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Loneliness, sense of control, and risk of dementia in healthy older adults: A moderated mediation analysis

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Loneliness, Sense of Control, and Risk of Dementia in Healthy Older Adults: A Moderated Mediation Analysis

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ABSTRACT

Objectives

Despite the rising prevalence of dementia, little research has been conducted to identify modifiable psychological factors that alleviate the risk of dementia in older adults and the underlying mechanisms. Given that loneliness is, in part, concomitant with a weakened sense of control, we examined whether sense of control would mediate the relation between loneliness and dementia risk. Further, considering that working -memory capacity is a critical cognitive resource that serves as a buffer against age-related cognitive decline, we examined a second-order moderated mediational model whereby working-memory capacity moderates the relation between control beliefs and dementia risk in older adults.

Methods

We administered a series of measures to older community-dwelling adults (ages 60–93; N = 69), including the participant-rated AD8 to assess the risk of dementia. Using the PROCESS macro, we examined the moderated mediation model for the relation between loneliness, sense of control, and dementia risk.

Results

We found that sense of control significantly mediated the relation between loneliness and risk of dementia. Moreover, the indirect effect of loneliness on dementia risk via lowered sense of control was significant only in individuals with poorer working-memory capacity. Notably, these findings held true when important covariates were controlled for.

Conclusions

Our findings underscore the critical role of control beliefs and working memory in protecting against dementia risk.

Clinical implications

Our findings have implications for intervention programs that target alleviating dementia risk and promoting healthy aging in older adults by improving socioemotional health and cognitive functioning.

KEYWORDS: control beliefs, dementia, loneliness, perceived constraints, working memory

Approximately 50 million people worldwide have been diagnosed with dementia (WHO, 2019)—a condition characterized by a progressive decline in mental abilities (Ferrari, Cravello, Bonacina, Salmoiraghi, & Magri, 2005)—and the number is predicted to triple by 2050. In addition, recognition of dementia as a public health priority (WHO, 2019) underscores the importance of research in this area. Despite dementia's rising prevalence, however, little research has been conducted to (a) identify modifiable psychological (rather than biological) factors that could alleviate the risk of dementia during a period of healthy cognitive aging (Anstey, Eramudugolla, Hosking, Lautenschlager, & Dixon, 2015) and (b) investigate a mediational pathway that links these psychological factors to the risk of dementia. In light of these gaps in the literature, our objectives are to examine, first, the mediating role of sense of control in the relation between loneliness and dementia risk and, second, the moderating role of working-memory capacity in the mediational relation between sense of control and dementia risk in healthy older adults.

Psychological mechanism

Our primary goal was to examine the predictive role of loneliness in dementia risk and the psychosocial mechanism that underlies this relation. Loneliness, defined as the subjective experience of isolation and a deficit in feelings of social fulfillment (Andrew & Meeks, 2018), has received attention in recent research and been found to be a crucial socioemotional risk factor for cognitive decline and the risk of dementia (e.g., Boss, Kang, & Branson, 2015).

Previous studies suggest that loneliness is influenced by interwoven factors, such as the size of one's social network (Ashida & Heaney, 2008) and frequency of engagement with others (i.e., social contact; Drageset, 2004). Subjective evaluations of the extent to which one has fulfilling relationships (i.e., social connectedness; Coleman, 1988; O'Rourke & Sidani, 2017) and access to help from others (i.e., social support) are notable concepts that have also been linked to loneliness (Liu, Gou, & Zuo, 2016).

Although the socioemotional selectivity theory maintains that older adults are motivated to maximize positive emotional experiences by investing their resources in emotionally rewarding social networks (Carstensen, Isaacowitz, & Charles, 1999), they are increasingly susceptible to loneliness owing to various late-life stressors such as dwindling social networks, transition into care facilities, cognitive decline that impairs communication and interactions, and poorer health, which hinders physical functioning (Hicks, 2000). In view of this, several large-scale longitudinal studies have demonstrated that perceived loneliness vastly increases the risk of dementia in older adulthood (e.g., Rafnsson, Orrell, D' Orsi, Hogervorst, & Steptoe, 2020). Despite a considerable amount of research on this subject, however, there is a dearth of research that sheds light on the psychological mechanism that drives the predictive effect of loneliness on dementia risk (Boss et al., 2015). It is vital, therefore, that we understand the mediational process that accounts for the link between loneliness and risk of dementia in late adulthood.

As a potential mediating factor, we sought to determine whether sense of control, defined as a set of beliefs regarding the amount of control and autonomy over one's environment (Alloy, Clements, & Koenig, 1993), would mediate the pathway from loneliness to dementia risk. Sense of control has two facets: personal mastery (i.e., beliefs about one's self-efficacy) and perceived constraints (i.e., beliefs about the presence of uncontrollable external barriers and obstacles; Lachman & Weaver, 1998). Empirical evidence has substantiated the negative association between loneliness and perception of control (Cacioppo & Hawkley, 2005; Newall et al., 2009). According to Hawkley and Cacioppo's (2010) theoretical model of loneliness, feelings of loneliness engender perceptions that one's social environment is unsafe or threatening (Perlman, 2004). This would, in turn, weaken one's sense of control over his or her circumstances (Gierveld, 1998). In a similar vein, studies have shown that lonely individuals are more likely to attribute their social isolation to uncontrollable external causes (Anderson & Riger, 1991). Consequently, the pessimistic and hypervigilant outlook generated by loneliness would couple with a helpless attribution style, which together would diminish perceived control over one's circumstances (Gierveld, 1998). It is plausible, therefore, that loneliness would adversely impact sense of control in late adulthood.

