being	Depressive symptoms – DIA-S4 (0 to 4)	Included	Included	Included
	Positive affect – PANAS (1 to 5)	Not included	Included	Included
Demographics	Age (80 to 104)	Included	Included	Included
	Sex (male, female)	Included	Included	Included
	Education (low, medium, high)	Included	Included	Included
	Form of living (private, institutional)	Included	Included	Included
Health	Functional ability (0 to 2)	Included	Included	Included

Note. Included, not included. Some variables were transformed for the studies and are therefore not presented in their original scales.

Cognitive Measures

As noted, the NRW80+ Study only includes data on cognitive performance, not its underlying cause. Therefore, we can identify cognitive impairment but cannot determine whether it is part of dementia. However, since most cases of severe cognitive impairment in

very old age are caused by dementia (Sachdev et al., 2014), major cognitive impairment can be considered indicative of dementia.

In the target-person interviews, cognition was assessed with the Dementia Detection Test (DemTect) (Kalbe et al., 2004). Compared to the widely used Mini-Mental State Examination (MMSE), the DemTect has shown higher sensitivity for detecting mild forms of cognitive impairment (Kalbe et al., 2005). It comprises five subtests that assess different cognitive domains: Immediate recall, number transcoding, verbal fluency, digit span, and delayed recall. In immediate recall, participants hear a list of ten words twice and are asked to recall them immediately after each presentation. The number transcoding task requires participants to convert numbers from verbal and numerical form and vice versa (e.g., “209” = “two hundred nine”; “six hundred eighty-one” = “681”). During the verbal fluency task, participants must name as many supermarket products as possible within 60 seconds. The digit span backward task involves repeating number sequences in reverse order. In the delayed recall task, participants are asked to freely recall the word list from the first task after approximately ten minutes. A total score is computed from the five subtests using an age-adjusted scoring scheme (Kessler et al., 2014). It yields a score between 0 and 18 points. The total performance can be classified as follows: 13 to 18 points indicate age-appropriate performance, 9 to 12 points indicate mild cognitive impairment, and fewer than 9 points indicate severe cognitive impairment or probable dementia.

In the proxy interviews, cognitive functioning was rated by the proxy using the GDS (Reisberg et al., 1982). The GDS is a seven-point scale assessing the severity of cognitive impairment, ranging from 0 (“no cognitive impairment”) to 7 (“very severe cognitive impairment”). Scores of 1 to 2 indicate no cognitive impairment, a score of 3 reflects mild cognitive impairment, and scores of 4 to 7 indicate severe cognitive impairment or probable dementia.

Social Measures

The present study included several social variables. They were initially categorized as structural, functional, or qualitative, following Holt-Lunstad's (2018) classification. These categories are only approximate, as most variables overlap and include multiple dimensions. Each variable was therefore assigned to the category it most represented. Subsequently, we further organized the variables according to whether they primarily reflected bonding or bridging mechanisms, with structural aspects relating more to social bridging and functional and qualitative aspects relating more to social bonding.

Structural Aspects

Structural aspects included overall network size, contact frequency, social activity, marital status, and current partnership. Measures of network size were oriented towards the Lubben Scale but were simplified to reflect the circumstances of very old age better (Wenner et al., 2023). First, the close network size was assessed by asking participants to name up to four of their most important network members. Overall network size was measured by asking participants to list all additional individuals they currently felt close to. Responses were capped at 30 individuals to limit the influence of extreme outliers (as fewer than 2% named more than 30 persons). Similarly, contact frequency was assessed separately for the close and overall network. For each of their most important ties, participants rated the frequency of contact on a scale from 1 ("less than yearly") to 5 ("daily"). A mean score indicated the average interaction with their close network. To assess contact frequency with the overall network, a single item asked how often participants spend time with others. It was rated from 1 ("never") to 5 ("very often"). Social activity was measured as the average frequency of participation in 14 possible activities. These included (1) doing sports, (2) having tea parties, (3) visiting a café, (4) traveling, (5) going to the cinema, (6) visiting a concert, theater, or museum, (7) engaging in artistic activity, (8) volunteering, (9) playing board games, (10) continuing education, (11) joining a political event, (12) strolling, (13) hosting visitors, (14)

participating in another hobby (specified if applicable). Each activity was rated from 0 (“never”) to 5 (“daily”), and the scores were summarized to obtain a mean. Included activities varied slightly across studies. In the first paper, we applied a strict definition of social activity, including only seven activities. In the other studies, we used a broader definition and acknowledged the challenge of classifying activities as purely social. Next, marital status was originally measured using seven categories (“married”, “married but living apart”, “registered civil partnership”, “registered civil partnership but living apart”, “single”, “divorced”, “widowed”). Categories were recoded into a three-level variable (“married or registered civil partnership”, “single”, “divorced”). The variable on the current partnership was categorized into “yes” and “no”.

Qualitative Aspects

As stated above, participants named up to four of their most important ties. For each, they also rated perceived closeness on a scale from 1 (“not close at all”) to 4 (“very close”). If participants named fewer than four close contacts, a “0” was assigned for each missing person. For some studies, the individual scores were recoded to 0 (“no or less close tie”), 1 (“close tie”), and 2 (“very close tie”) and summarized into a total score.

Functional Aspects

For functional aspects, we included a measure of received social support and loneliness. Social support received was quantified by averaging two items that assessed received instrumental and emotional support over the past year. Each item was rated on a scale from 1 (“never”) to 5 (“always”). Although the classification of loneliness as a functional social aspect is debatable, we regarded it as reflecting unmet social needs and indicating low social function, in accordance with Holt-Lunstad (2018). It was assessed using a single item that asked participants how lonely they felt during the past week. Participants responded on a scale from 1 (“never”) to 4 (“almost always or always”). Throughout the studies, the

measure was used in its original form, dichotomized (“not lonely”; “lonely”), and transformed into a three-point scale (“never”, “sometimes”, “often to always”) to better reflect the data (as fewer than 3% reported feeling (almost) always lonely).

Well-Being Measures

Depressive symptoms were measured using the Depression in Age - Short Scale (DIA-S4). It is a screening tool comprising four yes/no items about the presence of depressive symptoms during the last two weeks (Heidenblut & Zank, 2010). Positive affect was measured using the positive subscale of the Positive and Negative Affect Schedule – Short Scale (PANAS) (Kercher, 1992; Watson et al., 1988). The subscale includes five items assessing the frequency of positive emotions, such as enthusiasm and excitement, experienced in the past year. Their frequency is rated on a scale from 1 (“never”) to 5 (“very often”).

Control Measures

Age was indicated as a continuous variable with two decimal places. Sex was dichotomized into “male” and “female”. Education was classified as “low”, “medium”, and “high”. Housing form was categorized as “private” or “institutional”. Functional ability was assessed by asking participants to rate their independence in seven instrumental activities of daily living. For each activity, it was rated on a scale from 0 (“requires full assistance”) to 2 (“independent”), and a mean score was calculated.

Statistical Approaches

Across the three papers, statistical analyses were conducted using SPSS (IBM Corp., 2021) and R (R Core Team, 2023). SPSS was used for the data preparation, including sample selection, assumption checking, and variable transformation. Missing data imputation was

performed in R using the “mice” package (Buuren & Groothuis-Oudshoorn, 2011). All main analyses were conducted in R, including multilevel linear growth curve analysis with the “lme4” package (Bates et al., 2015) and hierarchical linear regression (R Core Team, 2023).

