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PERSONALITY PROCESSES AND INDIVIDUAL DIFFERENCES

Openness to Experience and Culture-Openness Transactions Across the Lifespan

Ted Schwaba
University of California, Davis

Maike Luhmann
Ruhr University Bochum

Jaap J. A. Denissen and Joanne M. Chung
Tilburg University, Netherlands

Wiebke Bleidorn
University of California, Davis

We examined the life span development of openness to experience and tested whether change in this personality trait was associated with change in cultural activity, such as attending the opera or visiting museums. Data came from the Dutch Longitudinal Internet Study for the Social Sciences panel, which includes 5 personality assessments across a 7-year period of a nationally representative sample of 7,353 individuals, aged 16 to 95 years. Latent growth curve analyses indicated that on average, openness remained relatively stable in emerging adulthood before declining in midlife and old age. At each stage of life, there were significant individual differences in openness development, and changes in openness were correlated with changes in cultural activity. Autoregressive cross-lagged analyses indicated that increases in cultural activity precipitated increases in openness, and vice versa. These culture-openness transactions held across different age and education groups and when controlling for household income. We found less consistent codevelopmental associations between cultural activity and the other Big Five traits. We discuss the implications of these results for personality development theory and the role of cultural investment in personality trait change.

Keywords: cultural activity, life span development, openness to experience, personality development

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Over the past 20 years, research on personality trait development has flourished (for recent reviews, see Bleidorn, 2015; Roberts, Wood, & Caspi, 2008; Specht et al., 2014). This burgeoning literature has consistently shown that the Big Five personality traits change throughout the life span. One robust finding from descriptive research is that on average, young adults show remarkable increases in emotional stability, conscientiousness, and to a lesser degree, agreeableness (Bleidorn, 2015; Roberts & Mroczek, 2008). Less consistent results have been reported for the other two Big Five traits, particularly for openness to experience. Some studies have found that openness increases in emerging and middle adulthood (Roberts, Walton, & Viechtbauer, 2006), some have found that it decreases during this time (Terracciano, McCrae, Brant, & Costa, 2005; Wortman, Lucas, & Donnellan, 2012), and others have found openness to be mostly unchanging throughout adulthood (Lucas & Donnellan, 2011; Specht, Egloff, & Schmukle, 2011). Perhaps because of these inconsistent descriptions of the normative openness trajectory throughout the life span, little attention has been given to theoretical explanations of the conditions and correlates of openness change across the life span.

In the present study, we address the descriptive and explanatory gaps in the extant literature concerning the development of openness. First, we examine the average trajectory of openness across the life span in a large, longitudinal sample that is representative of the Dutch population. Second, we test the hypothesis that investment in cultural activity, such as attending concerts, the opera, or museums, is associated with change in openness over time. These *culture-openness transactions* (cf. Neyer & Asendorpf, 2001) may account for individual differences in openness development throughout the life span. Acquiring a better understanding of the nature and conditions of change in openness across adulthood will contribute to comprehensive theories of personality trait development. Moreover, because openness has been associated with a variety of important life outcomes, including life satisfaction (Stephan, 2009), educational attainment (Lüdtke, Roberts, Trautwein, & Nagy, 2011; Ozer & Benet-Martinez, 2006), physical and mental functioning in older adults (Gregory, Nettelbeck, & Wilson, 2010) and mortality (Ferguson & Bibby, 2012; Jonassaint et al., 2007; Turiano, Spiro, &

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Ted Schwaba, Department of Psychology, University of California, Davis; Maike Luhmann, Department of Psychology, Ruhr University Bochum; Jaap J. A. Denissen and Joanne M. Chung, Department of Psychology, Tilburg University, Netherlands; Wiebke Bleidorn, Department of Psychology, University of California, Davis.

Correspondence concerning this article should be addressed to Ted Schwaba, Department of Psychology, University of California Davis, One Shields Avenue, Davis, CA 95616. E-mail: tedschwaba@gmail.com

Mroczek, 2012), there is practical importance in describing and explaining the development of openness.

Openness and Its Development Across the Life Span

Openness to experience reflects the breadth and depth of an individual's consciousness and reflection (McCrae & Costa, 1997; McCrae & Sutin, 2009), their intellectual curiosity, imagination, and aesthetic sensitivity (Soto & John, 2016). People high on openness are likely to experience chills when encountering something that is aesthetically pleasing (McCrae, 2007), tend to daydream (Zhiyan & Singer, 1997), and hold liberal political views (McCrae & Costa, 1997).