Further, a perceived lack of control has been suggested as a psychological risk factor for cognitive impairment in older adults (Dixon & Lachman, 2019). As theorized by De Frias, Dixon, and Backman (2003), sense of control provides a motivational resource for developing effortful strategies to compensate for cognitive limitations or losses, thereby, facilitating cognitive performance. Having a stronger sense of control is also associated with lower levels of anxiety and stress reactivity, which, in turn, promote better performance on cognitive assessments (Soederberg Miller & Lachman, 2000). In contrast, older adults with lower levels of perceived control showed greater memory decline (Windsor & Anstey, 2008) and poorer performance on a verbal fluency task over a period of 2 years than their counterparts who hold positive control beliefs (Robertson, King-Kallimanis, & Kenny, 2016). Given the evidence that loneliness impairs sense of control, which in turn aggravates cognitive decline—a key defining characteristic of dementia (Jessen et al., 2010)—it is plausible that older adults' sense of control would mediate the relation between loneliness and the risk of dementia.

Working memory as a moderator

Our second goal was to determine whether individual differences in working-memory capacity would modulate the relation between sense of control and dementia risk in healthy older adults. Studies have documented that patients living with dementia undergo a progressive decline of cognitive abilities (Ferrari et al., 2005) and show significant impairment on indices of executive function such as cognitive control, verbal fluency (e.g., McGuinness, Barrett, Craig, Lawson, & Passmore, 2010), and control processes in working memory (Morris & Baddeley, 1988). Working memory, as a fundamental component of executive function, is a core cognitive resource that enables the simultaneous storage processing and information manipulation that underlie a wide range of complex cognitive tasks, such as problem solving, reasoning, learning, and comprehension (Baddeley, 1992). Given that age-related cognitive impairment serves as a precursor to and aggravates the risk of dementia (Jessen et al., 2010), the literature hints at the potential association of working memory with sense of control (Dixon & Lachman, 2019) and dementia (i.e., cognitive impairment). Considering that control beliefs in healthy older adults are positively related to various cognitive processes, such as memory processing, processing speed, and verbal intelligence—all of which implicate aspects of working memory (Lachman & Andreoletti, 2006; Windsor & Anstey, 2008)—it is conceivable that one's control beliefs and working-memory capacity may have an intricate relation.

Further, since working memory deficits are a crucial factor in cognitive decline and have been shown to be a defining characteristic of dementia in older adults, it is plausible that working memory deficits and dementia risk are closely associated in older adults. Specifically, studies have found that older adults diagnosed with dementia of the Alzheimer type showed poorer performance on working-memory tasks (i.e., the backward-digit-span task) than healthy controls (Kessels, Molleman, & Oosterman, 2011), which sheds light on the crucial relation of working memory and dementia risk. Although it is not clear whether individual differences in working memory directly predict dementia, the literature implicates working memory as a vital underlying cognitive reserve that buffers against long-term memory decline caused by multiple sclerosis (Sandry & Sumowski, 2014) and traumatic brain injury (Sandry, DeLuca, & Chiaravalloti, 2014). In a similar vein, individuals who maintain lower cognitive reserves are shown to be more susceptible to and have poorer compensatory abilities with respect to age-related cognitive decline (Balbag, Pedersen, & Gatz, 2014), which is indicative of greater dementia risk. Therefore, given that working memory undergirds cognitive reserve and serves as a protective resource that has been shown to alleviate cognitive decline, greater working-memory capacity would likely attenuate dementia risk. Taken together, it is reasonable that working memory would moderate the relation between sense of control and dementia risk. Specifically, if poorer sense of control augments dementia risk, this negative association should be more evident in older adults who have lower working-memory capacity but not in those with higher working-memory capacity.

In sum, to understand the psychological mechanism that underlies the impact of loneliness on dementia risk in healthy older adults, we focused on the mediating role of sense of control in the loneliness-dementia link and the moderating role of working memory in the mediational pathway from sense of control to dementia. Building on the accumulated evidence for negative relations between loneliness and sense of control and between sense of control and dementia, we hypothesized that loneliness would impair

the sense of control, which would in turn engender a greater risk of dementia. Further, given the role of working memory as a critical component of cognitive reserve in older adults, we predicted that working memory would buffer against cognitive decline by modulating the relation between sense of control and dementia risk. Specifically, we hypothesized that a negative association between sense of control and dementia risk would be more pronounced in individuals with relatively lower working-memory capacity than those with higher working-memory capacity.

Method

We examined a second-order moderated mediation model and controlled for a host of covariates (age, sex, education, income, marital status, number of chronic diseases, intelligence, neuroticism, and depression) that have been shown to influence loneliness, sense of control, working memory, and risk of dementia (e.g., Hartanto & Yang, 2019; Von Soest, Luhmann, Hansen, & Gerstorf, 2020).

Participants

Sixty-nine healthy and functioning older adults (M_{age} = 70.39 years, *SD* = 7.32; 76.8% female) were recruited via word of mouth or through local senior centers that conduct programs for healthy elders in the community. The majority of participants were Chinese (89.39%), had completed secondary education (78.79%) or earned a diploma (71.21%), and had experienced fewer than two chronic illnesses (60.6%; see Table 1). [1]

Table 1. Descriptive statistics of predictor, covariates, mediator, and criterion variables.

