Psychology and Aging
2017, Vol. 32, No. 4, 388–399

0882-7974/17/$12.00 http://dx.doi.org/10.1037/pag0000174

Genetic and Environmental Sources of Individual Differences in Views on Aging

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Views on aging are central psychosocial variables in the aging process, but knowledge about their determinants is still fragmental. Thus, the authors investigated the degree to which genetic and environmental factors contribute to individual differences in various domains of views on aging (wisdom, work, fitness, and family), and whether these variance components vary across ages. They analyzed data from 350 monozygotic and 322 dizygotic twin pairs from the Midlife Development in the U.S. (MIDUS) study, aged 25–74. Individual differences in views on aging were mainly due to individual-specific environmental and genetic effects. However, depending on the domain, genetic and environmental contributions to the variance differed. Furthermore, for some domains, variability was larger for older participants; this was attributable to increases in environmental components. This study extends research on genetic and environmental sources of psychosocial variables and stimulates future studies investigating the etiology of views on aging across the life span.

Keywords: views on aging, behavior genetics, life span, age stereotypes

Supplemental materials: http://dx.doi.org/10.1037/pag0000174.supp

Views on aging, such as what people think about older people in general (age stereotypes), how they see themselves as older persons (self-perceptions of aging), and how old people feel (subjective age), are central psychosocial variables in the aging process. As motivators of age-related action regulation and interpretational frames for experiences they influence developmental outcomes such as health, well-being, and mortality throughout adulthood and older age (Levy, 2009). Considering that numerous studies deliver evidence for this influence of views on aging on development (for meta-analyses, see Meisner, 2012; Westerhof et al., 2014), it is surprising that research on the determinants of individual differences in views on aging is still scarce and rather fragmental. In the present study, we thus investigated the contributions of genetic and environmental factors to individual differences in domain-specific views on aging and how these contributions were moderated by age, using a sample covering a broad age range.

This article was published Online First May 4, 2017.

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The MIDUS I study (Midlife in the U.S.) was supported by the John D. and Catherine T. MacArthur Foundation Research Network on Successful Midlife Development. The analyses have been previously presented at the 50th Meeting of the German Psychological Association in September 2016 and the 69th Annual Meeting of the Gerontological Society of America in November 2016.

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Views on Aging Influence Development

People's views on aging influence how they age themselves (Levy, 2009). This is especially interesting considering that at first, these views on aging are targeted at an outgroup: Younger people do not belong to the group of old persons, and one's own old age is still rather far away. In her stereotype embodiment theory (SET), Becca Levy (2009) thus argued that in younger years, these mostly negative perceptions and stereotypes of old age are not questioned, and internalized over time. However, as people age, the distal outgroup of old persons turns into a more proximal one, and eventually becomes one's own ingroup—the ideas about old age in general that one harbored in younger years are becoming self-relevant.

SET proposes that internalized views on aging influence development via physiological (e.g., by influencing bodily stress responses and cardiovascular reactivity; Levy, Hausdorff, Hencke, & Wei, 2000), psychological (e.g., by influencing self-efficacy and self-regulatory processes; Wurm, Warner, Ziegelmann, Wolff, & Schüz, 2013), and behavioral (e.g., by influencing behavior and age-related action selection; Kornadt, Voss, & Rothermund, 2015b) pathways. This influence culminates in the long-term effect that older persons with more negative views on aging have worse physical (e.g., Sargent-Cox, Anstey, & Luszcz, 2012b; Wurm, Tesch-Römer, & Tomasik, 2007) and psychological health (Rothermund, 2005), and even die younger than people with more positive views on aging (Levy, Slade, Kunkel, & Kasl, 2002). Considering these detrimental outcomes and their relevance for "successful aging," it is of utmost importance to understand what determines individual differences in views on aging throughout life.

Potential Determinants of Views on Aging

So far, research on influences on the development of individual differences in views on aging has followed two approaches: The first one is to investigate how views on aging form in childhood, adolescence, and early adulthood; the second one is interested in later adulthood and older age. Both lines of research have delivered evidence on factors influencing the characteristics of views on aging.

With regard to potential factors influencing views on aging in younger years, much emphasis has been put on environmental influences, such as contact with older persons and their depiction in the media. Intergenerational contact is assumed to influence children's perceptions of old age (Gilbert & Ricketts, 2008) that, in turn, may have an effect on attitudes toward old age. The classic example is the picture of an older witch in the media as the prototype of older women that is learned by children (cf. Levy, 2009). The portrayal of older persons in the media has been credited with negatively affecting images of older persons, although few studies have actually investigated this hypothesis (Donlon, Ashman, & Levy, 2005; Mayer, Lukas, & Rothermund, 2005; for a critical evaluation see Bowen, Kornadt, & Kessler, 2014). An additional explanation for the often-found negativity toward old age in younger persons is that their fear of their own death and dying is driving this devaluation of old age (Martens, Goldenberg, & Greenberg, 2005). People differ in their levels of fear of the unknown (e.g., death or strangers) and individual differences in anxiety—a personality trait underlying individual differences in the frequency and intensity of everyday fear experiences—has been shown to be both environmentally and genetically influenced (e.g., Kandler & Ostendorf, 2016; Kandler, Riemann, Spinath, & Angleitner, 2010).

In adulthood, as people make their own experiences with the aging process, these experiences are credited with becoming the main influence on views on aging. Age is thus a strong moderator of the content and valence of people's views on aging—they become more diverse and sometimes even more positive as people age (Hummert, Garstka, Shaner, & Strahm, 1994; Kornadt & Rothermund, 2011). This may be due to the variety of age-related experiences people make as they age, such as the aging of their own bodies and the experience of age-related societal and personal transitions (Bowen et al., 2014). Those experiences influence personality and the self-concept and are in turn projected into what people think about older people in general (Clement & Krueger, 2002; Kornadt, Voss, & Rothermund, 2015a; Rothermund & Brandtstädter, 2003). In other words, an increase of environmental variance due to the heterogeneity of individual aging experiences seems to be responsible for the increase of individual differences in views on aging across adulthood.