Some features of openness set it apart from the other Big Five traits. First, it has a unique structure. Openness is the last of the Big Five traits to emerge from factor analysis, meaning it is the least internally consistent of the Big Five traits (Saucier et al., 2000). Unlike the other Big Five traits, openness is not anchored by a central facet, meaning it is unclear what composes the core of the trait (Soto & John, 2016). Consequently, there is debate as to what the trait should technically be named (DeYoung, 2014); here we use the term *openness*.

Second, in contrast to the other Big Five traits, openness is associated more with cognition, and less with specific behaviors (Wilt & Revelle, 2015; Funder & Sneed, 1993). A behavior may be associated with openness in one population and not another because the cognitive implications of the behavior differ across these populations. In a sample of 90-year-olds, Internet use may exemplify intellectual curiosity, making the behavior diagnostic of high openness. In a sample of 20-year-olds, however, Internet use may be a normative behavior that is unrelated to a person's openness. Because of openness' structure and relations to behavior, it is often more difficult to conceptualize and study openness than the other Big Five traits (McCrae & Sutin, 2009).

Perhaps because of these features, openness has often been treated as the last and least of the Big Five. Researchers do not understand the development of openness across the life span as well as they understand the development of emotional stability, agreeableness, and conscientiousness. In the following section, we review past research regarding different types of openness change across the life span: rank-order, mean-level, and individual-level change.

Rank-Order Consistency

Rank-order consistency describes the stability of the relative ordering of individuals' personality traits in a sample over time (Roberts et al., 2008). A meta-analysis of longitudinal studies on rank-order consistency of the Big Five traits showed that the rank-order consistency of openness increases from early childhood through midlife, plateaus around age 60, and decreases in old age (Roberts & DelVecchio, 2000), following an inverted U-shaped trajectory. More recent large-sample studies have since replicated this pattern (Lucas & Donnellan, 2011; Specht et al., 2011; Wortman et al., 2012). Across studies, the rank-order consistency of openness and the other Big Five traits has never reached unity at any point in the life span. This suggests that personality can and does change throughout the life span.

Mean-Level Change

Mean-level change measures the average amount of absolute change in a personality trait in a sample of people across time (Specht et al., 2014). Many longitudinal studies have estimated the mean-level development of openness across the life span using large samples (Lucas & Donnellan, 2011; Roberts et al., 2006; Specht et al., 2011; Terracciano et al., 2005; Wortman et al., 2012). Unfortunately, this research has provided mixed results about the normative trajectory of openness across the adult life span. For example, some research has found that in emerging adulthood (roughly ages 18 to 25; Arnett, 2000, 2007), people tend to become more open (Borghuis et al., 2017; Roberts et al., 2006) whereas other research has found openness to be mostly stable during this life stage (Specht et al., 2011; Lucas & Donnellan, 2011; Wortman et al., 2012). In middle adulthood, some research has found that openness decreases (Lucas & Donnellan, 2011; Specht et al., 2011; Terracciano et al., 2005; Wortman et al., 2012), contrary to other research that found no change in openness across midlife (Roberts et al., 2006). Somewhat more consistent results have been reported for old age, which seems to be characterized by substantial decreases in openness (Specht et al., 2011; Lucas & Donnellan, 2011; Roberts et al., 2006; Wortman et al., 2012).

In sum, previous research on mean-level change in openness has provided mixed results about the normative trajectory of openness across the life span, especially with respect to emerging and middle adulthood. There are a few potential explanations for this. First, each of these studies examined personality development in a different nation. Specific cultural factors may influence trajectories to vary by nation (e.g., Bleidorn et al., 2013). Second, each study assessed openness with a different personality measure, and these measures were often abbreviated, so the latent openness construct measured varied across studies. Finally, these studies generally assessed openness across only two measurement occasions, which reduced the precision of trajectory estimates. In the present study, we examine openness development across adolescence and adulthood (age 16 – 95) using data from a nationally representative longitudinal sample of the Netherlands that provided personality data at five assessment waves over a period of 7 years using a 10-item openness questionnaire. This allows us to provide a precise description of the shape and magnitude of mean-level change in openness across the life span, in a nation whose life span mean-level personality development has not yet been studied.