	M	*SD*	Min	Max	Skewness	Kurtosis
Covariates						
Age (years)	70.39	7.32	57	94	0.81	1.11
Gender (% female)	76.8	-	-	-	-	-
Marital status[1]	2.10	1.66	1	6	1.14	−.14
Education[2]	3.13	2.30	1	9.00	1.57	0.29
Household income[3]	2.01	1.37	1	6	1.19	.57
Subjective SES	5.72	1.81	1	10	0.27	1.29
Perceived physical health	71.30	17.67	30	100	−0.42	−.48
Perceived mental health	75.43	16.99	25	100	−0.57	−.06
Physical functioning	70.65	25.21	0	100	−0.76	−0.17
Chronic illness[4]	2.09	1.95	0	8	0.86	0.40
Nonverbal intelligence	9.10	5.46	0	25	−0.75	−0.03
Depression	0.64	1.16	0	6	2.78	8.89
Social support	9.29	2.43	1	12	−0.88	0.57
Social strain	2.73	2.67	0	12	1.05	1.07
Neuroticism	8.794	3.51	0	18	0.11	−0.42
Focal predictor						
Loneliness	4.32	1.49	3	9	0.78	−0.23
Mediators						
Sense of control[5]	48.52	8.12	30	60	−0.41	−0.54
Personal mastery	24.55	4.26	14	30	−0.49	−0.41
Perceived constraints	23.51	6.39	7	30	−0.73	−0.34
Moderator						
Working memory	7.75	2.78	1	16	0.33	0.73
Criterion						
Dementia risk	1.69	1.92	0	8	1.19	0.89

[1]Marital status was reported on a 6-point scale (1 = *Married*, 2 = *Divorced*, 3 = *Separated*, 4 = *Single*, 5 = *Other*, 6 = *Widowed*).
[2]Education was reported on a scale of *1* (*no school*) to *12* (*PhD, EDD, MD, DDS, LLB, LLD, JD, or other professional degree*).
[3]Income was measured based on participants' combined monthly household income through wages, pension, social security, and other sources.
[4]Chronic illness was indexed by the total number of chronic health problems experienced in the past 12 months. Higher numbers of chronic problems denote poorer heath status.
[5]Responses were recoded such that higher values reflect higher personal mastery and lower perceived constraints.

Measures

Loneliness

A modified three-item version of the UCLA Loneliness Scale (Version 3; Hughes, Waite, Hawkley, & Cacioppo, 2004) was administered to measure feelings of loneliness, which encompass feelings of disconnectedness, not belonging, and isolation. Participants reported the frequency with which they experienced emotions such as "feeling isolated from others" on a 3-point Likert scale (*1 = Hardly ever, 2 = Some of the time, 3 = Often)*. Item scores were summed to obtain a total score ranging from 3 (minimum) to 9 (maximum), with higher scores denoting stronger feelings of loneliness. This scale demonstrated good internal consistency (α = .82). Independent psychometric assessments have also demonstrated that the scale gauges general feelings of loneliness and is robust across in-person or telephone interviews (Hughes et al., 2004).

Sense of control

Sense of control was assessed using a 7-point Likert scale (*1 = Strongly agree, 7 = Strongly disagree*; Lachman & Weaver, 1998). The measure contains two subscales: (a) personal mastery (four items; α = .71), which assessed efficacy in carrying out personally important goals (e.g., "When I really want to do something, I usually find a way to succeed at it") and (b) perceived constraints (eight items; α = .83), which assessed the perception of obstacles beyond one's control that interfere with reaching personally pertinent goals (e.g., "There is little I can do to change the important things in my life"). After the subscale for personal mastery was reverse-coded, item scores from both subscales were averaged such that higher values represent greater sense of control (i.e., higher personal mastery and lower perceived constraints).

Risk of dementia

We used the eight-item participant-rated AD8 (Galvin, Roe, Coats, & Morris, 2007) to measure dementia risk in healthy community-dwelling older adults; note that our use of the AD8 was not to clinically diagnose dementia but rather to index potential risk of mild forms of dementia. Each of the eight items on the scale was scored either 0 (*No, no change*) or 1 (*Yes, a change*), and item scores were summed such that higher scores reflect greater severity of cognitive impairment—that is, increased risk of dementia. The participant-rated AD8 has been shown to sensitively distinguish older adults without dementia from those with even the mildest forms of dementia, with better utility for mildly impaired individuals (Chin, Ng, Narasimhalu, & Kandiah, 2013; Galvin et al., 2007). Besides excellent internal consistency (α = .84), the participant-rated AD8 has demonstrated good convergent validity by showing significant correlations with criterion standards for dementia assessments and global cognitive assessments such as the Clinical Dementia Rating, Mini-Mental State Examination, and Short Blessed Test scores (Galvin et al., 2007).

Working-memory capacity

To assess working memory, the backward digit span task from the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV; Wechsler, 2008) was used. Participants listened to 14 progressively longer strings of numbers, starting with two-digit strings, and were asked to recall each number series in reverse order. The assessment ended when the participant made recall errors for two consecutive digit strings, and the number of correct trials in which each digit string was accurately recalled backward was recorded.