Sample Characteristics

The following section provides relevant information on the participants included in the presented studies. It includes cross-sectional data from W_1 participants and panel data from participants who were assessed in both measurement waves. Participants without an indication of cognition by either the DemTect or the GDS were excluded from the descriptive analyses, as they were not included in any of the present studies. The tables and figures, therefore, include data from 1516 cross-sectional participants and 673 panel participants. All data are reported unweighted, as weighting produced slightly different results depending on the inclusion and exclusion criteria of each study.

Key sociodemographic and cognitive characteristics of the participants are shown in Table 2. No imputation was needed, as there were no missing values. Table 3 demonstrates descriptive statistics for the social variables and well-being measures, for which missing data were imputed to maintain consistent sample sizes. Figure 4 displays the frequency of cognitive impairment by age group, and Figure 5 illustrates the average change in cognitive performance from W_1 to W_2 . Only participants from the target-person interviews ($n = 654$) were included in Figure 5, because the cognitive assessment in proxy interviews was categorical and did not allow calculation of average change.

Table 2*Sociodemographic and Cognitive Characteristics of the Unweighted and Unimputed Samples*

Variables	Means (SD) and Frequencies		
	Cross-sectional	Panel sample	
	sample	Wave 1	Wave 2
Target-person interview	88.70 %	97.20 %	-
Age	86.80 (4.50)	85.90 (4.12)	87.70 (4.11)
Male sex	49.30 %	51.30 %	-
Education			
Low	24.60 %	20.40 %	-
Medium	49.40 %	49.30 %	-
High	26.00 %	20.30 %	
Private household	92.20 %	94.40 %	91.20 %
Cognition (combined)			
No cognitive impairment	66.80 %	81.10 %	71.80 %
Mild cognitive impairment	16.00 %	12.30 %	17.50 %
Severe cognitive impairment (probable dementia)	17.20 %	6.60 %	10.70 %
DemTect ^a	14.30 (3.88)	15.30 (3.13)	14.60 (3.73)
DemTect – Wordlist ^a	3.99 (2.57)	4.50 (2.44)	4.05 (2.51)
<i>n</i>	1516	673	

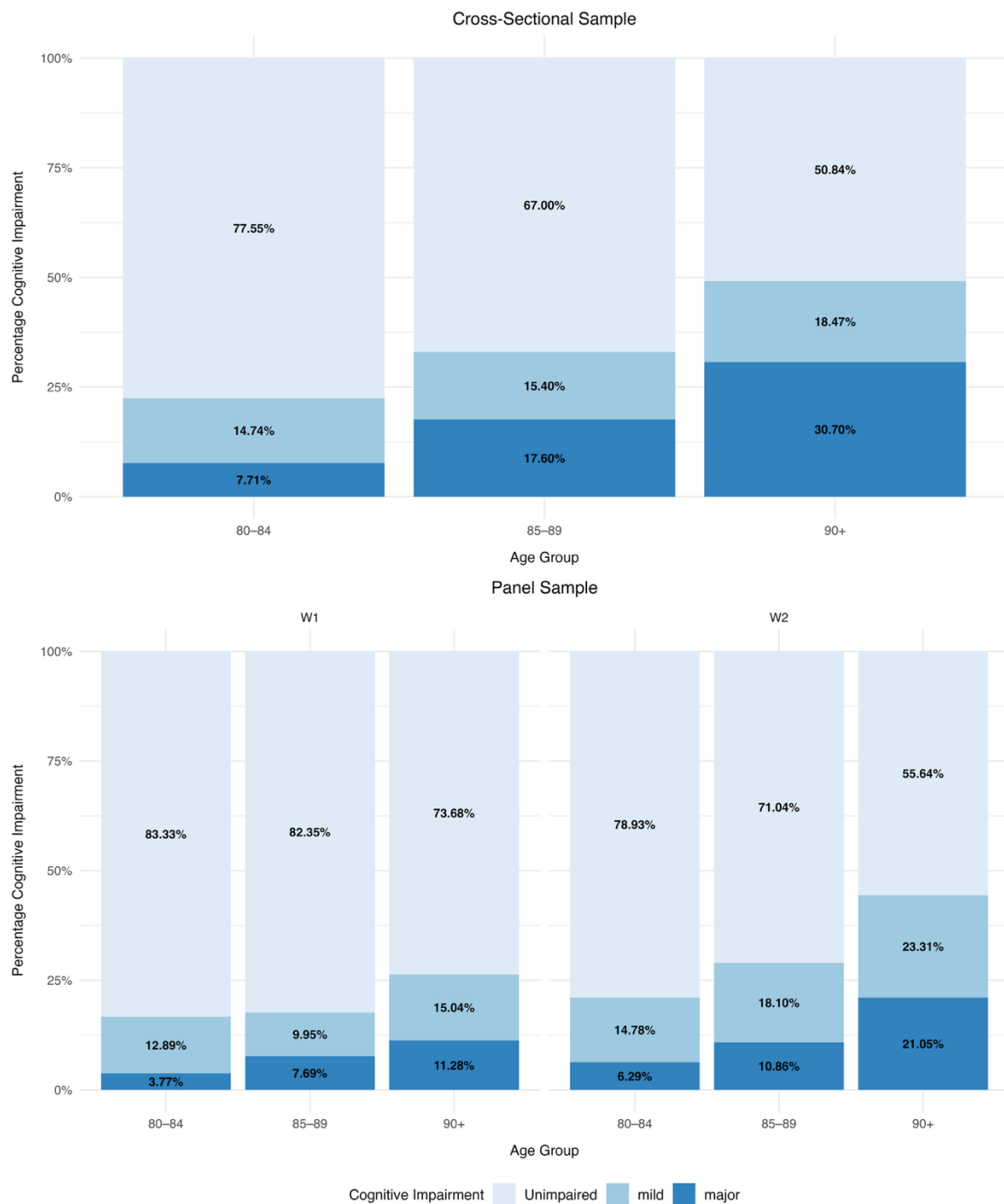
Note. Differences in sample sizes for the DemTect and the Wordlist arise because participants in proxy interviews were not assessed with the DemTect. In the panel sample, interview type, sex and education represented time-invariant variables.

^a Cross-sectional sample: $n = 1344$; panel sample: $n = 654$.

Table 3*Social and Well-Being Measures of the Unweighted and Imputed Sample*

Variables	Means (SD) and Frequencies		
	Cross-sectional	Panel sample	
	sample Wave 1	Wave 1	Wave 2
Overall network size (0 to 30)	7.08 (6.59)	7.79 (6.57)	7.98 (7.16)
Contact frequency – close network (1 to 5)	3.39 (1.21)	3.52 (1.11)	4.06 (0.75)
Contact frequency – overall network (1 to 5)	3.55 (0.97)	3.62 (0.89)	3.52 (0.97)
Social activity (0 to 5)	0.98 (0.57)	1.47 (0.61)	1.34 (0.63)
Marital status			
<i>Married or registered partnership</i>	42.10 %	43.70 %	39.40 %
<i>Widowed</i>	51.60 %	50.20 %	54.50 %
<i>Single</i>	6.30 %	6.10 %	6.10 %
Currently in a partnership	54.00 %	51.40 %	44.80 %
Close network index (0 to 4)	2.84 (1.05)	2.98 (0.96)	2.95 (0.96)
Loneliness			
<i>Never</i>	73.00 %	77.20 %	74.10 %
<i>Sometimes</i>	20.30 %	18.70 %	19.70 %
<i>Often</i>	4.10 %	2.50 %	4.30 %
<i>(Almost) always</i>	2.60 %	1.60 %	1.90 %
Social support (1 to 5)	2.83 (1.05)	2.65 (1.01)	2.73 (0.99)
Depressive symptoms – DIA-S4 (0 to 4)	0.93 (1.12)	0.71 (0.99)	0.84 (1.07)
PANAS – Subscale positive affect (1 to 5)	3.23 (0.90)	3.37 (0.84)	3.31 (0.88)
<i>n</i>	1516	673	