In addition to environmental experiences, individual characteristics, such as health and personality might play a role in determining what people think about aging and older persons, as they grow older. A study by Sargent-Cox, Anstey, and Luszcz (2012a) found that deterioration in self-perceptions of aging was predicted by increased problems with activities of daily living and number of medical conditions. Moreover, recent research found evidence for the fact that basic personality characteristics, such as the Big Five traits, were associated with the views on aging people harbor (Bryant et al., 2016). In their study, particularly Neuroticism (people higher in neuroticism had less positive attitudes toward aging as a time for psychological growth), Extraversion, and Agreeableness (both were negatively related to the perception of age as a time of social losses) prospectively predicted attitudes toward aging. Because individual differences in core personality traits show substantial heritability (i.e., the degree to which personality differences can be accounted for by genetic differences) with estimates around .40 (Vukasovic & Bratko, 2015) and are associated with diverse attitudes and self-perceptions (Kandler, Zimmermann, & McAdams, 2014), they are promising candidate characteristics that can mediate genetic influences on attitudes toward aging. Considering this evidence, and also referring back to the previously reported findings on anxiety, the presumption arises that variance in views on aging may show a genetic component.

A Behavioral Genetic Approach

Because views on aging are psychosocial variables that do not come to mind first when thinking about genetically influenced aging factors, this approach might first seem rather unusual. Environmental influences (contact with older people, age-related experiences, etc.) are mainly seen as responsible for the development, change, and stability of views on aging throughout life. Thus, these environmental factors should mainly contribute to individual differences in views on aging across life. However, some studies suggest that also individual personality characteristics, aging processes, and thus genetic differences might play a role. Therefore, as already outlined, the expectation of genetic influences on individual differences is plausible and the investigation of the potential contributions of genetic and environmental sources to the individual variability in views on aging can shed more light on their etiological roots.

Several genetically informative studies have been conducted with regard to the sources of individual differences in attitudes, such as social and political attitudes (e.g., Olson, Vernon, Harris, & Jang, 2001), religious attitudes (e.g., D'Onofrio, Eaves, Murrelle, Maes, & Spilka, 1999), ethnocentrism (e.g., Orey & Park, 2012), prejudice and discriminatory tendencies toward foreigners (Kandler, Lewis, Feldhaus, & Riemann, 2015), as well as group identity (e.g., Weber, Johnson, & Arceneaux, 2011). These studies have shown that besides environmental factors individual differences in attitudinal variables are due to genetic influences, accounting for about 20% to 50% of the variance (for overviews, see Bouchard & McGue, 2003, and Kandler, Bell, Shikishima, Yamagata, & Riemann, 2015). It is therefore interesting and necessary to extend this line of research to views on aging, especially because research on the determinants of individual differences in views on aging so far mainly involved environmental variables. Besides clarifying the role of genetic influences for individual differences, a behavioral genetic approach enables to control for genetic differences and is thus important to strengthen the evidence for environmental influences (Johnson, Turkheimer, Gottesman, & Bouchard, 2009).

In addition, evidence for genetic effects might open the floor for more research on mediating mechanisms between genotype and phenotype and thus extend research on potential mediators of genetic influences, such as personality characteristics, as further determinants of individual differences in views on aging beyond environmental factors. This is especially important because personality has been shown to (at least partially) mediate the genetic differences in attitudinal variables, such as political attitudes (Kandler, Bleidorn, & Riemann, 2012) or group identification (Weber et al., 2011). Thus, personality traits might also reflect important partly heritable mediators of the genetic variance in views on aging. Therefore, the disentanglement of genetic and environmental variance in views on aging is a logic first step to get closer to the sources of what people think about older persons across the life span.

The Role of Age and Multidimensionality

By showing that individual differences in views on aging are due to a genetic component, we extend previous research on the sources of attitudes to the field of views on aging. However, because recent meta-analyses show that virtually any characteristic is at least partly heritable (e.g., Polderman et al., 2015), this result itself may not be surprising. Nevertheless, two peculiarities of views on aging raise interesting questions that can be addressed by a behavior genetic approach: Do genetic and environmental contributions vary across age and different domains of views on aging?

Even though it was long assumed that views on aging are a unidimensional construct ranging from a negative to a positive pole, more recent approaches operationalize views on aging as multidimensional (e.g., concerning life domains such as wisdom, work, family, and fitness), accounting for the heterogeneity of the aging process itself (e.g., Diehl et al., 2014; Kornadt & Rothermund, 2011). This claim has been supported in a variety of studies (for an overview, see Kornadt & Rothermund, 2015). Showing that individual differences in views on aging in different domains are based on different amounts of genetic and environmental components would strengthen this line of reasoning and thus add to the validity of a multidimensional approach in views on aging research.

In addition, views on aging are a special kind of variable due to their developmental trajectories. As already elaborated in previous sections, what people think about the aging process and older persons already develops early in life. At this time, the group of old persons is a social group that one does not belong to and own age-related experiences are still scarce. Thus, views of younger people represent internalized and more or less unquestioned views about this outgroup (i.e., prejudice toward old people or age stereotypes). Genetic contributions relative to environmental influences might thus be larger in younger years. This changes as people get older, enter the group of older persons, and gather more age-related environmental experiences: The heterostereotype (or prejudice) becomes an autostereotype (or self-perception). Genetic and environmental effects have been shown to differ in this regard, for example for ingroup favoritism and outgroup derogation (Lewis, Kandler, & Riemann, 2014). Thus, it is of special importance to pursue an age differential approach when investigating the genetic and environmental sources of individual differences in views on aging. Taken together, it has been shown that views on aging change and have different manifestations as people age themselves. Therefore, one of the driving forces behind our research was to identify the genetic and environmental sources of individual differences in these views on aging, and to investigate whether genetic and environmental contributions vary by age.