Nonverbal reasoning

The matrix reasoning subtest from the WAIS-IV (Wechsler, 2008) was used as a measure of nonverbal intelligence. The task, which contains 26 items, measures nonverbal abstract problem solving, inductive reasoning, and spatial reasoning ability. Participants were asked to view an array of printed pictures with one missing square and select the picture that fits the array from five options. The assessment ended when the participant made three incorrect responses consecutively. We then recorded the highest number of items answered correctly.

Health status

The general-health subscale of the Short-Form Health Survey (SF-36; Ware & Sherbourne, 1992) was used to measure (a) general perceptions of physical and mental health, (b) physical limitations due to health problems, and (c) the number of chronic diseases. These facets were measured using the appropriate subscales of the SF-36, containing 10 items each for the general perceptions and physical limitations subscales and 22 items for the chronic diseases subscale. Participants self-reported general perceptions of their physical and mental health on a 5-point Likert scale (*1 = Excellent, 5 = Poor*) and the degree of limitation they faced in performing a practical activity of daily life on a scale of *1* (*No, not limited at all*) to *3 (Yes, very limited)*. Participants' responses on each item were recoded using preassigned numeric values ranging from *0* to *100* (e.g., response choice 1 corresponding to 100; 2, to 75; 3, to 50; and so on), such that higher scores reflect more favorable health status. Lastly, the number of chronic diseases was operationalized as the total number of chronic diseases participants had experienced in the past 12 months.

Personality

Participants completed the 20-item, short-form International Personality Item Pool (mini-IPIP; Donnellan, Oswald, Baird, & Lucas, 2006), which was adapted from the original 50-item scale (Goldberg, 1999). The mini-IPIP assesses the Big Five factors of personality (John & Srivastava, 1999): extraversion (α = .77), agreeableness (α = .70), conscientiousness (α = .69), neuroticism (α = .68), and intellect/imagination (α = .65). Participants reported their agreement with statements such as "have frequent mood swings" on a 5-point Likert scale (*1 = Strongly disagree* to *5 = Strongly agree*). After reverse-coding negatively worded items, overall scores were calculated by summing across items corresponding to each personality dimension.

Depressive symptoms

As a measure of depressive symptoms in older adults, a seven-item variant of the Geriatric Depression Scale (GDS; Brink et al., 1982) was used. Participants answered yes or no to questions such as "do you feel that your life is empty?" The overall depression score was obtained by summing across all items, and higher scores denoted greater general depressive symptoms. The scale showed reliability of .67.

Social support and strain

The social support and strain scales (Schuster, Kessler, & Aseltine, 1990; Walen & Lachman, 2000) contained four items each. The support subscale (e.g., "How much do they really care about you?") and the strain subscale (e.g., "How often do they criticize you?") were rated with reference to family and friends, using a 4-point Likert scale (*1 = Not at all* to *4 = A lot)*. After reverse-coding relevant items, a mean score was calculated for each subscale, with higher scores reflecting a greater level of support and strain. Notably, both subscales had acceptable reliability: α = .76 for social support and α = .85 for social strain.

Demographic variables

Demographic information (age, gender, marital status, household income, and subjective experience of socioeconomic status) was obtained via the self-report questionnaire. Given the multifaceted aspects of socioeconomic status (SES), we measured this using proxies: education attainment, household income, and subjective SES. Participants reported their highest education attainment on a scale from *1* (*no school*) to *12* (*PhD, EDD, MD, LLB, LLD, JD, or other professional degree*). Household income was measured based on participants' combined monthly household income from wages, allowances from family members, dividends, and other sources. Participants' subjective SES was recorded using the MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo, & Ickovics, 2000). In this, participants were presented with an image of a ladder and asked to rate their self-perceived social standing in their community by selecting the most appropriate rung, ranging from *1* (*lowest SES*) to *10* (*highest SES*).

Procedure

Participants were first asked to complete the backward digit span and matrix reasoning tasks from the WAIS-IV, followed by a series of self-report questionnaires. The design of and procedures for the study received relevant approvals from the university's institutional review board, and all participants consented to take part in the study prior to participation. The study was not preregistered.

Results

We performed ordinary least squares (OLS) regression analyzes, with loneliness as the focal predictor, sense of control as the central mediator, working memory as a moderator, and dementia risk as a criterion. We included a host of covariates—age, gender, marital status, education, subjective socioeconomic status, household income, perceived mental health, perceived physical health, physical functioning, number of chronic illnesses, nonverbal intelligence, depression, social support, social strain, and neuroticism—that have been shown to be associated with either loneliness or sense of control (Von Soest et al., 2020). The focal predictor and covariates were included in Model 1, followed by the mediator in Model 2 in OLS regressions. Mediation and moderated mediation analyzes were conducted using the PROCESS macro (Hayes, 2018), which estimated 95% bootstrap confidence intervals (CI) for indirect effects based on 5,000 bootstrapped samples. Our sample had 98.8% power to detect an indirect effect in the mediation analysis. We also conducted separate analyzes with respect to the two subscales of sense of control (personal mastery and perceived constraints) to examine whether they would differentially affect the mediational pathway from loneliness to dementia. No evidence of multicollinearity was found (for zero-order correlations, see Table 2). Further, due to a relatively larger proportion of females than males in the sample, we controlled for sex as a covariate in the analysis and found little evidence that the unequal sex ratio affected our results.