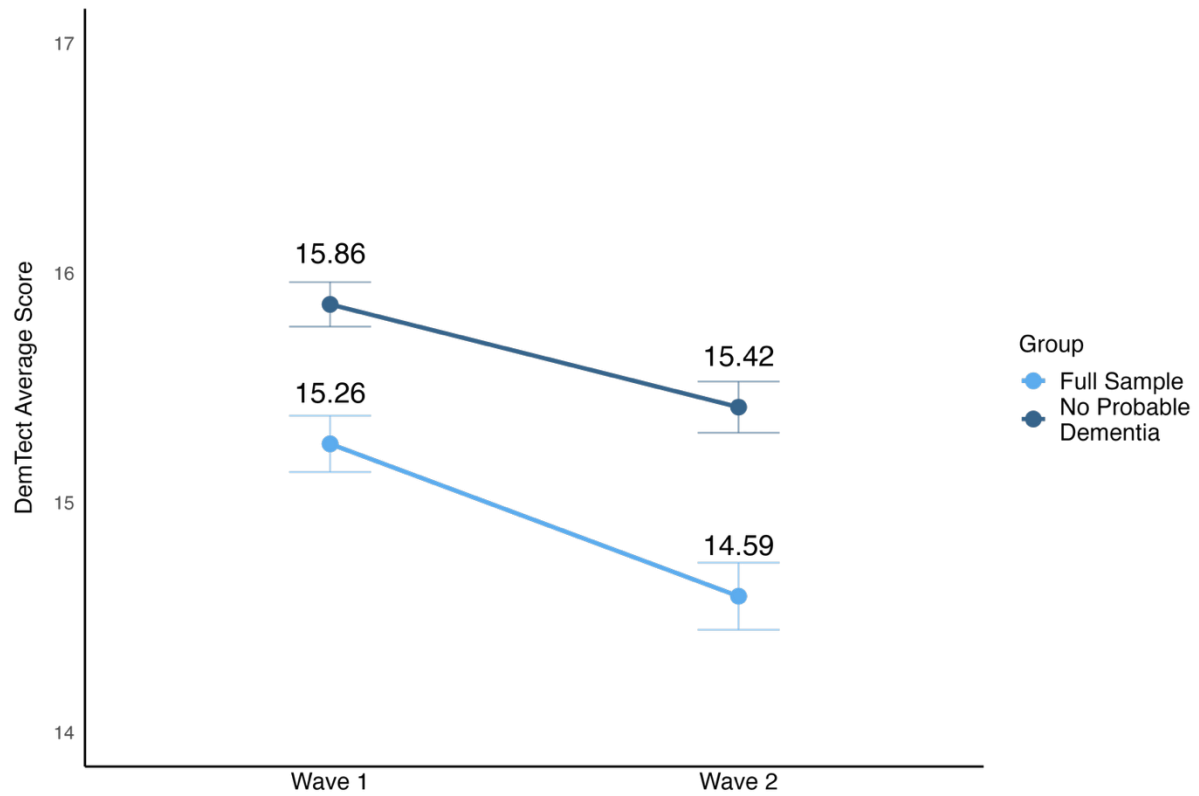
Note. Missing values were all below 5% except for depressive symptoms in W₂.

Figure 4*Frequencies of Cognitive Impairment in the Samples by Age Group*

Note. Cross-sectional sample: $n = 1516$; panel sample: $n = 673$.

Figure 5

Changes in DemTect Total Scores From W_1 to W_2 for all Participants and Those Without Probable Dementia / Severe Cognitive Impairment at W_1 .



Note. Full sample: $n = 654$; sample without participants with no probable dementia / severe cognitive impairment at baseline: $n = 518$.

Scientific Articles

Article 1

“Exploring the Associations Between Structural and Functional Aspects of Social Relationships and Cognition in Very Old Age.”

The first study investigated the associations between social aspects and cognitive performance in very old adults without probable dementia (Vogel et al., 2024a). We aimed to determine whether social relationships and cognition remain positively associated in very old age, as research on this topic has been mixed (Grothe et al., 2022; Huang et al., 2023; Röhr et al., 2020; Vos et al., 2017). We were also interested in which aspects of social relationships would be most strongly related to cognitive performance. Specifically, we hypothesized that structural aspects would be more strongly associated with cognitive performance because they serve as crucial indicators of social bridging (Perry et al., 2022).

To test the hypotheses, we analyzed data from participants in the NRW80+ Study who participated in both measurement waves. We only included participants without an indication of probable dementia/ severe cognitive impairment as defined by the DemTect. By doing so, we sought to reduce the risk of reverse causality, since cognitive impairment can also affect social aspects. Figure 6 provides a more detailed view of our selection process. The final sample included 518 participants. We included various structural (network size, contact frequency, and social activity) and functional social aspects (loneliness, social support, and relationship closeness). We hierarchically modeled global cognition in very old age using multilevel linear growth curve models. The baseline model only included age as a predictor of global cognition. We sequentially added further predictors: Structural aspects, functional aspects, and important control variables (sex, education, housing form, functional ability, depressive symptoms). Model fit and predictive power were compared across the nested models. Furthermore, we compared the models with only structural versus only functional aspects in their explanatory power.

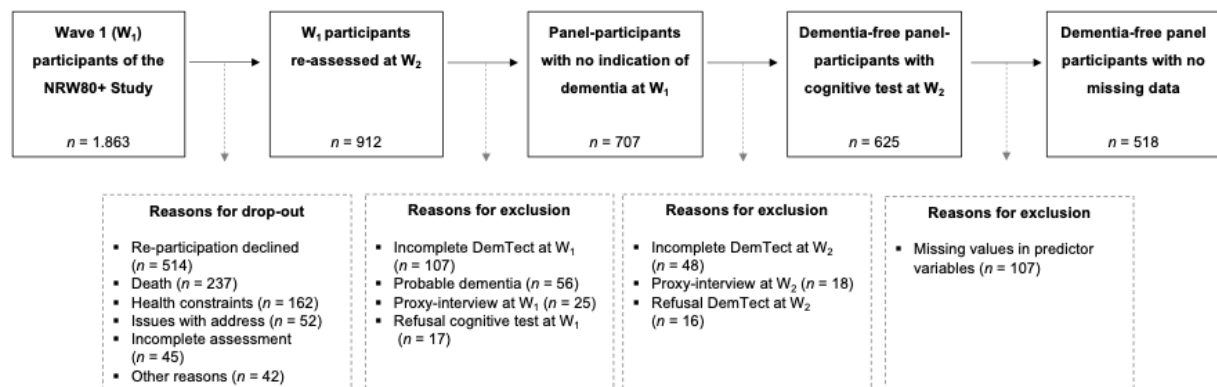
The results showed that network size ($\beta = 0.05$ [0.02, 0.08], $p = 0.002$) and contact frequency ($\beta = 0.16$ [0.03, 0.28], $p = 0.013$) were positively associated with cognitive performance. In contrast, functional aspects were not associated with global cognition. Furthermore, the model with structural aspects provided an improved model fit than the one including only functional aspects ($\chi^2(2) = 16.17$, $p < .001$). In the fully controlled model, which included structural, functional, and control variables, the fixed effects explained 15% of the variation in global cognition. In sum, the results demonstrate that structural aspects of social relationships showed a stronger association with cognition and accounted for a larger share of the variability in cognition than functional social aspects in very old age.