The Current Study

The current study had four aims. First, we disentangled genetic and environmental variance in views on aging. Here, referring to behavior genetic research on attitudes and variables related to views on aging, we hypothesized that besides environmental contributions to the variance in views on aging, genetic influences should be important as well, as indicated by statistically meaningful variance components. However, also considering previous research on attitudes, we expected genetic influences in general to be smaller than those of the environment, even after controlling for random measurement error variance which is confounded with estimates of nonshared environmental variance components.

Second, to test whether and in how far personality contributes to the sources of views on aging, we adjusted individual views on aging for the potential contribution of personality differences. Because personality traits are individual characteristics that have been found to at least partially mediate the genetic component in different attitudes, we expected a smaller genetic component in adjusted scores of views on aging.

Third, we analyzed whether and to what extent genetic and environmental components in views on aging differ between various domains of views on aging: wisdom, work/life, family/relationships, and fitness/energy. Because this research question is a more exploratory one, we do not formulate specific hypotheses for all domains. However, differing amounts of genetic and environmental contributions would validate the domain-specific approach in research on views on aging.

The final and main research question concerns differences in genetic and environmental contributions for different age groups. Here, two different hypotheses can be derived from previous findings: On the one hand, genetic influences on individual attitudes toward outgroups (e.g., older persons) may be more important in people (e.g., younger adults) without or with less experience with these groups (Kandler, Lewis, et al., 2015) and may decrease as people gain more experiences with these groups. When people get older and the former outgroup becomes the ingroup, age-related experiences might become more important sources of views on aging. These age-related experiences are shared by twins, because they share the same age. As a consequence, relatively stronger (shared) environmental effects on individual differences in views on aging can be expected for older adults. On the other hand, however, the reduction of environmental stability and pressure in old age (e.g., less fixed time structures due to the exit from work life, less age- and role-related normative expectations; Freund, Nikitin, & Ritter, 2009) and an increase of individual differences in health problems that might be due to individual genetic predispositions may find their expression in increased genetic contributions to individual differences in older persons' views on aging. Our research design allowed us to test these hypotheses. To address our research questions, we draw on a large twin sample spanning a broad age range that provided multidimensional ratings of old persons.

Method

Sample

We base our analyses on the twin sample of the Midlife Development in the U.S. study (MIDUS I; Brim, Ryff, & Kessler, 2004).

In 1995–1996 (T_1), a total of 7,108 Americans that were selected through random digit dialing completed a phone interview and a self-administered questionnaire. This sample comprised a subsample of 1,914 monozygotic (MZ) and dizygotic (DZ) twins that were identified via a phone screening of 50,000 representatively selected households (for more information on the sampling procedure and sample, see Johnson & Krueger, 2004, and Kessler, Gilman, Thornton, & Kendler, 2004). The MIDUS twin sample is generally comparable to the overall MIDUS sample with regard to demographic characteristics (Johnson & Krueger, 2005; Keyes, Myers, & Kendler, 2010). Because the relatively small sample size does not provide enough power to detect qualitative gender differences, and estimates would be biased when including opposite gender twins in the presence of such effects (Johnson & Krueger, 2005; Keyes et al., 2010) we excluded DZ twins of opposite gender ($n = 497$). In addition, twins with missing or unclear zygosity information ($n = 31$) and as a last step single twins of incomplete pairs ($n = 42$) were excluded. The remaining sample thus consisted of 350 MZ (53% female) and 322 DZ (61% female) same gender twin pairs aged 25 – 74 years ($M_{Age} = 44.63$, $SD_{Age} = 12.17$), and includes all complete twin pairs that provided information relevant for the current study.

Measures

Zygosity. Twins' zygosity was determined using a self-report questionnaire that asked for example about the similarity of eye and hair color, or misidentification of each other in childhood. The zygosity classifications derived from this technique are generally more than 90% accurate (cf. Johnson & Krueger, 2004; Kessler et al., 2004).

Views on aging. Views on aging were assessed with a questionnaire on "Images of Life Change." Participants had to rate how well 13 adjectives (e.g., energetic) and domains (e.g., marriage/close relationship) described "people in their late 60s (65–70 years old)" on a 10-point scale ranging from 0 (*not at all/worst*) to 10 (*very much/best*). Detailed scale development is reported in Kornadt (2016). First, an exploratory factor analysis on the 13 items was conducted with the entire MIDUS sample. A combination of the Eigenvalue criterion and theoretical considerations was used to determine the four factors that were used in the current paper. In addition, a confirmatory factor analysis was performed on a subsample of older adults in the MIDUS sample, which yielded a satisfactory fit. The four resulting scales represent what people think of older persons in different domains covering major developmental tasks for older adulthood (Hutteman, Hennecke, Orth, Reitz, & Specht, 2014; Staudinger & Kunzmann, 2005): family/relationships (three items: contributions to others, marriage/close relationship, relationship with their children), fitness/energy (three items: willing to learn, energetic, physical health), work/life (three items: work, finances, overall lives), and wisdom (four items: calm, caring, wise, knowledgeable). Internal consistency in the current sample ranges from Cronbach's alpha = .71 (family/relationships) to $\alpha = .76$ (wisdom, work/life, fitness/energy). To get a general overview of the effects, we also computed an aggregated scale that represents the general positivity versus negativity of participants' views on aging. Internal consistency for this scale was $\alpha = .88$.