Individual-Level Change

Whereas mean-level change describes the average person's trajectory over time, individual-level change describes each participant's trajectory separately. Individual trait trajectories often deviate from the mean level trajectory, leading to individual differences in personality trait change (Roberts & Mroczek, 2008). Several studies have reported significant individual differences in openness trajectories across different time intervals (Allemand, Zimprich, & Hertzog, 2007; Robins, Fraley, Roberts, & Trzesniewski, 2001; Small, Hertzog, Hultsch, & Dixon, 2003; Terracciano et al., 2005).

However, research has yet to test whether individual differences in openness change vary in prevalence across the life span. For example, young adults may develop heterogeneously in openness, with some increasing, some decreasing, and some remaining stable

in their trait. In midlife, individuals may develop more homogenously, such that most middle-aged adults remain stable in openness while only a few increase or decrease. Finding that there is more variability in development in some age groups than in others would prompt explanatory work that uncovers the processes responsible for this variability.

In sum, past research has established that individuals differ in their amount of openness change over time, but it remains an open question how much individual differences in change vary across different stages of the life span. To address this question, we analyze whether individual-level openness change varies across emerging adulthood, middle adulthood, and old age.

When and Why Does Openness Change?

Despite the apparent inconsistencies in the descriptions of change in openness at different stages in life, there is now a large body of evidence that indicates that openness can and does change throughout the life span. Several theories have been developed to explain when and why personality traits change (e.g., McCrae & Costa, 2008; Roberts, Wood, & Smith, 2005; Roberts & Jackson, 2008). Each emphasizes the role of genetic influences and intrinsic maturation processes on personality trait development. However, accounts differ in how much weight is given to environmental influences on personality trait change. In recent years, several longitudinal behavioral genetic studies have shown that both genetic and environmental factors contribute to individual differences in personality trait change (e.g., Bleidorn et al., 2009; Hopwood et al., 2011; for reviews, see Bleidorn, Kandler, & Caspi, 2014; Briley & Tucker-Drob, 2014; Kandler, 2012). The question remains, however, which factors in the environment matter, and why. To begin addressing this question, several studies have examined how personality traits change in the context of environmental changes.

For openness in particular, longitudinal studies have found that trait increases are associated with studying abroad in college (Zimmermann & Neyer, 2013), using psilocybin mushrooms (MacLean, Johnson, & Griffiths, 2011), increasing one's level of physical activity (Allen & Vella, 2015; Allen, Magee, Vella, & Laborde, 2017; Stephan, Sutin, & Terracciano, 2014), and being promoted at work (Nieß & Zacher, 2015). Researchers have also found increases in openness in men who divorce their wives (Specht et al., 2011), and in older adults who undergo a year-long cognitive training intervention (Jackson et al., 2012; but see Sander, Schmiedek, Brose, Wagner, & Specht, 2016, for a cognitive intervention that was not associated with lasting openness change). Decreases in openness have been associated with experiencing extremely traumatic events (Löckenhoff, Terracciano, Patriciu, Eaton, & Costa, 2009), depression (Hakulinen et al., 2015), marriage (Specht et al., 2011), and increasing chronic disease burden (Jokela, Hakulinen, Singh-Manoux, & Kivimäki 2014; Sutin et al., 2013). To develop theories of openness development, more research is needed to establish the common threads that tie together this eclectic medley of findings.

Exploration and Openness Change

We believe that experiences that have been associated with openness change share two commonalities. One commonality is that experiences associated with increases in openness tend to put people into novel situations, pushing them past the boundaries of their previous experiences. For example, students who study abroad for an extended period must adapt to an entirely new culture (Zimmermann & Neyer, 2013). On the other hand, experiences associated with decreases in openness may direct people away from novel situations, reinforcing the boundaries of their previous experiences. For example, people who experience traumatic events (Löckenhoff et al., 2009) may be especially likely afterward to avoid the unknown.

A second commonality between many experiences associated with openness change is that they are cognitively stimulating. Openness is composed of relatively more cognitive content than the other Big Five traits (Wilt & Revelle, 2015), and past research has found that levels and changes in intelligence (Ziegler, Cengia, Mussel, & Gerstorf, 2015) and verbal fluency (Von Stumm & Deary, 2013) predict openness change. Indeed, experiences such as using hallucinogens (MacLean et al., 2011) or spending a year in an intensive cognitive training intervention (Jackson et al., 2012) may trigger or entail prolonged cognitive stimulation.[1]