The findings underline that social aspects remain positively linked with cognitive performance in very old adults without an indication of dementia. It mainly addressed structural aspects such as network size and contact frequency. Structural aspects not only emerged as the only significant predictors, but they also provided a better model fit to the cognitive data than functional aspects. It supports the social bridging hypothesis, which suggests that socially stimulating environments are associated with preserved cognitive functioning (Perry et al., 2022). Meanwhile, some limitations must be considered when interpreting the results. Most importantly, only two time points per participant were available, which restricts the within-person information of the analyses. Furthermore, although the multilevel approach included two data points per person, these were treated in a rather cross-sectional approach, as we did not focus on within-person change. Therefore, no directions or causality can be assumed from the results.

Overall, the study provides evidence that the positive associations between social relationships and cognition continue into very old age. This mainly involves aspects related to social bridging, which are thought to promote mental stimulation. It emphasizes the need for opportunities that foster broader social engagement in very old adults, as research indicates that wider activity and peripheral contacts decline with age, and the focus shifts to close networks. Creating and adapting barrier-free social spaces and environments could be a first step toward providing such opportunities for very old adults.

Figure 6

Flowchart of the Sample Selection Process in the First Paper



Note. Adapted from Vogel, S., Oliva y Hausmann, A., & Zank, S. (2024). Exploring the associations between structural and functional aspects of social relationships and cognition in very old age. *Aging & Mental Health*, 28(12), 1642–1649.

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Article 2

“Does the Positive Association Between Social Relationships and Cognition Continue Until Very Old Age?”

The work of the second study expands on the first study by examining not only cross-sectional associations between social aspects and cognition but also over a timeframe of 2 years (Vogel et al., 2024b). We investigated whether social aspects are associated with cognitive performance cross-sectionally and over a two-year period in very old adults without probable dementia. Based on prior research in young old adults, we hypothesized that positive associations between social aspects and cognition would be observable both cross-sectionally and over time (Kuiper et al., 2016; Piolatto et al., 2022).

We used cross-sectional data from 1207 participants and panel data from 639 participants of the NRW80+ Study. Again, we excluded individuals with probable dementia / severe cognitive impairment, as defined by the DemTect. Further details on the sample selection process are presented in Figure 7. In contrast to the first study, we included two cognitive measures, namely global cognition and episodic memory. Episodic memory was added because it represents a more time-sensitive measure of cognition and is more vulnerable to change during aging (McFall et al., 2019; Salthouse, 2019). Therefore, we expected changes over a relatively short timeframe of 2 years to become more visible in this domain compared to global cognition. Episodic memory was represented by the performance in the delayed recall task from the DemTect. Another change from the first study was the inclusion of slightly different social predictors. Greater emphasis was placed on structural aspects because these were the most relevant predictors of cognition in the first paper. Additionally, we tried to operationalize them according to the different intimacy levels described by the Convoy Model. Finally, we included overall social network size, social activity, close network size, and loneliness as social predictors of cognition. To examine whether they were associated with cognitive performance cross-sectionally and longitudinally, we used hierarchical linear regression models. All models were adjusted for

relevant demographic and health-related covariates, including age, sex, education, functional ability, and depressive symptoms. In the panel analyses, they further controlled for baseline cognitive performance.

The cross-sectional analyses revealed positive associations between social aspects and cognitive functions in very old age, particularly overall network size and social activity. Overall, the regression models explained 7% of the variation in episodic memory and 13% of global cognition. More social activity was linked to higher episodic memory ($\beta = 0.53$ [0.26, 0.79], $p < .01$) and better global cognition ($\beta = 0.50$ [0.22, 0.79], $p < .01$). A larger overall network was associated with better global cognition ($\beta = 0.04$ [0.02, 0.07], $p < .01$). No associations were observed between social aspects at W_1 , and episodic memory and global cognition at W_2 .

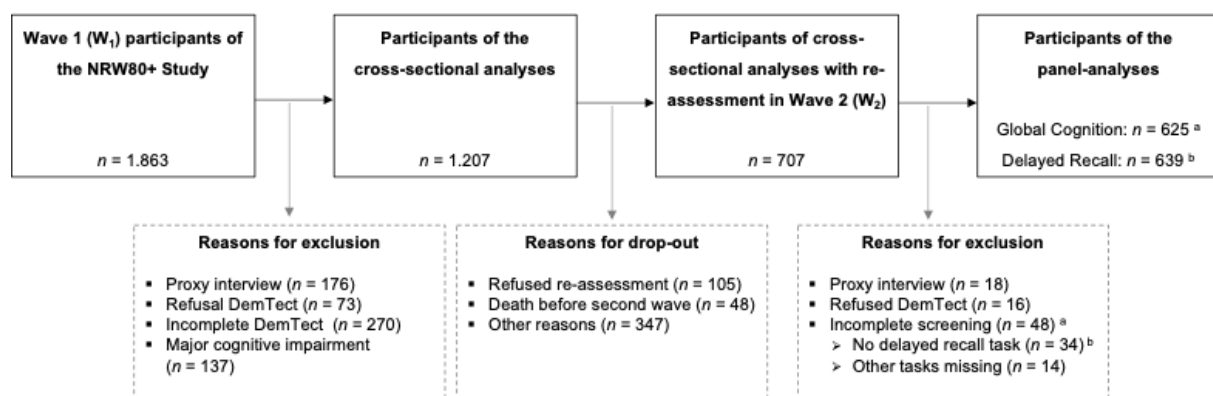
The findings again underline the persistent associations between social relationships and cognition in very old age. Cross-sectionally, very old adults who were more socially active and had larger social networks tended to show a higher cognitive performance. Meanwhile, social aspects did not predict cognitive performance 2 years later. This contrasts findings from young old adults, in which social factors often predicted cognitive trajectories over time (Kuiper et al., 2016; Piolatto et al., 2022). Several explanations may account for these discrepancies. All reflect the unique circumstances of very old age compared to younger age. First, the accumulation of pathological processes in very old age may reduce the extent to which modifiable lifestyle factors, such as social interactions, can influence cognitive performance (Vos et al., 2017). It relates to the earlier comparisons that the “hardware” may no longer respond to the “software”. A second explanation could be selective processes. Individuals who maintain cognitive functioning until very old age despite certain risk factors, such as low social activity, may possess other unmeasured protective factors that make lifestyle factors less predictive of cognitive decline (Grothe et al., 2022). The third explanation lies in the methodological nature of the present study, which is also noteworthy as a limitation. Since we included data from only two time points, approximately 2 years apart, the relatively short interval may have limited the ability to detect more gradual changes

in cognition and social aspects. Including longer time frames might therefore change the observed associations.

In conclusion, we again showed that positive associations between some social aspects and cognition persist into very old age. However, these were only cross-sectional, and we did not find a link between social aspects and cognitive performance 2 years later. It suggests that interventions to prevent cognitive decline and cognitive impairment should ideally begin earlier than in very old age, and social relationships should not be viewed as a “quick fix” but rather as a lifelong resource that gradually benefits cognition. Nevertheless, it is important to foster social environments that support participation until very old age, ensuring that social connections and resources are preserved and not lost during this life phase. As stated before, this includes reducing age-related barriers in social spaces, such as sensory and physical barriers.

Figure 7

Flowchart of the Sample Selection Process in the Second Paper



Note. Adapted from Vogel, S., Oliva y Hausmann, A., & Zank, S. (2024). Does the positive association between social relationships and cognition continue until very old age? *European Journal of Ageing*, 21(1), 39. <https://doi.org/10.1007/s10433-024-00835-9>. CC BY 4.0.

Article 3

“Important for Preventing but Also Living Well With Cognitive Impairment – The Associations Between Social Relationships, Well-Being, and Cognition in Very Old Adults.”