Personality. Big Five personality traits were assessed with the Midlife Development Inventory adjective list (MIDI, Lachman & Weaver, 1997). We used the 24 items that were shown to have good measurement properties in all age groups by Zimprich, Allemand, and Lachman (2012): conscientiousness (three items: organized, responsible, hardworking); openness to experience (seven items: creative, imaginative, intelligent, curious, broad-minded, sophisticated, adventurous); agreeableness (five items: helpful, warm, caring, softhearted, sympathetic); extraversion (five items: outgoing, friendly, lively, active, talkative); neuroticism (four items: moody, worrying, nervous, calm [recoded]). Participants had to rate how well each item describes them on a range from 1 (*a lot*) to 4 (*not at all*). To facilitate interpretation of relations, all answers were recoded so that higher values indicate higher agreement with the statement. To obtain orthogonal factor scores that could be used as uncorrelated predictors of views on aging we ran a factor analysis with Varimax rotation and saved the factor scores derived by the method proposed by Anderson and Rubin (1956).

Relationships between views on aging measures and personality are presented in Table 1. Overall, associations of personality factor scores and views on aging were small, explaining between 4% (fitness/energy) and 9% (wisdom, average) of the variance. Bivariate correlations were mostly significant, except for openness, which did not show a relation with the work/life and family/relationship domains, and positive (people with higher values on personality scores had more positive views on aging), except for neuroticism (people with higher values on neuroticism had more negative views on aging). The size of the coefficients was small to medium-sized, the largest relations were found for conscientiousness.

Analyses

We applied univariate genetically informative variance decomposition models (see Neale & Maes, 2004). These models allow us to decompose variance in views on aging into an additive genetic component (A), a component due to environmental influences shared by twins raised together (C), and a component attributable to environmental influences not shared by twins including error variance (E; see Figure 1). MZ twins reared together share 100% of their genetic make-up as well as shared environmental factors, whereas DZ twins reared together share on average 50% of their segregating alleles and shared environmental effects. A prerequisite for the interpretation of effects from twin models is the

Table 1
Correlations Between Views on Aging and Big Five Personality Factor Scores

Dependent variables	O	A	E	N	C	*Correlation* R^2
Wisdom	$.09^{**}$	$.21^{**}$	$.11^{**}$	$-.04$	$.16^{**}$	$.09^{**}$
Work/life	.00	$.17^{**}$	$.12^{**}$	$-.07^{**}$	$.13^{**}$	$.06^{**}$
Fitness/energy	$.06^{*}$	$.14^{**}$	$.11^{**}$	$-.07^{**}$	.05	$.04^{**}$
Family/relationships	.03	$.20^{**}$	$.16^{**}$	$-.06^{**}$	$.09^{**}$	$.07^{**}$
Average	$.06^{*}$	$.22^{**}$	$.15^{**}$	$-.08^{**}$	$.13^{**}$	$.09^{**}$

Note. $N = 1,344$. O = openness to experience; A = agreeableness; E = extraversion; N = neuroticism; C = conscientiousness.
$^{*} p < .05$. $^{**} p < .01$.

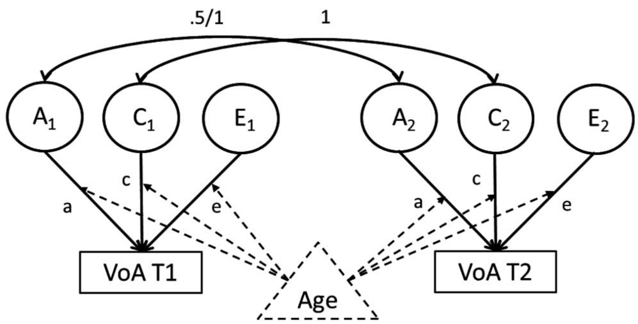

Figure 1. Univariate variance decomposition model, disentangling additive genetic (A, a), shared environmental (C, c) and nonshared environmental (including measurement error) factors and effects (E, e) to individual differences in views on aging (VoA). Variances of factors A, C, and E are fixed to one. Correlations between latent factors A_1 and A_2 are $r = 1$ for MZ twins and $r = .5$ for DZ twins. For the moderation analyses, age was added as moderation variable of genetic, shared environmental, and nonshared environmental contributions (dashed lines); T1 = Twin 1; T2 = Twin 2.

assumption that shared environmental influences affect DZ twins' resemblance to the same degree as they contribute to the similarity of MZ twins (equal environment assumption, EEA). The EEA has been supported in several studies (e.g., looking at misclassified twins, Conley, Rauscher, Dawes, Magnusson, & Siegal, 2013), and only recently, a study that integrated previous research and also reanalyzed the MIDUS twin sample found that even though the EEA might not be completely true for all outcomes, the resulting bias is negligible (Felson, 2014). We therefore think the EEA can be maintained for our study and thus, differences between MZ and DZ twin similarities can be attributed to genetic influences whereas within-pair differences are attributable to nonshared environmental influences. Strong shared environmental influences that act to make twins more similar are indicated in case of low within-pair differences and low differences between MZ and DZ twin similarities. The models further rest on the assumptions that there is no assortative mating of twins' parents with respect to the traits of interest and also that gene–environment interaction or correlation are absent. Estimates of additive genetic effects derived from twin models have been shown to be good estimations of broad-sense heritability including additive and nonadditive genetic factors (Hill, Goddard, & Visscher, 2008).

Missing values (7.0–7.5% per scale) were imputed using the expectation maximization algorithm (Dempster, Laird, & Rubin, 1977), and ratings were corrected for participants' gender before entering them into the analyses using a regression procedure (McGue & Bouchard, 1984). Standardized residuals derived from these regressions were used for further analyses. A model was fitted for each domain of views on aging, and also for an aggregate across domains, respectively. To investigate the mediating role of personality we additionally corrected the views on aging scale scores for individual differences in the Big Five factor scores using the same regression procedure and reran the model analyses with the resulting standardized residual scores. These results thus represent the estimates of genetic and environmental sources of individual differences in views on aging controlled for the contribution of personality characteristics.