Table 2. Zero-order correlations between predictor, covariates, mediators, and criterion variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	-																	
2. Gender	−.08	-																
3. Marital status	−.01	**.33**	-															
4. Education	.11	.05	.06	-														
5. Household income	**−.27**	.03	.12	**.29**	-													
6. Subjective SES	.04	−.03	−.02	.11	.23	-												
7. Physical health	.12	.11	.09	.13	.10	.23	-											
8. Mental health	−.09	.09	.13	.19	.08	.16	.58	-										
9. Physical functioning	−.21	.10	−.08	.05	.20	.17	.08	.08	-									
10. Chronic illness	.04	−.14	−.12	−.09	−.16	−.17	−.44	−.34	.08	-								
11. Intelligence	**−.39**	.02	.06	**.24**	**.49**	.003	.05	.04	.05	−.18	-							
12. Depression	.07	.04	.08	−.16	−.13	−.15	**−.40**	**−.35**	−.02	**.39**	.16	-						
13. Social strain	.01	−.04	.16	**.26**	.07	−.19	−.20	−.08	−.08	.20	.09	**.27**	-					
14. Social support	−.26	.18	.13	−.07	.15	−.02	.16	.23	.11	−.04	.18	−.16	−.09	-				
15. Neuroticism	.04	−.17	−.15	−.21	−.13	−.14	**−.35**	**−.50**	.03	**.41**	−.07	**.36**	.19	−.13	-			
16. Working memory	**−.40**	.16	.06	.09	**.27**	.08	−.07	.09	**.25**	**.53**	**−53**	**−.26**	.09	−.19	−.12	-		
17. Sense of control	**−.35**	.02	−.10	−.01	.13	.10	.06	**.39**	.24	−.03	.12	**−.47**	**−.24**	.20	**−.36**	**.25**	-	
18. Loneliness	.18	−.04	.03	−.01	.06	−.02	−.12	−.22	.02	.31	−.23	**.41**	**.43**	−.23	.21	**−.26**	**−.58**	-
19. Dementia risk	**.33**	.045	.07	**.45**	.03	−.03	.05	−.10	**−.26**	.08	.07	.09	.11	−.13	−.12	−.15	**.56**	**.28**

Notes. Significant results are marked in boldface; $p < .05$.

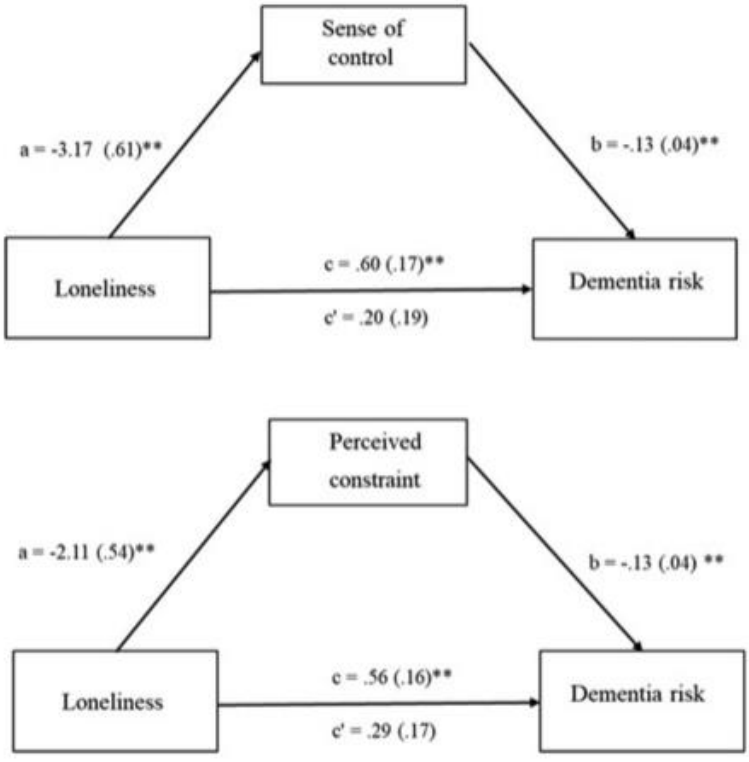
We found that loneliness significantly predicted dementia risk when all other covariates were controlled for (B = .60, 95% CI [.24, .95], p = .001). In Model 2, sense of control (B = −.24, 95% CI [.20, −.05], p = .002) also significantly predicted dementia risk (see Table 3). Our simple mediation analysis revealed a significant indirect effect for sense of control (B = .40, 95% CI [.14, .67]; see Figure 1). When two separate mediation analyzes were performed with respect to personal mastery and perceived constraints, we found a significant indirect effect for perceived constraints (B = .27, 95% CI [.07, .52]) but not for personal mastery (B = −.05, 95% CI [−.25, .16]). These results indicate that the mediational relation between loneliness and dementia risk is driven by sense of control in overcoming various constraints in everyday life (see Figure 1).

Table 3. Regression coefficients for dementia risk.