The last study took a different perspective by focusing on people who already experience probable dementia / severe cognitive impairment (Vogel et al., 2026). As demonstrated by the previous studies, much research has addressed social aspects as preventive targets against cognitive impairment. However, only a few studies go beyond that and examine the role of social relationships after cognitive impairment has occurred. From the perspective of the Convoy Model and the Unmet Need Models, cognitive impairment is an age-related event that heavily challenges the fulfillment of our social needs (Antonucci et al., 2014; Cohen-Mansfield & Werner, 1995). Indeed, people with cognitive impairment express a strong desire for staying socially connected but typically show more loneliness and social isolation than people without impairment (Dyer et al., 2021; Patterson et al., 2018).

Therefore, the present study examined how cognitive impairment is associated with social aspects and how these associations relate to psychological well-being. Based on previous research, we expected cognitive impairment to be associated with lower social outcomes (Dyer et al., 2021; El Haj et al., 2016), and lower social outcomes to be associated with reduced well-being (Tragantzopoulou & Giannouli, 2021). We further hypothesized that the latter associations would be stronger among individuals with cognitive impairment, because their reduction in social engagement is often involuntary (Cohen-Mansfield et al., 2015; Huizenga et al., 2022; Patterson et al., 2018).

We analyzed cross-sectional data from 1516 very old adults from W₁ of the NRW80+ Study. 66.80% of participants had no cognitive impairment, 15.00% showed mild impairment, and 18.20% had severe cognitive impairment. Details on the selection process are shown in Figure 8. We included target-person and proxy interviews to give a voice to people who are often excluded from research. These are usually people with severe cognitive impairment

who cannot respond to questions personally. Depending on the interview type, cognitive impairment was assessed using the DemTect (target-person interviews) or the GDS (proxy interviews). Three social aspects were included: A close network index, social activity, and loneliness. Psychological well-being was assessed with depressive symptoms and positive affect. Control variables included interview type, age, sex, education, housing form, functional ability, and relationship status. Linear regression models including interaction terms were used to test the hypotheses.

Our results showed that cognitive impairment was associated with lower social aspects and reduced well-being. Especially, participants with severe cognitive impairment showed a consistently higher risk of lower social outcomes and mental health, while individuals with MCI and those without impairment were more similar. Social aspects, in turn, were positively associated with fewer depressive symptoms and higher positive affect. Introducing interaction terms between social aspects and cognition improved the model fit for depressive symptoms ($\chi^2(6) = 4.03, p < .001$), which was further supported by comparing the average AIC (Model A = 4556.67; Model B = 4537.59). The model accounted for 27% of the variation in depressive symptoms. Importantly, depressive symptoms in participants with severe cognitive impairment were more strongly associated with social activity than in those without cognitive impairment ($B = -0.53 [-0.83, -0.23], p < .001$). They reported relatively more symptoms when socially less active and fewer symptoms when more active, compared to the other groups. Including interaction terms did not improve the model fit for positive affect. The model without interactions accounted for 26% of the variation in positive affect.

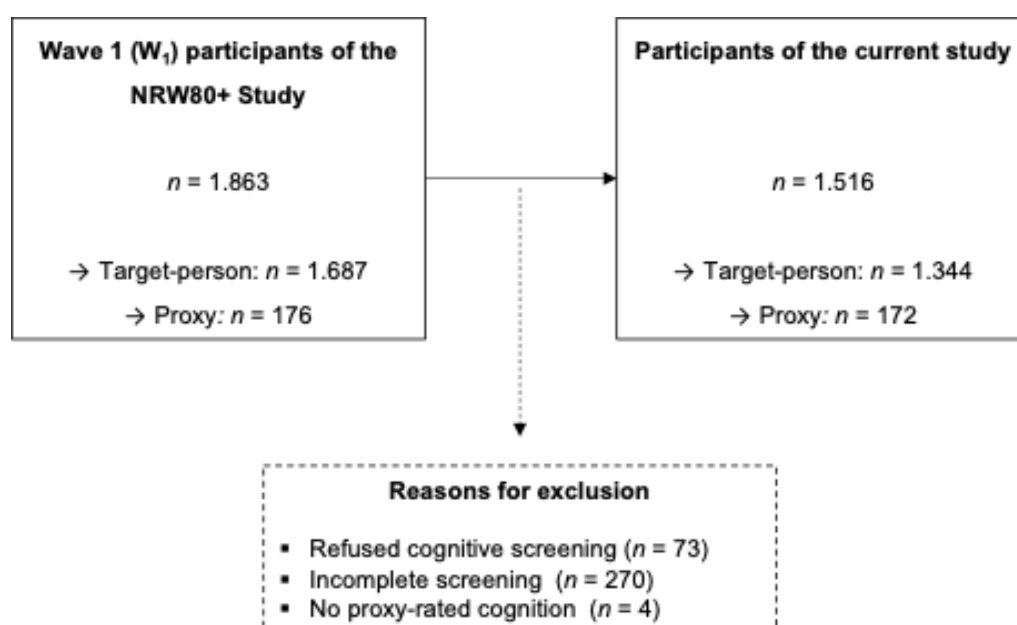
The results support the assumption that cognitive impairment can be viewed as an age-related life event associated with changes in our social relationships. It also supports the Unmet Needs Model, which posits that cognitive impairment makes it harder to fulfill social needs, which, in turn, influences well-being (Cohen-Mansfield & Werner, 1995). Thereby, it underscores the need to support people with cognitive impairment in maintaining social connections and engagement. While these insights into the social and emotional correlates of cognitive impairment are valuable, several limitations must be acknowledged. As the

analyses were cross-sectional, no causal interpretations can be drawn. Furthermore, cognitive status was treated categorically rather than continuously, which may have reduced variability and precision. Lastly, while proxy information is essential for including individuals with more severe cognitive impairment, this may have introduced bias, as the information did not come from the individuals themselves (Wu et al., 2020).

Taken together, our last study emphasizes that social relationships are not only protective against cognitive impairment but also essential for living well with it. Social relationships are important for well-being in very old age, especially among people who have challenges in fulfilling their social needs, such as those with cognitive impairment. Therefore, efforts should not only focus on promoting social participation to preserve cognition but also on supporting it in individuals with cognitive impairment and dementia. It reinforces previous suggestions that barriers to social participation and integration should be reduced, which also includes barriers related to cognitive impairment.

Figure 8

Flowchart of the Sample Selection Process in the Third Paper



Discussion

This dissertation examined the bidirectional associations between social relationships and cognition in very old age. It first assessed how social relationships relate to cognitive performance in very old adults without probable dementia, addressing a gap in research that has largely focused on young old adults. We investigated whether positive associations were also observed in very old age, given its distinct health and social contexts. The studies also identified the social factors that predicted cognition and how these associations emerged over time. Acknowledging the bidirectional nature of these associations, this dissertation further explored how cognitive impairment is associated with aspects of social relationships and how this relates to well-being in participants with varying levels of cognitive impairment.

In particular, the dissertation answered two research questions. First, it examined which social factors are positively associated with cognitive performance in very old age and may reduce the risk of cognitive impairment in this age group. We hypothesized that social factors, especially structural aspects, would be positively linked to cognitive performance both cross-sectionally and over time. Second, it explored the associations between cognitive impairment and social relationships, and whether social relationships moderate the link between cognitive impairment and well-being. We hypothesized that individuals with cognitive impairment would have lower social outcomes and show reduced well-being than those without impairment. We also expected that social outcomes would moderate the associations between cognitive impairment and well-being.