To address the role of participants' age moderating genetic and environmental influences, the same models (without controlling for personality) were extended by age as a moderator variable (model elements of Figure 1 with dashed lines; see also Purcell, 2002). All genetically informative structural equation models were run using the statistical software package Mx (Neale, Boker, Xie, & Maes, 2003). For all univariate ACE variance decomposition analyses of views on aging without age-moderation, twin variance-covariance matrices were analyzed via maximum likelihood procedures. For all age-moderation model analyses, genetic and environmental variance components were estimated via raw data maximum likelihood procedures. The significance of genetic and environmental components was evaluated by 95% confidence intervals and by comparisons of nested models based on the χ^2-difference test in case of ACE model analyses without moderation by age and based on the $-2LL$-difference test in case of age-moderation ACE model analyses.

Results

Genetic and Environmental Components in Views on Aging

To address our first research aim, we first inspected genetic and environmental contributions to the aggregated views on aging scale (see upper part of Table 2). For this scale, additive genetic factors accounted for 39% of the variance. The contribution of shared environmental factors was negligible, whereas nonshared environmental influences (including error of measurement) explained 61% of the variance. A model allowing for additive genetic and nonshared environmental effects (AE model), provided the best fit to the data (see Table S1 in the online supplementary material). After correction for random error of measurement ($1 - \alpha$), genetic influences explained 44% ($a^2/\alpha = .39/.88 = .44$) of the variance, whereas individual-specific environmental sources accounted for 56%—$(e^2 - [1 - \alpha])/\alpha = (.61 - .12)/.88 = .56$—of individual differences in views on aging.

Breaking down this variable into the domain-specific views on aging allowed us to address our research question regarding the domain differences of genetic and environmental contribution to views on aging. Similar results were found for the domains regarding Fitness/Energy and Family/Relationships, with the largest amount of variance explained by nonshared environmental (see upper part of Table 2; 58% and 55% after error correction) and additive genetic factors (42% and 45% after error correction), whereas shared environmental influences were negligible. A somewhat different picture emerged, however, for the domains regarding wisdom and work/life, indicating domain-specific differences. Whereas the highest amount of variance was still explained by nonshared environmental factors (see upper part of Table 2; 66% and 62% after error correction), the full model suggested both the genetic and the shared environmental component to be not significant. However, fixing both components to zero led to a significant reduction in model fit ($\Delta\chi^2 > 10$, $\Delta df = 2$, $p < .01$ for both wisdom and work/life; see Table S1). This indicated small but significant contributions of genetic (17% and 22% after error correction) and shared environmental factors (17% and 16% after error correction) to individual differences in views on aging regarding wisdom and work/life.

Table 2
Twin Correlations and Univariate Variance Decomposition Results for Views on Aging

Variables	r_{MZ}	r_{DZ}	a^2	95% CI	c^2	95% CI	e^2	95% CI
Corrected for gender differences								
Wisdom	.28*	.17*	.13 (.17)	[.00, .34]	.13 (.17)	[.00, .29]	.74* (.66)	[.66, .83]
Work/life	.30*	.19*	.17 (.22)	[.00, .37]	.12 (.16)	[.00, .31]	.71* (.62)	[.62, .80]
Fitness/energy	.40*	.12*	.32* (.42)	[.07, .41]	.00 (.00)	[.00, .21]	.68* (.58)	[.59, .76]
Family/relationships	.36*	.06	.32* (.45)	[.18, .40]	.00 (.00)	[.00, .11]	.68* (.55)	[.60, .77]
Average	.40*	.18*	.39* (.44)	[.14, .46]	.00 (.00)	[.00, .21]	.61* (.56)	[.54, .69]
Corrected for gender and personality differences								
Wisdom	.26*	.17*	.07 (.09)	[.00, .30]	.14 (.18)	[.00, .26]	.79* (.73)	[.70, .88]
Work/life	.26*	.18*	.09 (.12)	[.00, .33]	.15 (.20)	[.00, .29]	.76* (.68)	[.67, .85]
Fitness/energy	.36*	.10	.27* (.35)	[.03, .35]	.00 (.00)	[.00, .20]	.73* (.65)	[.65, .82]
Family/relationships	.32*	.03	.25* (.35)	[.11, .34]	.00 (.00)	[.00, .11]	.75* (.65)	[.66, .84]
Average	.35*	.14*	.27* (.31)	[.01, .36]	.00 (.00)	[.00, .23]	.73* (.69)	[.64, .82]

Note. r_{MZ} = monozygotic twin correlation; r_{DZ} = dizygotic twin corelation; a^2 = additive genetic variance component; c^2 = shared environmental variance component; e^2 = nonshared environmental variance component plus error variance; CI = confidence interval. Values in parentheses represent estimates corrected for random error of measurement: $1 - \alpha$.
* $p < .05$.

The Role of Personality Characteristics

Because we were also interested in how far the results regarding views on aging are attributable to personality differences, we ran the behavior genetic analyses with values corrected for both gender and personality differences. The general pattern of model fitting results did not change (see Supplemental Table S2 in the online supplementary material). However, we found the expected decreases in the genetic component and relative increases in the environmental components, suggesting that personality differences partially mediate genetic variance in views on aging (see lower part of Table 2).

The Role of Participants' Age

Our final research question was concerned with age differences in genetic and environmental contributions to views on aging. Using age as a moderator of individual differences as well as genetic and environmental components in views on aging, we found an even more differentiated picture. In general, individual differences in views on aging increased with participants' age. Whereas additive genetic contributions to the variance tended to be reduced for older persons, environmental variance components increased (see Figure 2). The reduction of the genetic variance was not statistically significant (dropping the interaction Age × A did not lead to a significant decline in model fit: Δ-2*LL* = 1.38, Δdf = 1, p = .24; see also Supplemental Table S3 in the online supplementary material). The best fitting model in terms of parsimony-fit balance thus indicated no difference in the genetic component across age. The increasing variance in views on aging was attributable to higher contributions of shared and nonshared environmental influences for the older participants. These trends were statistically significant (dropping the interactions led to significant declines in model fit; for Age × C = 0: Δ-2*LL* = 11.33, Δdf = 1, $p < .001$; for Age × E = 0: Δ-2*LL* = 11.23, Δdf = 1, $p < .001$).