Novel situations and cognitive stimulation, two commonalities of experiences that have been associated with openness change, are also the two key ingredients of mentally exploratory behavior. Considering these findings, we theorize that exploration plays a key role in openness change. That is, people who increase the amount of time that they spend in novel situations that require cognitive stimulation will become more open over time, and vice versa. Indeed, past theory has conceptualized exploratory tendencies as one major component of openness (DeYoung, 2014; DeYoung et al., 2011; see Denissen & Penke, 2008, for a review of alternate conceptualizations of openness). One class of behaviors that may be particularly indicative of exploration, and relevant to openness change, is increases in the breadth of a person's cultural activity. We define cultural activity as *behaviors done in one's leisure time involving the humanities* (Jackson, 2011; Kraaykamp & Van Eijck, 2005). Cultural activity includes such cognitively stimulating behaviors as attending the opera and musicals, visiting museums, and going to concerts. We believe that when people engage in new cultural activities, expanding the breadth of their behavior, they may be exploring and particularly likely to become more open. In turn, people who become more open may be likely to engage in more cultural activities (Roberts et al., 2008).

In summary, we hypothesize that increases in breadth of cultural activity is indicative of exploratory behavior and may thus be related to change in openness. If people engage in novel, cognitively stimulating experiences, such as attending the opera for the first time, they may subsequently increase in openness. Why might a person who attends an opera for the first time become more open? We believe that openness and cultural activity may influence each other before, during, and after a night at the opera. Going to the opera in the first place may signal that a person is exploring; for example, she may have just moved to a new city with an opera house, or she is being introduced to *Turandot* by a

[1] In addition to the experiences described here, a number of studies have shown longitudinal associations between physical activity and openness, but physical activity fulfills neither of these exploratory criteria. This underscores the reality that a single, specific mechanism is unlikely to fully explain change in a broad personality trait.

new friend (Zimmermann & Neyer, 2013). At the opera, exploration happens, as attendees are aesthetically and intellectually stimulated (McCrae & Costa, 1997). And afterward, the first-time operagoer may continue her exploratory behavior, which puts her more frequently in a highly open state (Wrzus & Roberts, 2016). Accordingly, she may begin to see herself as a more open person (Roberts & Wood, 2006), and as she accrues more experiences, changes in openness may also occur (Roberts et al., 2008). Yet, this scenario assumes that openness and cultural activity are related to each other. In the next section, we review evidence for this assertion.

Associations Between Openness and Cultural Activity

Past research has shown that people scoring higher on openness are more likely to have artistic interests and to demonstrate artistic behavior (Costa, McCrae, & Holland, 1984; Feist & Brady, 2004; Furnham & Chamorro-Premuzic, 2004; McCrae & Costa, 1997; McCrae & Sutin, 2009). For example, a large-scale Internet study of more than 91,000 participants found that openness was the "strongest and only consistent personality correlate of artistic preferences," and that peoples scoring higher on openness visited art galleries more often (Chamorro-Premuzic, Reimers, Hsu, & Ahmetoglu, 2009). Potentially, people high in openness use art to provide them intellectual and aesthetic stimulation that they desire (McCrae & Costa, 1997). As such, interest in poetry, for example, has been used to assess openness in some personality questionnaires (cf. John & Srivastava, 1999; Soto & John, 2016). In addition to interest in art, cultural activity also includes behavior related to the humanities, like going to pop concerts, cabaret shows, and museums. For example, Kraaykamp and van Eijck (2005) found that people's level of openness predicted the books they read, the types of TV shows they watched, and their cultural behavior. Within this last category, openness was the only Big Five trait that predicted how much a person attended classical concerts, historical museums, and art museums. In summary, cross-sectional studies have consistently demonstrated that openness relates to both the arts and humanities that make up cultural activity. These associations have not been found for the other Big Five traits.

Despite strong evidence that open people are more invested in cultural activity, only one study has investigated how these two constructs co-develop. Jackson (2011) examined associations between personality traits and the educational experiences of German students. He found that participants' level of openness in high school predicted their level of cultural activity[2] in college. During college, increases in openness were associated with increases in cultural activity. Cross-lagged analyses showed that changes in cultural activity predicted future changes in openness, and vice versa. These bidirectional associations provided evidence for both selection and socialization effects between openness and cultural activity.

To the best of our knowledge, no longitudinal research has examined whether such culture-openness transactions generalize beyond college students. Transactions may differ based on level of education, level of income, and/or age group, and codevelopment between cultural activity and personality may extend to other Big Five traits (Caspi & Roberts, 2001; Roberts et al., 2008). Differences between demographic groups offer insight into the nature of openness change, while similarities between these groups allow us to be more confident that it is changes in cultural activity, rather than age, education, or income, that are responsible for changes in openness.