In line with our first hypothesis, we found positive associations between social aspects and cognitive functioning, including global cognition and episodic memory, in very old adults without probable dementia. Structural aspects, such as network size and social activity, were the primary predictors of cognitive performance. The associations appeared only in the cross-sectional analyses, whereas social aspects did not predict cognitive performance after 2 years. Consistent with our second hypothesis, cognitive impairment was associated with lower social outcomes and reduced well-being, including more depressive

symptoms and less positive affect. Moreover, social aspects moderated the association between cognitive impairment and well-being. Specifically, the association between social activity and depressive symptoms was stronger in participants with cognitive impairment than in those without cognitive impairment.

Research Question 1

Cross-Sectional Associations Between Social Aspects and Cognitive Performance

We hypothesized that social aspects, particularly structural aspects, would show positive cross-sectional associations with cognitive performance in very old adults without probable dementia. The hypothesis was based on findings in very old and young old adults, in which structural factors, such as network size and social activity, were especially predictive of cognitive functioning (Fan et al., 2021; Huang et al., 2023; Kuiper et al., 2016; Röhr et al., 2020). Indeed, we observed positive cross-sectional associations between structural social aspects and cognitive functions in very old age, including social activity, contact frequency, and network size. Therefore, our results strengthen prior findings and support the underlying social bridging hypothesis. Social bridging suggests that diverse and regular social contacts activate the brain, thereby supporting cognitive functioning in older age (Perry et al., 2022). These activating interactions are typically found in broader and more peripheral social contacts, which involve fewer routines and more novelty than close relationships.

However, broader and peripheral social ties tend to decline with increasing age (Fuller et al., 2020). This decline results from both external and internal changes, as outlined by the Convoy Model and SST (Antonucci et al., 2014; Carstensen, 2006). External factors include health declines, mobility restrictions, loss of loved ones, or moving to institutional care. Internal factors involve motivational and behavioral shifts, with older adults focusing more on emotionally meaningful relationships and investing more energy in close ties than in peripheral contacts. Our findings highlight the benefits of maintaining peripheral social

contacts, in addition to close ties, to promote cognitive health. Very old adults can be supported in sustaining more distant social ties by creating age-friendly social spaces and environments that encourage broader social engagement. Additional interventions may include volunteering opportunities, neighborhood programs, or initiatives to enhance digital skills for online connecting (Sommerlad et al., 2023).

In contrast, we did not observe cross-sectional associations between functional or qualitative social aspects and cognitive functioning, which are primarily linked to social bonding (Perry et al., 2022). Social bonding is assumed to benefit cognition by reducing stress and promoting mental well-being. The results may seem unexpected, especially given that SST emphasizes the importance of close and emotionally meaningful relationships among older adults (Carstensen, 2006). From this perspective, bonding is expected to play a significant role in cognition. Meanwhile, findings on functional and qualitative social aspects are generally less consistent than those on structural aspects, even among young old adults (Costa-Cordella, 2021; Piolatto et al., 2022). Several explanations are possible for this. First, functional and qualitative aspects are more subjective and relative, making them harder to measure. A good example is received social support. While high levels of received support are linked to better cognitive functioning (Costa-Cordella, 2021), this benefit appears only when the support is reciprocal. An imbalance between giving and receiving support may be counterproductive and potentially cause stress (Sims et al., 2014). Similarly, loneliness is a subjective and complex construct, and its impact on cognition may depend on whether it is transient or chronic loneliness. Momentary loneliness may not be harmful and can even motivate social reconnection, while chronic loneliness may induce stress and thereby contribute to cognitive decline (Victor et al., 2022). Such nuances are difficult to capture in research. Another reason for the lack of positive associations may be our explicit focus on very old adults. According to SST, individuals prioritize positive close relationships as they perceive their lifespans to be limited (Carstensen, 2006). Thus, very old adults are expected to have very fulfilling relationships, as they are most aware of their limited time. This is also reflected in our data, where participants reported high relationship quality and low levels of

loneliness. Consequently, many very old adults may have already maximized the quality and function of their social relationships, resulting in limited variability, which reduces the likelihood of detecting associations with cognition. Finally, bonding aspects may be more context-dependent in their association with cognition and may only become important under chronic stress in very old age. Reflecting on SAVI, it is assumed that older adults improve their ability to regulate emotions by positively reinterpreting situations and avoiding conflicts. This leads to lower stress, which is a key mechanism of social bonding. In high-arousal stress situations, however, older adults tend to show stronger physiological responses than younger adults, which may be negatively associated with cognition (Charles, 2010). Therefore, bonding aspects could be particularly important in these situations. Indeed, prior research has shown that social aspects related to bonding, such as emotional support and a close network, can buffer the negative effects of widowhood on cognition (Hülür et al., 2022). These findings suggest that associations between functional and qualitative social aspects and cognitive functioning in very old age may be more context-specific.

Overall, our findings indicate that structural social aspects related to social bridging are positively associated with cognitive functioning in very old adults without probable dementia, whereas bonding-related aspects play a smaller role. This raises the question of whether the observed associations are solely due to the activating potential of structural social aspects. If this is the case, similar benefits could be achieved through low-threshold activities such as games, quizzes, or AI-assisted technologies. However, social structures offer additional qualities that are difficult to replicate, including connectedness, mutual exchange, and shared experiences. Although research often categorizes social aspects as structural, functional, or qualitative, these distinctions are mostly theoretical. In practice, social aspects often combine multiple dimensions. For example, social activity reflects not only the frequency and diversity of contacts (structural) but also support (functional) and a sense of belonging (qualitative). In summary, structural social aspects may provide a foundation for mental activation while also offering other psychosocial benefits, making them a unique target for interventions to support cognitive functioning in very old age.

Panel Associations Between Social Aspects and Cognitive Performance

While we found cross-sectional associations between social aspects and cognitive functioning in very old adults without probable dementia, we did not find any associations between social aspects and cognition after 2 years. These results diverge from those studies reporting longitudinal associations between social relationships and cognition in young old adults and some studies on very old adults (Huang et al., 2023; Kuiper et al., 2016; Röhr et al., 2020).

These differences could result from methodological and conceptual variations. Huang et al. (2023) reported longitudinal associations between a sum score of social isolation and cognitive impairment in very old adults but found no consistent effect for loneliness. Their study used a binary cognitive impairment outcome based on the MMSE, rather than assessing cognitive performance along a continuum. Such binary outcomes capture more pronounced changes that are easier to predict over time. Continuous measures as used in our study reflect more subtle variations that may be less detectable, especially over a short timeframe of 2 years. Furthermore, Röhr et al. (2020) reported longitudinal associations between social networks and dementia onset in very old adults without cognitive impairment. However, these associations disappeared after adjusting for survival bias in a follow-up study (Grothe et al., 2022). In our study, we also accounted for survival bias. It suggests that results in very old adults are vulnerable to being overestimated when sample selection biases are not addressed. Sample selectivity may generally explain why the associations between social aspects and cognitive trajectories are less consistent in very old adults than in young old adults. Very old adults without cognitive impairment may represent a selective group, possibly possessing unknown protective factors that account for the absence of cognitive impairment despite age-related risks (Vos et al., 2017). Another explanation is that, at some point during aging, pathological brain changes may limit the impact of lifestyle factors. It means that biological processes may increasingly outweigh the effects of lifestyle factors. This perspective is supported by Gerstorf et al. (2023), who found that although the

mean cognitive performance improved across cohorts, the rate and timing of cognitive decline remained largely unchanged.