Similar age trends were found for the specific domains wisdom and family/relationships (see Figure 3). For views on aging in these domains, variance increased with participants' age. This was due to increases of nonshared environmental variance, and in the case of wisdom additionally due to increases of the shared environmental component (see Supplemental Table S3). Again, a domain-specific picture emerged, because for the domains regarding work/life and fitness/energy we did not find a significant change in the degree of individual differences and its genetic and environmental components with higher age of participants (see Figure 3).

Discussion

The first aim of our study was to apply a behavior genetic approach to investigate the genetic and environmental contributions to individual differences in views on aging. We thus analyzed a sample of MZ and DZ twins covering a large age range that rated people in their late sixties in different domains of views on aging. In line with our hypothesis, and not surprisingly, considering evidence from other variables with regard to attitudes and group identification (e.g., Kandler, Bell, et al., 2015; Lewis et al., 2014) we found that variance in views on aging is due to both environmental and genetic influences and that genetic variance in views on aging is partly mediated by personality variables. Furthermore, our results demonstrate that the degree of heritability and also environmental influences on views on aging differ by stereotype domain, which extends and validates the growing body of research showing the multidimensionality of views on aging. We also found that the amount of contribution by genetic and environmental factors varies as a function of participants' age. Views on aging are different from any other attitude or group stereotype, becaue people move from a nonstereotyped into a stereotyped group as they get older, and thus views on aging become relevant for the aging self and influence developmental processes (Levy, 2009). Therefore, knowledge on the sources of views on aging across the life span is central to our understanding of the aging process.

Corroborating previous research on the determinants of individual differences in views on aging, the largest proportion of variance in views on aging was due to environmental effects not shared by twins reared together even after controlling for random measurement error variance. This is in line with effect sizes for results on prejudice or ethnocentrism, and was true for the aggregated scale as well as for the domain-specific indicators of views on aging. Nonshared environmental effects are defined as those

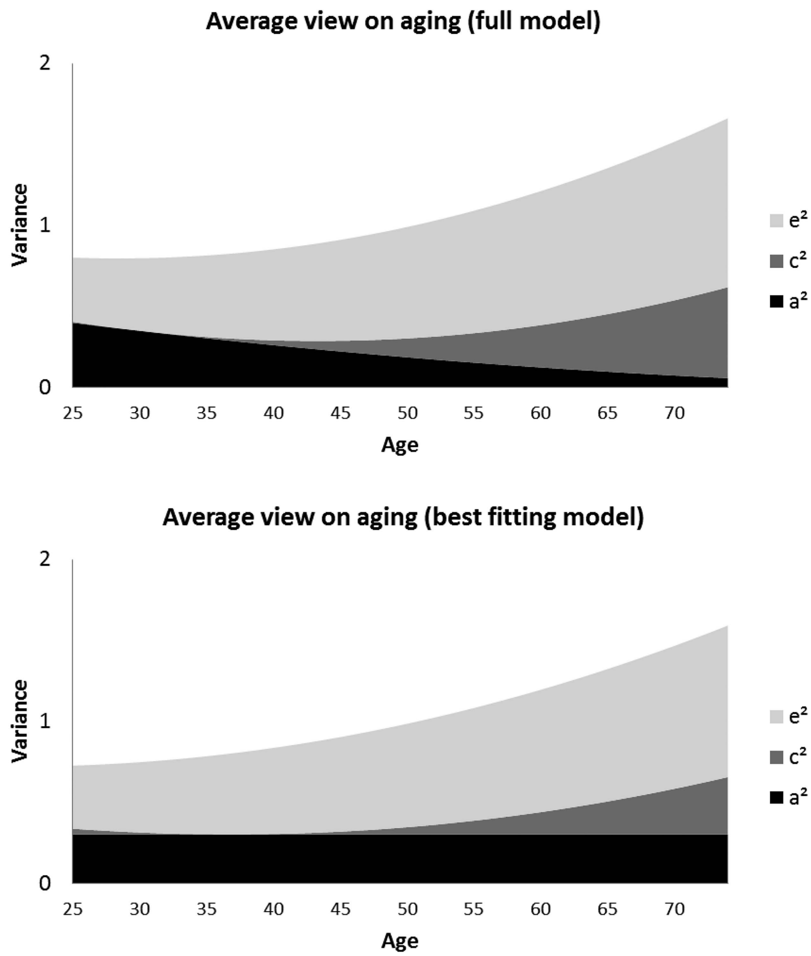

Figure 2. Age moderated the overall variance in average views on aging: The variance increased for older participants due to statistically significant increases of shared (c^2) and nonshared (e^2) environmental components. No significant age-related differences were found for additive genetic components (a^2).

influences that contribute to the dissimilarity among individuals. Thus, people's idiosyncratic experience of contact with older persons, age-related events and transitions, such as their retirement, grandparenthood, or changes in their activities, seem to predominantly contribute to individual differences in views on aging. These results are in line with research showing that people's views on aging were influenced by people's self views over 4 years in domains in which age-related experiences were experienced (e.g., health, leisure, finances; Kornadt et al., 2015a). Future research should now aim at specifically identifying these experiences and incorporating them into analyses of change to better understand the conditions under which personal experiences influence people's views on aging.