	Model 1		Model 2	
	B (*SE*)	β	B (*SE*)	β
Predictor				
Loneliness	**.60 (.175)**	**.452**	.202 (.199)	.152
Covariates				
Age (years)	.036 (.034)	.137	.031 (.031)	.118
Gender (% female)	−.294 (.512)	−.062	−.189 (.466)	−.040
Marital status	.056 (.127)	.048	−.017 (.117)	−.015
Education	**.444 (.100)**	**.532**	**.363 (.094)**	**.436**
Household income	−.294 (.188)	−.210	−.126 (.178)	−.090
Subjective SES	−.040 (.122)	−.036	−.032 (.111)	−.029
Perceived physical health	.007 (.016)	.068	−.004 (.015)	.037
Perceived mental health	−.033 (.018)	−.273	−.014 (.017)	−.117
Physical functioning	**−.018 (.009)**	**−.223**	−.008 (.008)	−.106
Chronic illness	−.170 (.129)	−.161	−.015 (.126)	−.014
Nonverbal intelligence	.063 (.047)	.178	.047 (.043)	.132
Depression	.236 (.247)	.117	−.011 (.237)	−.006
Social support	.039 (.089)	.048	.017 (.081)	.021
Social strain	**−.203 (.095)**	**−.270**	−.137 (.089)	−.182
Neuroticism	−.101 (.073)	−.184	**−.172 (.070)**	**−.313**
Mediators				
Sense of control	-	-	**−.126 (.038)**	**−.522**

Notes. *SE*s are shown in parentheses. Significant results are marked in boldface; $p < .05$.

Figure 1. Mediational models with sense of control (top panel) and perceived constraint (bottom panel) as mediators for dementia risk. Note that a and b signify indirect effects for sense of control and c and c' signify total and direct effects, respectively. The indirect effect of loneliness on dementia risk via personal mastery is not significant. All values represent unstandardized regression coefficients with standard errors in parentheses. *$p < .05$; **$p < .001$.



We also performed a second-order moderated mediation analysis to examine whether working memory modulates the mediational link between sense of control and risk of dementia. We found a significant sense of control × working memory interaction term ($B = .02$, 95% CI [.01, .04], $p = .003$). The index of

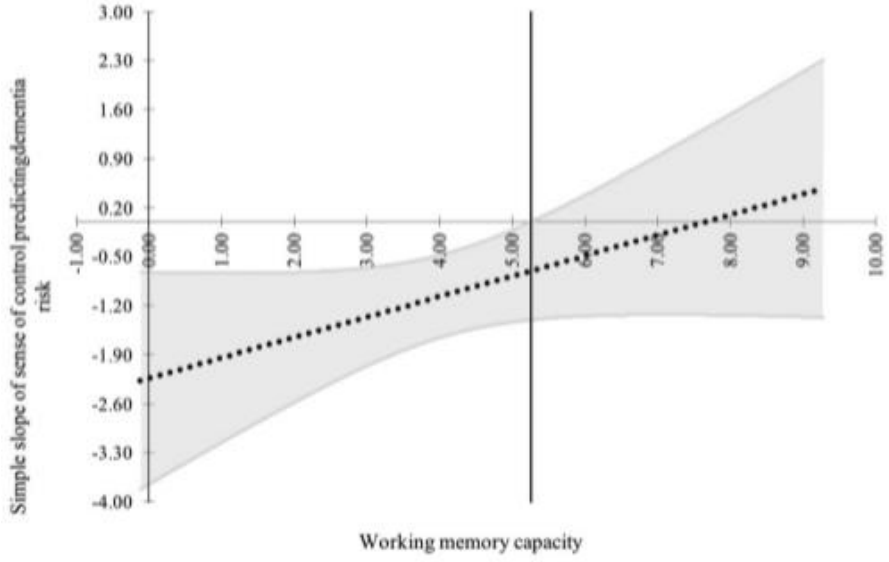
moderated mediation (B = −.07, 95% CI [−.14, −.02]) for sense of control was also significant, indicating that the indirect effect of loneliness on dementia risk through sense of control was moderated by the individual's working-memory capacity. Specifically, the mediational pathway from loneliness to dementia risk via lowered sense of control was significant only for participants with poorer working-memory capacity but not for those with higher working-memory capacity (Table 4). To further probe the significant interaction effects, the Johnson-Neyman technique was used to determine the significance regions for working memory (see Figure 2). We found that the relation between sense of control and dementia risk was significant only at lower levels of working memory (a cutoff working-memory score of 5.26 and below; i.e., 0.44 *SD* below the mean) but not at higher levels of working memory. This result suggests that working-memory capacity serves to protect individuals from the deleterious effect of lower sense of control on dementia risk. Notably, however, the second-order moderated mediation model was significant only for the composite score of sense of control—that is, the overall facets of sense of control comprising both greater mastery and lowered constraints. In contrast, the indexes of moderated mediation with respect to perceived constraints (B = −.02, 95% CI [−.09, .04]) and personal mastery (B = −.05, 95% CI [−.12, .01]) were not significant.

Table 4. Results for second-stage moderated mediation analyses for loneliness and dementia risk via sense of control.

	Working-Memory Capacity					
	16th percentile		50th percentile		84th percentile	
	Conditional indirect effect	95% CI	Conditional indirect effect	95% CI	Conditional indirect effect	95% CI
Sense of control	**.5498 (.1707)**	**[.2473,.9199]**	**.3787 (.1416)**	**[.1092,.6804]**	.1683 (.1547)	[−.1628,.4450]
Perceived constraints	**.3044 (.1513)**	**[.0701,.6639]**	**.2660 (.1205)**	**[.0688,.5422]**	.1891 (.1596)	[−.1144,.5466]
Personal mastery	.0628 (.1216)	[−.1545,.3396]	−.0549 (.1002)	[−.2597,.1491]	−.1997 (.1460)	[−.5167,.0636]

Notes. Values represent unstandardized coefficient estimates with standard errors in parentheses for conditional indirect effects. Significant results marked in boldface; $p < .05$.