The absence of longitudinal associations, together with our cross-sectional findings, suggests that social relationships primarily serve as long-term rather than short-term resources for cognition in very old age. This interpretation is supported by the concept of relational reserve, which complements the idea of cognitive reserve. It emphasizes how long-term patterns of social engagement, instead of transient interactions, help protect against cognitive decline (Cullati et al., 2018). Our panel associations primarily captured such transient associations, predicting cognition at W_2 based on social aspects at W_1 . In contrast, our cross-sectional associations may reflect the cumulative and sustained benefits of lifelong social patterns. More longitudinal research beginning early in life is needed to clarify this assumption.

In conclusion, our studies show that promoting cognitive health through social relationships should begin earlier in life, rather than in very old age. Although interventions at a younger age seem more effective (Kuiper et al., 2015; Kuiper et al., 2016; Piolatto et al., 2022), programs should support participation and continued access throughout very old age. Especially considering that aging is often associated with a reduction in broader social interaction. Including very old adults in such interventions and ensuring their continued access requires programs to remove possible age-related barriers such as mobility limitations, health conditions, and sensory impairments.

Research Question 2

Associations Between Cognitive Impairment, Social Relationships, and Well-Being

The final hypothesis proposed that individuals with cognitive impairment would show lower social outcomes and reduced well-being compared to those without cognitive impairment. We also expected that low social outcomes would exacerbate the negative associations between cognitive impairment and well-being. These expectations were based

on previous findings that people with dementia and cognitive impairment often experience more loneliness and are less socially integrated, although they show a strong need for social connections (Dyer et al., 2021; El Haj et al., 2016; Huizenga et al., 2022). As posited by the Unmet Needs Model, cognitive impairment makes it more challenging to autonomously fulfill social needs due to increased dependency and communication barriers, leading to involuntary lower social engagement and connection (Cohen-Mansfield & Werner, 1995). Research supports this idea by showing that social engagement decreases with the diagnosis of cognitive impairment (Hackett et al., 2019).

Consistent with our hypotheses, participants with severe cognitive impairment, as indicative of dementia, faced the highest risk of reduced social and mental health compared to participants without cognitive impairment and those with MCI. They had a lower close network index, reported more loneliness, and showed lower social activity. They also had more depressive symptoms and lower positive affect than the other groups. Meanwhile, lower social outcomes were associated with reduced well-being, especially in participants with severe cognitive impairment. Participants with severe cognitive impairment who had low social activity levels showed more depressive symptoms than those without cognitive impairment with the same level of social activity. On the other hand, when they showed high social activity, they showed fewer depressive symptoms than participants without cognitive impairment with similar levels of activity. The findings highlight the importance of supporting social relationships in very old age for individuals both with and without cognitive impairment.

Our results support the Convoy Model, proposing that social networks change in response to life events, including health conditions such as cognitive impairment (Antonucci et al., 2014; Kahn & Antonucci, 1980). Participants with severe cognitive impairment showed lower social engagement, more loneliness, and even fewer close network members. Generally, close ties are more stable over the life course and serve as key resources for emotional well-being. Severe cognitive impairment appears to change the ability to maintain close relationships, which increases the risk of reduced well-being. This process is also described in the Unmet Needs Model, which emphasizes that cognitive impairment limits the

ability to meet social needs, resulting in poorer mental health and more psychiatric symptoms (Cohen-Mansfield et al., 2015).

The findings further indicate that low social engagement explains some part of the negative associations between cognitive impairment and well-being. Notably, participants with severe cognitive impairment and low social activity experienced more depressive symptoms than those without cognitive impairment with the same level of social activity. Conversely, those with high social activity had fewer depressive symptoms than their counterparts without cognitive impairment. It highlights the importance of maintaining a sense of belonging and social connection for people with cognitive impairment. Other studies have also emphasized the need for social connection in people with cognitive impairment (Huizenga et al., 2022; Patterson et al., 2018).

The findings have important practical implications. These align with approaches such as “living well with dementia”, which emphasize that aging is not only about promoting successful aging in terms of the absence of disease, but also about supporting people with illness to age well despite their condition. A crucial element for promoting quality of life in such groups is social connection and participation (Kim & Shin, 2023). Social relationships are, therefore, not only relevant for preventing cognitive impairment but also essential for those already experiencing cognitive impairment. Beyond promoting well-being, social relationships appear to prevent further cognitive decline, improve daily functioning, and reduce behavioral symptoms in people with dementia (Cohen-Mansfield et al., 2015; McDermott et al., 2019; Sun et al., 2020). Given that cognitive impairment affects about 43% of very old adults (Brijoux & Zank, 2023), opportunities should be created to support participation in this group. Strategies may include activity groups, training caregivers and families in nonverbal communication, and addressing underlying stigma that fosters social exclusion (Lee et al., 2017; McDermott et al., 2019; Rippon et al., 2024). Furthermore, environmental interventions, such as improving accessible transportation, seem useful, given that transportation difficulties have been shown to significantly reduce engagement among

people with dementia (Mank et al., 2022). Overall, reducing cognitive barriers in social spaces can foster social connection and well-being in individuals with cognitive impairment.

Overarching Findings

Collectively, the studies provide a comprehensive understanding of the mutual associations between social relationships and cognition in very old age. Among very old adults without probable dementia, aspects related to social bridging were cross-sectionally linked to higher cognitive functioning, highlighting the value of maintaining both close and peripheral relationships. Broad and diverse social networks often decline in very old age due to health, mobility, and motivational challenges (Carstensen, 2006; Fuller et al., 2020). It is important to create opportunities for very old adults to make it easier to sustain these broader connections. Since the associations were only cross-sectional, social relationships should be viewed as a long-term resource for cognitive health in very old age, not as a short-term booster. Fostering social ties should be considered a lifelong task, with particular attention paid to age-related transitions such as retirement, widowhood, or health decline. Finally, the studies show that social relationships are linked to higher positive affect and lower risk of depressive symptoms in very old adults. This addressed structural, functional, and qualitative aspects. At the same time, vulnerable groups such as individuals with cognitive impairment are at risk of experiencing lower social resources and thereby lower well-being. Hence, promoting social connection is an important task in very old age, particularly for risk groups.

Several shared recommendations emerge from the findings of the present studies. All encourage the creation of age-friendly and accessible social spaces, especially for those motivated to participate but lacking opportunities to do so. Interventions should address age-related barriers such as sensory, health, mobility, and cognitive impairment. Health and social care systems can further assist in this process by screening older adults for unmet social needs and providing guidance during key life transitions, including the onset of dementia (Lawlor et al., 2024). Screening may also help raise awareness among those who are less

motivated to connect with others. In general, promoting social connection for health and well-being should be considered a lifelong task. Creating or adapting age-friendly social spaces would not only benefit very old adults but also other groups facing participation barriers. Our studies underscore the importance of addressing these issues throughout the life course.

Additional Considerations

Some thoughts arose during the writing process that do not represent the main findings but are closely related to them. The reflections aim to deepen the understanding of the present findings and offer additional insights.

Research often highlights the need for secondary and tertiary health interventions, such as community programs to reduce social isolation and loneliness. This dissertation also underscores the importance of primary interventions. Although the focus was on age-related challenges, social relationships are influenced by both age-dependent and age-independent factors, consistent with the life course perspective. Age-independent risk factors, including low socioeconomic status, limited financial resources, and lower education, significantly limit opportunities for social participation in later life from an early stage (Hurst et al., 2013). Therefore, it is important to address both types of risk factors and consider early primary interventions to promote social relationships over the life course.