Besides these individual-specific environmental effects, we also found meaningful (i.e., their elimination from the model resulted in a significant drop in model fit) contributions of environmental influences that are shared by twins growing up together and thus increase the similarity of family members. These effects are especially interesting because these influences are usually negligible in adult samples for variables such as personality traits and other attitudes (e.g., Kandler, Lewis, et al., 2015; Kandler et al., 2010; Vukasovic & Bratko, 2015). They also emerge already for participants in midadulthood (especially for the aggregated scale and the Wisdom domain, Figure 2), and they even appear to increase with advancing age, when shared family environments usually lose influence (e.g., Tucker-Drob, Briley, & Harden, 2013). A possible explanation might be that aging parents and grandparents that are shared by MZ and DZ twins alike influence what the twins think about older persons in general, especially in the domains wisdom and work/life of older persons. Besides, having one's own aging process mirrored by a sibling of the same age might contribute to these effects. The twins may actually experience the same age-related events and enter the group of older persons at the same time and this might be visible as an environmental effect shared by twins. However, the role of one's aging parents or siblings for the development of views on aging has so far not been explored. This is thus one interesting avenue for further research.

Because the role of environmental effects in the genesis of psychosocial variables such as views on aging is unquestioned, the finding that around one third of the variance in views on aging was due to additive genetic influences is remarkable. To our knowledge, our study is the first to show that views on aging are

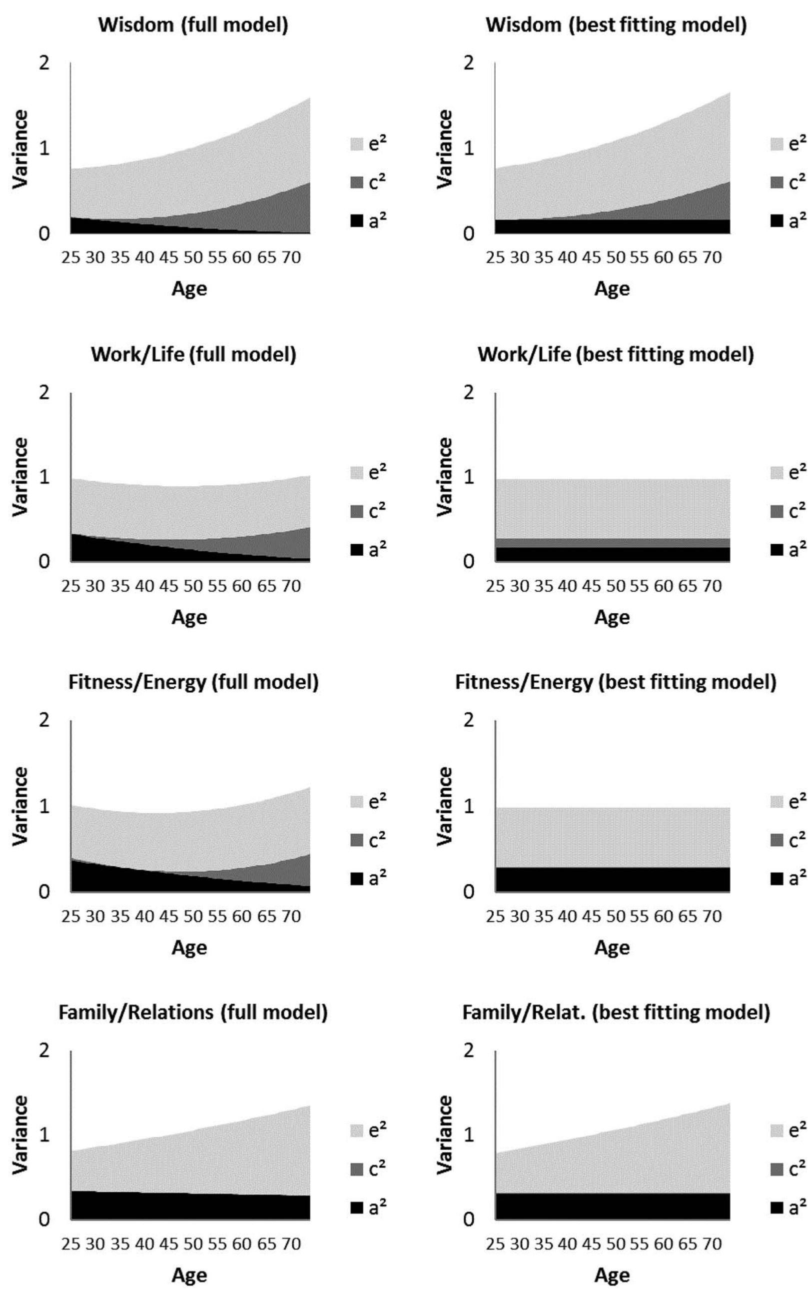

Figure 3. Age moderated the overall variance in facets of views on aging: The variance increased with age for views regarding wisdom and family/relationships due to statistically significant increases of shared (c^2) and nonshared (e^2) environmental components in case of wisdom and due to an increasing nonshared environmental component in case of family/relationships. No significant age-related differences were found for additive genetic components (a^2).

influenced by genetically driven factors. It is highly unlikely that views on aging are directly influenced by genetic differences, so mediating mechanisms and individual characteristics have to be identified. Considering the association of personality traits with people's views on aging (Bryant et al., 2016) and that variance in those variables is substantially genetically influenced (e.g., Vukasovic & Bratko, 2015), one further aim of our study was to test the role of personality as one possible mediating mechanism of genetic influences. In line with our expectations, genetic effects indeed decreased when controlling the views on aging ratings for personality differences. This allows the conclusion that parts of the genetic variance in views on aging are mediated by personality characteristics. However, decreases were rather small and the genetic contributions to individual differences in views on aging remained meaningful. This (and also the small bivariate associations between personality traits and views on aging in our data) suggests that genetic influences on views on aging may also be mediated by other characteristics not considered in the current study.