Figure 2. This Johnson-Neyman plot illustrates the slope of sense of control that predicts dementia risk (i.e., the dash-dot line with 95% confidence bands) at varying levels of working-memory capacity. The negative association between sense of control and dementia risk is significant only at working-memory scores of 5.26 and lower (i.e., 0.44 *SD* below the mean), as indicated by the solid vertical line.



To ascertain the directionality of our moderated mediation model, we examined an alternative first-order moderated mediation model in which dementia risk led to loneliness via sense of control and working memory modulated the mediational pathway between dementia risk and sense of control. As indicated by the index of moderated mediation (B = −.024, SE = .023, 95% CI [−.08, .02]), the conditional indirect effect of dementia risk on loneliness was not significant and working-memory capacity did not moderate the mediational relation between dementia risk and sense of control. These results suggest that the

pathway from loneliness to dementia risk via sense of control is more plausible than the reversed pathway. Together, these results highlight the mediating and moderating roles of sense of control and working-memory capacity, respectively, in explaining the relation between loneliness and dementia risk.

Discussion

Our study demonstrates that feelings of loneliness in healthy older adults are indirectly linked to elevated risk of dementia via sense of control over obstacles that interfere with the attainment of goals (i.e., perceived constraints). These findings lend support to empirical evidence for an association between feelings of loneliness and sense of control in healthy older adults (Andrew & Meeks, 2018). Further, this finding is, in part, consistent with Hawkley and Cacioppo's (2010) model of loneliness, which postulates that loneliness facilitates the perception of social isolation; this, in turn, triggers heightened vigilance for social threat and feelings of vulnerability or a lack of safety in one's social environment (Hawkley & Cacioppo, 2010). As a result, lonely individuals who lack social fulfillment would feel helpless, with little control over their circumstances (Gierveld, 1998; Perlman, 2004) and thus experience lowered sense of control.

Interestingly, we found a distinction between perceived constraints and personal mastery; only the former—perceptions of barriers or impediments beyond one's control that interfere with goal accomplishment—significantly accounted for the association of loneliness with dementia; whereas, the latter—one's sense of efficacy and competence in achieving long-term goals—did not (Lachman & Weaver, 1998). Given that perceptions of obstacles that hinder goal attainment are more salient for and pertinent to older adults' daily functioning, these findings highlight the relative importance of perceived constraints over personal mastery in the context of loneliness and dementia risk in healthy older adults. However, given that personal mastery is closely linked to loneliness (Fry & Debats, 2002), it is difficult to explain why personal mastery fails to mediate the relation between loneliness and dementia risk. Although this is speculative, given that personal mastery is based on perceived self-efficacy in various domains (e.g., interpersonal, instrumental, emotional, social, financial, physical, nutritional, and spiritual), we believe that the mediating role of personal mastery may be more evident in certain areas, such as interpersonal relations or emotional regulation, that are more directly relevant to loneliness (Fry & Debats, 2002). Since our measure of personal mastery does not specify different domains of self-efficacy, future study in this regard is warranted.

Furthermore, our study contributes by validating the relation between loneliness and dementia risk (e.g., Zhou, Wang, & Fang, 2018) while at the same time elucidating its psychological mechanism via sense of control (specifically, perceived constraints). Given that dementia is characterized by cognitive decline and impairment, our findings also corroborate previous studies that hint at the association between sense of control and age-related cognitive decline (Lachman, Neupert, & Agrigoroaei, 2011). Specifically, longitudinal studies have demonstrated that older adults who perceive a greater sense of control over their cognitive functioning perform objectively better on tasks of memory, speed, and verbal intelligence (Dixon & Lachman, 2019; Windsor & Anstey, 2008). In view of this, it is important to examine whether sense of control, as a critical mediator, would intervene in the relation between loneliness and severe forms of dementia, which substantially threaten crucial aspects of daily functioning in older adults.

Importantly, our finding that working-memory capacity moderates the relation between sense of control and dementia risk underscores the crucial role of working-memory capacity as a valuable protective resource against dementia risk and other related forms of cognitive impairment. These results also highlight the potential contribution of working memory as a cognitive reserve in attenuating the risk of dementia. Further, although the literature has focused on various sources of cognitive reserve, such as educational attainment (Stern, Albert, Tang, & Tsai, 1999) and occupational cognitive requirements (Pool et al., 2016), the cognitive and neural mechanisms underlying these cognitive-reserve factors remain relatively unknown (Stern, 2012). Given our finding that working memory safeguards against the risk of dementia, it is possible that individual differences in working-memory capacity, which is known to be malleable to one's external and experiential factors (e.g., Hartanto, Toh, & Yang, 2016; Toh, Hartanto, Tan, & Yang, 2018), might underlie the protective and beneficial impacts of cognitive reserves. Further,

given that recent research has demonstrated that working memory in older adults is trainable (Heinzel et al., 2014), it is possible that working-memory interventions for individuals with lower sense of control may be conducive to attenuating dementia risk. Thus, more attention should be paid to individual differences in higher-order cognitive functioning as a cognitive reserve against dementia risk.