At the same time, it should be acknowledged that social isolation and loneliness are an inevitable part of life to a certain extent. Periods of solitude or social withdrawal are common and can sometimes be restorative by supporting personal growth (Rokach & Patel, 2024). Similarly, momentary loneliness is a common experience (Victor et al., 2022) and can even be beneficial, motivating individuals to reconnect with others (Cacioppo & Cacioppo, 2014). Occasional social isolation and loneliness are, therefore, not inherently harmful. As the saying goes: “The dose makes the poison”. Therefore, interventions should focus on chronic isolation and loneliness rather than normal fluctuations in social engagement.

A final point regarding interventions is that social relationships are not the only aspects important for social health. Equally important is self-connectedness, such as the ability to enjoy one's own company. It involves maintaining a positive relationship with oneself and being comfortable with occasional solitude. Self-connectedness can influence feelings of loneliness as much as meaningful social ties (Reinhard & Padberg, 2025). It is essential to recognize that social health interventions should include both fostering connection with others and with oneself.

Limitations and Strengths

The studies have several limitations and strengths that should be considered when interpreting the findings. Some issues have already been discussed in the individual articles.

First, our findings rely on cross-sectional and two-wave data, limiting our ability to assess long-term trajectories and establish causality. While research often interprets the positive associations between social relationships and cognition as mainly driven by social relationships, multiple models are possible. Low social resources may lead to cognitive decline, cognitive decline may reduce social resources, a reciprocal cycle may occur, or both may be influenced by a common underlying factor (Cohen-Mansfield, 2025). Even longitudinal studies cannot definitively determine which model is correct, as randomized controlled trials are challenging in this research field. Accordingly, uncontrollable factors remain possible. For example, individuals with subtle yet unobjectifiable cognitive decline may underestimate their network size, which could explain the long-term associations between social network size and subsequent cognitive decline (Roth et al., 2021). These factors make firm conclusions difficult.

Second, we applied survey weights to reduce selectivity bias, but the approach cannot fully eliminate selectivity and composition biases. For example, very isolated individuals are less likely to participate, potentially leading to an underestimation of associations. Additionally, adaptive coping strategies, such as positivity biases, may help

older adults manage social challenges but also cause them to underestimate loneliness (Lay et al., 2024). As a result, our samples may remain somewhat selective, and age-group biases could affect the outcomes.

Third, we aimed to capture the complexity of social relationships by including multiple aspects. However, this approach also has challenges. Some variables, such as loneliness and network size, were measured with single items. It limits their informational depth. For example, loneliness is a complex construct with various types and trajectories, and a single-item measure cannot capture all these dimensions (Victor et al., 2022). Similarly, focusing only on network size overlooks its diversity and composition (Ellwardt et al., 2015). While we included several aspects, some received more attention than others. For instance, social support was only briefly addressed to avoid overcomplicating the analyses, as its association with cognition is not straightforward (Costa-Cordella et al., 2021; Sims et al., 2014). As a result, some social information was not fully captured. It highlights the challenge of representing social relationships in detail without overloading the analysis.

Fourth, household composition and living arrangements were not included in most analyses because the sample comprised individuals living in both private and institutional settings. Although we conducted sensitivity analyses with only private household participants, we could not fully assess the impact of living arrangements on social integration and cognitive outcomes. However, living alone and related social conditions are important predictors of cognition and well-being in older adults, and prime intervention targets (Clare et al., 2024; Piolatto et al., 2022).

Fifth, it should be acknowledged that the effect sizes and explanatory power of our models were generally small to moderate. While it is expected in large-scale, non-experimental data, it underscores that many factors beyond social variables contribute to cognition and well-being in very old age. Social factors are only part of a broader context.

Lastly, these studies adopt a lifespan perspective rather than a comprehensive life course approach. However, it should be noted that the findings pertain to the current

generation of very old adults. Cohort effects, such as changes in education, lifestyle, and social norms, may limit generalizability to future generations. Most participants were born in the 1930s, and historical shifts like advances in women's rights, education, and family structures are likely to alter the meaning of social relationships in very old age. Increased life expectancy not only expands the group of very old adults but also transforms the experience of aging (Albertini & Vignoli, 2025). For instance, retirement now often lasts 30 years or more, requiring individuals to find meaningful activities for a longer period. Family structures have also evolved, with more generations alive simultaneously, but each generation being smaller (Albertini & Vignoli, 2025). As a result, great-grandparents and great-grandchildren may live at the same time, but great-grandparents often have fewer nearby relatives to support them. Further life course research will be essential to comprehend how societal and demographic shifts redefine social relationships and health outcomes in very old age.

Despite these limitations, our studies also have notable strengths. The biggest one is that our analyses are based on a large, representative sample of very old adults. Such large-scale studies on very old age are scarce. We furthermore included proxy interviews to capture information from individuals who are often excluded from research, thereby enhancing sample representativeness (Wu et al., 2020). Methodologically, we used sensitive measures of cognition and social relationships. For example, DemTect was chosen for its sensitivity to MCI (Kalbe et al., 2005). Moreover, instead of using social sum scores, we analyzed social variables separately, which provides greater precision and clearer intervention targets. Analytically, we applied diverse statistical methods and conducted extensive sensitivity analyses to ensure robust results. Overall, these studies aimed to provide a detailed and nuanced understanding of social relationships, cognition, and well-being in very old age.

Conclusions

This dissertation presented findings from three empirical studies on the bidirectional associations between social relationships and cognition in very old age. Research on this group has been limited due to their small population size in the past (Statistisches Bundesamt, 2022). As their numbers increase and their life circumstances tend to differ from those of young old adults, their inclusion in research is increasingly relevant. Importantly, differences between very old adults and younger groups should not be viewed solely in a deficit-oriented manner, because aging also reflects strengths and adaptation. Our data support this view and show that, despite ongoing social challenges, participants in the NRW80+ Study maintained close social connections and reported low levels of loneliness.

This work addressed two research questions. First, it examined which social aspects are positively associated with cognitive performance in very old age and may prevent cognitive impairment in this age group. Second, it explored how cognitive impairment relates to social relationships and how their interaction is associated with well-being. For the first question, we found that structural social aspects related to social bridging were cross-sectionally associated with higher cognitive functioning in very old adults without probable dementia. This finding highlights the benefits of broad social connections in a life phase, in which older adults tend to focus on and prioritize engagement with their close ties. However, the absence of longitudinal associations over 2 years suggests that social relationships do not serve as short-term protective factors for cognition in very old age. Instead, they should be considered a life course resource, with benefits arising from sustained engagement and patterns of connection.

Regarding the second research question, social aspects were generally linked to higher well-being in very old adults. Individuals with severe cognitive impairment represented a risk group for lower social and mental health, and their well-being was more strongly linked to social engagement. These findings underscore the vulnerability of individuals who seek social connection but lack opportunities to do so, further emphasizing the importance of

supporting social participation in very old age. Given the prevalence of cognitive impairment in very old age (Brijoux & Zank, 2023), our findings suggest that social relationships should be viewed not only as a means to prevent cognitive impairment but also as a way to support quality of life for those living with it.

In summary, policies should recognize social relationships as both a means of promoting health and as an area shaped by health. Common age-related barriers, including sensory, physical, and cognitive impairment, can limit people's ability to maintain the social relationships they desire (Jaul & Barron, 2017). Age-friendly environments can therefore support social connection and preserve well-being. While research has long focused on helping people age without illness, it is time for a paradigm shift toward strategies that also help people age well with conditions such as cognitive impairment. As Robert Waldinger, Director of the Harvard Study of Adult Development, has noted: "Good relationships don't just protect our bodies, they protect our brains" (Waldinger, 2015). At the same time, our bodies and brains also help to protect our social relationships. When physical or cognitive decline occurs, the impact on our social well-being depends greatly on the environment in which we live and the barriers it encompasses.

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