Fear- or anxiety-based variables might be relevant in this regard because views on aging, especially in younger years, can be based on fear of one's own mortality (Martens et al., 2005) or scarce resources (North & Fiske, 2012). Therefore, mediation might happen through threat sensitivity processes that have also been discussed for other attitudinal variables, such as prejudice toward outgroups (cf. Kandler, Lewis, et al., 2015). Another possible genetic mediation explanation might be related to the fact that views on aging could be influenced by genetically driven differences in actual physical and cognitive aging (e.g., Sargent-Cox et al., 2012a). Therefore, research of mediating mechanisms and characteristics besides personality is warranted for the future.

Because of the nature of views on aging as variables directly related to actual life span changes, it might even be the case that the underlying mechanisms of genetic effects change over the course of life, despite the amount of variance explained by genetic variation remaining invariant over time, as suggested by the current study. Genetic effects on views on aging in younger persons might be predominantly driven by threat mechanisms, whereas health-related differences might become more important in later life. Therefore, a life span approach is strongly warranted to understand the underlying causes of views on aging across life.

Because views on aging are subject to changes in characteristics and importance across the life span, and have been shown to be multidimensional, we expected that the amount of variance attributable to the respective components would be dependent on age and the domain of views on aging. Our results support these hypotheses and thus validate the hypothesis that views on aging can only be properly understood when conceptualized in a multidimensional, domain-specific way, and this additionally stresses the importance of a life span view on views on aging (Kornadt & Rothermund, 2015). Corroborating previous studies, the overall variance in age stereotypes was larger for older participants. Supporting our first line of reasoning, the age-related increase in variance was mainly due to shared and nonshared environmental factors and driven by the domains family/relationships and wisdom. This is especially interesting considering that these two domains are the two most salient positive views on aging: Wisdom and being integrated in one's family are among the most desirable features of older age (cf. Kornadt, 2016). It might thus be the case that especially these domains are open for positive or negative reinterpretation of views on aging following age-related experiences. Here, especially the increase in variance attributable to shared environmental effects in the domain wisdom stands out. This domain seems to be especially affected by age-related changes in influence from the twins' family of origin or their shared age-related experiences. Maybe seeing one's parents and grandparents age and confirm or disconfirm the cultural stereotype of wisdom is especially important for the twins' views on aging.

Compared to family/relationships and wisdom, the domains fitness/energy and work/life (incorporating work and finances), are among the strongest, societally shared negative stereotypes of old age with strong prescriptive character and thus generally lower variability (Bowen, Noack, & Staudinger, 2011; Kornadt, Hess, Voss, & Rothermund, 2016; North & Fiske, 2015). Furthermore, age-related experiences in these domains might corroborate negative views on aging that are harbored in younger years, and thus limit increases in variance due to environmental factors.

As already mentioned, conversely, the genetic influence for all views on aging scales that were investigated in our study seems to be fairly stable across participant ages. Genetic effects thus did not contribute to the increase in variance that was found in older ages, speaking against our second alternative hypothesis. It might instead be the case that genetic effects contribute mainly to continuity in individual differences in views on aging, whereas environmental effects primarily contribute to change in individual differences—similar to what has been found with regard to sources of personality continuity and change throughout life (Briley & Tucker-Drob, 2014).

Limitations and Further Directions for Future Research

To our knowledge, our study is the first that investigated the genetic and environmental sources of individual differences in views on aging. As such, it comes with a number of limitations that should be addressed by future research. First and foremost, even though we base our analyses on a large sample of twins covering a broad age range, the views on aging measure was not included in later waves of the MIDUS study. Thus, the implications we draw from our analyses are limited by the cross-sectional nature of the data and thus have to be embraced cautiously and backed up by longitudinal evidence. Instead of reflecting actual developmental effects, the differences we see between younger and older participants might be due to cohort effects. Furthermore, longitudinal studies allow for a closer inspection of sources of stability and change in variables (e.g., Briley & Tucker-Drob, 2014; South & Krueger, 2012). To address these questions, a longitudinal twin study in which participants report on their views on aging several years apart is desirable.

Even though we found a partial mediation of the genetic variance in views on aging by personality differences, the available measure of personality was limited in bandwidth and measurement accuracy (only 24 items). A broader and more heterogenous measure, such as the NEO-PI-R with 240 items and 30 personality facets (Costa & McCrae, 1992) or the HEXACO-PI-R with six domain traits and 24 facets (Lee & Ashton, 2006), may account for more variance in views on aging. Future studies might address this question with a more fine-grained and extensive measure of personality capturing different personality characteristics within a broad personality trait system to reassess its validity.

Furthermore, because of the study design being a classical twin design with a relatively small sample size and cross-sectional in nature, analyses of more complex processes and interactions are somewhat limited. It is for example well-known that the influence of genes and environment on phenotypic variance is by no means independent. Instead, genetic factors unfold differently depending on environmental circumstances and vice versa (e.g., Johnson, 2007). Therefore, the inclusion of gene–environment interaction and correlation is crucial for understanding their influence, especially in developmental contexts that are characterized by stability and change (Johnson et al., 2009). By addressing differences in genetic and environmental contributions across age ranges, we already show that participant age seems to play a role regarding the sources of views on aging. In addition, it might also be the case that individuals with a specific genetic makeup, for example with regard to health, end up in environments where they more likely encounter certain experiences that shape their views on aging as they age (e.g., doctor's offices or nursing homes). Genes might also be expressed differently based on environmental characteristics and, again, vice versa. To address these questions, more sophisticated designs (e.g., including more relatives of the twin pairs) and models as well as extensive measures of theoretically meaningful environmental and mediating variables are necessary to enable the specification of these effects (Hahn et al., 2016; Purcell, 2002).

Despite these limitations, this study provides a first insight into the genetic and environmental sources of views on aging and might thus give important impulses for future research on their determinants. The study also provides starting points for identifying specific environmental factors that influence views on aging, and thus in the long run may contribute to successful aging itself.

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Received November 11, 2016
Revision received April 10, 2017
Accepted April 12, 2017 ■