With respect to age, culture-openness transactions may be stronger in emerging adulthood than later in life. This is because emerging adults, who are not yet married or parents, are often exploring in the domains of love and work (Arnett, 2000; Erikson, 1959), rather than being committed to identity-reinforcing adult roles (Roberts et al., 2008). This may encourage openness increases (Bleidorn & Schwaba, 2016; Roberts & Davis, 2016). In old age, on the other hand, exploration may be relatively uncommon (Carstensen, 1995), and normative declines in functional health may force older adults to divest from cultural activity because it is difficult for them to leave their residence (House et al., 1994) or because they are more focused on conserving emotional ties within an increasingly selective social network (Carstensen, 1995). Accordingly, culture-openness transactions may be particularly weak in this stage of life.

Culture-openness transactions may also be contingent on education. People with college degrees tend to be more open (McCrae, 1994; Lüdtke et al., 2011), so they may be correspondingly more likely to increase in their openness after investing in cultural activity (Roberts et al., 2008). Those who are less educated may be socially constrained from investing in cultural activity; going to an art gallery, for example, is not a common activity for this group (Katz-Gerro, 1999). The opposite might also be true: those with low education might benefit more from cultural activity because it is particularly exploratory for this group.

Finally, it is important to rule out income as a potential third-variable explanation for culture-openness transactions. Some types of cultural activity may be expensive and limited to the wealthy (although low-income citizens of The Netherlands can apply for a card that allows free access to all museums). Furthermore, cultural activity, such as going to the museum, is less socially normative among low-SES groups (Dawson, 2014; Katz-Gerro, 1999). Thus, selection effects may become less strong when controlling for income: increases in wealth, rather than openness, may explain cultural activity.

Whereas past research has consistently shown that openness is the only Big Five personality trait related to interest in the arts and humanities, it is nonetheless important to investigate longitudinal associations between cultural activity and other Big Five traits. Cultural activity is a multifaceted construct; beyond cognitive exploration, a night at the opera may also reflect social engagement. Engagement in or disengagement from such social activities may influence development in other personality domains as well, such as extraversion (Lodi-Smith & Roberts, 2012; Roberts et al., 2008).

[2] Jackson defined cultural activity as artistic experiences, such as attending art museums and reading poetry. This is slightly different from our operationalization of the construct, and may have resulted in more construct overlap between cultural activity and openness. The activities included in our definition of cultural activity are more intrinsically social and many are not artistic (see Table 1 for cultural activity items).

The Present Research

The present study endeavors to advance both the descriptive and explanatory knowledge of life span openness development. We first examine developmental trajectories of openness and cultural activity across the life span using Latent Growth Curve (LGC) models. This allows us to visualize and quantify mean-level changes in development. It provides evidence that may clear up ambiguities found in previous studies. We also quantify how individual-level openness change may vary in prevalence across different age groups. Through these models, we describe life span openness development.

Culture-openness transactions may explain some individual-level variability in openness development. Accordingly, a second goal of this study was to examine whether changes in an individual's openness across the seven years of the study was associated with changes in their cultural activity. To do this, we estimated a series of bivariate LGC models and Autoregressive Cross-Lagged (ARCL) models. The bivariate LGC models examine correlated mean-level change between an individual's levels of personality and their levels of cultural activity across the seven years of the study. The ARCL models investigate rank-order change and establish temporality and directionality to culture-openness transactions, allowing us to disentangle selection and socialization effects across the seven years of the study. Together, these models provide information about rank-order and mean-level associations between cultural activity and openness. Finally, we examine if culture-openness transactions that we found hold when controlling for income, education, and age.

Method

LISS Panel

This study makes use of a publicly available de-identified archival dataset. It is thus exempt from Institutional Review Board approval. Other published work uses the same data, in part, as was used in the present manuscript. These publications can be viewed at http://www.lissdata.nl/dataarchive/publications. None of these works analyze the development of the personality trait Openness to Experience, which is the central focus of the submitted manuscript.