Our study is not without limitations. First, the lack of experimental control limits causal inference regarding the direction of the relation between loneliness and dementia risk. Although theoretical models of loneliness (Hawkley & Cacioppo, 2010) and sense of control (De Frias et al., 2003) as well as meta-analysis of longitudinal studies (see Lara et al., 2019) lend support to our moderated mediation pathway, the reversed pathway from dementia risk to loneliness is still viable, such that the increased cognitive impairment that accompanies dementia diminishes one's control beliefs and, in turn, magnifies one's perceptions of loneliness. Given this possibility, future research should employ a longitudinal design to ascertain the directionality of the association.

Second, although we found that sense of control works as a critical mediator underlying the link between loneliness and dementia, our data support only a partial mediation, which suggests the possibility of other mediators. Hence, future research should examine other mediators, such as health and social factors, that are closely intertwined with sense of control.

Third, given that we focused on general feelings of loneliness or a perceived lack of social fulfillment as our focal predictor, we were not able to precisely differentiate chronic loneliness, which is caused by internal personality factors, from situational loneliness triggered by external factors such as the loss of loved ones (Rubin & Rubin, 1992). Thus, it is important that future research examine how these different types of loneliness would contribute to sense of control and risk of dementia.

Fourth, although our sample size is small, our analysis is based on 5,000 bootstrapped samples, which are robust and unlikely to have power issues. However, given that our sample consisted of a small subset of predominantly healthy Chinese Singaporeans, our findings may be limited in their generalizability to other ethnic groups and not be applicable to more severely impaired clinical populations. In the same vein, although our participants' loneliness scores were normally distributed, they were positively skewed ($S_K = 0.78$), which indicates that a sizable proportion of participants reported lower levels of loneliness. Thus, our findings should be applied with caution to more-vulnerable populations of older people with higher clinical levels of loneliness. Given the demographic and psychosocial characteristics of our sample, future research should use a large representative sample with varying levels of loneliness and dementia severity.

Fifth, despite the evidence that supports the reliability and validity of the participant-rated AD8, we acknowledge the limitation of using this measure for more-severely-impaired or clinical populations. Specifically, since individuals with clinical cognitive impairments may not be able to accurately evaluate their own cognitive difficulties (Barrett, Eslinger, Ballentine, & Heilman, 2005), the informant-rated AD8 should be used instead. Given this drawback of the participant-rated AD8, our findings based on the measure may not be generalizable to individuals with more-severe impairment due to dementia. Moreover, future research should use a combination of the Mini-Mental State Examination and informant-rated AD8 (Chin et al., 2013) for more sensitive and inclusive detection of cognitive impairment across a wide variety of subclinical and clinical populations.

Lastly, we controlled for a host of covariates to minimize the possibility that the relation between loneliness and dementia risk was confounded by a third factor. There are, however, a few notable variables that were not assessed in our study but are crucial in explaining the relation between loneliness and dementia risk. Previous studies suggest that apathy, in particular, is associated with increased perceived loneliness (Groeneweg-Koolhoven, de Waal, van der Weele, Gussekloo, & van der Mast, 2014) and manifests as a common symptom of dementia (Ishii, Weintraub, & Mervis, 2009; Selbæk, Engedal, & Bergh, 2013). Further, given that apathy is associated with poorer performance on a wide range of tasks of executive functions (Kuzis, Sabe, Tiberti, Dorrego, & Starkstein, 1999; McPherson, Fairbanks, Tiken, Cummings, & Back-Madruga, 2002), it is possible that the degree of apathy, which significantly predicts

the transition from mild cognitive impairment to dementia (Chilovi et al., 2009), could play a role in our moderated mediation model. Moreover, previous studies delineate sleep quality (Hawkley, Preacher, & Cacioppo, 2010; Spira, Chen-Edinboro, Wu, & Yaffe, 2014) and alcohol consumption (Åkerlind & Hörnquist, 1992; Peters, Peters, Warner, Beckett, & Bulpitt, 2008; Ruitenberg et al., 2002) as important lifestyle variables relating to either loneliness or dementia. Hence, more studies are needed to examine the role of apathy, sleep quality, and alcohol consumption in the mechanism that underlies the link between loneliness and dementia risk in older adults.

Our findings serve as an important basis for the implementation of intervention programs aimed at lowering the risk of dementia. Given that loneliness and sense of control have been identified and substantiated as crucial risk factors for increased vulnerability to dementia risk in community-dwelling older adults, our study highlights the clinical importance of ensuring socioemotional support for older persons, such as evidence-based interventions that encourage greater social engagement to reduce feelings of isolation and loneliness. These include promoting one-to-one interventions and organizing discussion and support groups or teleconferencing programs (Findlay, 2003; Tsai, Tsai, Wang, Chang, & Chu, 2010) that can be tailored for the connective needs of healthy elders. Further, our findings provide cogent support for the use of preventive cognitive-training interventions (e.g., working-memory training via learning new skills, technology use, or games designed for "smart aging") for healthy older persons without dementia (Nouchi & Kawashima, 2017). In view of the pertinent role of working memory as a protective cognitive resource, these preventive cognitive interventions will be useful in attenuating dementia risk in healthy elders by preserving critical cognitive functions against potential impairments.

Clinical implications

- Ensuring healthy socioemotional support for older persons would improve sense of control in facing constraints and challenges and in turn contribute to lowering the risk or slowing the onset of dementia, thus, promoting healthy aging.
- Evidence-based cognitive training of working memory and greater cognitive engagement for older adults could protect against cognitive decline and dementia risk in later life.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

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