Data for this study came from the Longitudinal Internet Studies for the Social Sciences (LISS) panel, which has followed a representative sample of the Dutch population from 2008 to 2014. The panel is based on a true probability sample of households drawn from the population register (Scherpenzeel, Das, Ester, & Kaczmirek, 2010). LISS participants complete yearly Internet surveys on a variety of topics. Participants who did not have a computer or Internet connection were provided with one so that they could complete surveys. The initial cohort completed the personality survey at five occasions, in 2008, 2009, 2011, 2013, and 2014. The initial cohort completed the social integration and leisure behavior survey annually from 2008 to 2014.

Sample

In this study, we used data from all LISS participants who completed either the personality study or the social integration and leisure study in 2008, the first measurement wave (total N = 7,353). These participants came from a total of 4,584 households. Demographically, participants ranged from ages 16 to 95 in 2008 (M = 46.27, SD = 15.82), 53% were female, 2,388 (32%) participants had completed college, and the mean monthly (gross) household income for the sample was 4,346.92 Euros (SD = 6,716.75). Although additional recruitment waves were added to the panel in 2010, 2012, and 2014, we did not include these data in analyses because patterns of planned missing personality data were different for each group, such that additional recruitment cohorts completed the personality study in 2010 and 2012 when the initial cohort did not.

Measures

Big Five personality traits. Openness and the other Big Five personality traits were each assessed using the IPIP version of the Big-Five inventory (Goldberg, 1992). This openness measure is centered around the two facets of intellect (e.g., *am quick to understand things*) and imagination (e.g., *spend time reflecting on things*), rather than the facet of aesthetic sensitivity (Soto & John, 2016). Responses were measured on a five-point scale, ranging from 1 (*very inaccurate*) to 5 (*very accurate*). The alpha reliabilities for openness ranged from .76 to .78 across five measurement occasions. We transformed raw personality scores into standard t scores by standardizing across all participants across all waves to a mean of 50 and a standard deviation of 10. A difference of 2 t score points represents a small effect, a difference of 5 points represents a medium effect, and a difference of 8 points represents a large effect. These personality scales are publicly available at http://www.lissdata.nl/dataarchive/study_units/view/14.

Cultural activity. Cultural activity was assessed through an 11-item questionnaire that measured how often participants attended cultural activities over the past year (Did you visit any one of the following performances or facilities over the past 12 months? 1 = *no*, 2 = *yes*). Cultural activities were "a theater performance";" a cabaret performance"; "a concert of classical music"; "an opera or operetta"; "a concert of popular music, pop, jazz, musical or pop opera"; "a 'dance' event, houseparty"; and "a ballet". The item "'dance' event, houseparty" did not fit our definition of cultural activity because a house party is not an experience involving the humanities, so it was excluded from all analyses. For each item, we coded answers of "no" as 0. If participants answered yes, they were then asked how often they visited these performances or facilities during the past 12 months on a 1–4 scale (1 = *one time,* 2 = *2 to 3 times*, 3 = *4 to 11 times*, 4 = *12 times or more*). Item scores thus ranged from 0–4. We calculated cultural activity scale scores by summing the 10 item scores. Alpha reliabilities for cultural activity ranged from .66 to .69 across the seven waves of measurement.[3] This indicates that

[3] To address concerns about construct overlap between openness and cultural activity, this study measures openness with a questionnaire derived from Goldberg's (1992) lexical factors that excludes the facet of aesthetic sensitivity. It includes only the facets of intellect and imagination (Soto & John, 2016); it omits questions related to art.

Table 1
Means and Correlations Between Big Five Personality Traits and Cultural Activity Items (N = 7,353)

Variable	O	C	E	A	ES	Theater	Cabaret	Classical concert	Opera	Pop concert	Ballet	Cinema	Film house	Art gallery	Museum	Cultural activity
M	3.48	3.73	3.26	3.88	3.46	0.38	0.32	0.27	0.07	0.57	0.07	1.09	0.27	0.37	0.84	4.27
SD	.50	.52	.64	.49	.68	.71	.68	.69	.33	.89	.34	1.15	.74	.79	1.05	3.94
O																
C	.24															
E	.35	.11														
A	.27	.3	.32													
ES	.19	.22	.25	.06												
Theater	.10	−.01	.10	.06	.02											
Cabaret	.10	.00	.10	.06	.05	.27										
Classical concert	.11	.02	.04	.06	.04	.17	.07									
Opera	.06	.01	.03	.02	.01	.17	.10	.30								
Pop concert	.12	−.04	.11	.07	.02	.16	.22	.03	.04							
Ballet	.09	.01	.03	.04	−.01	.19	.09	.22	.19	.07						
Cinema	.16	−.07	.14	.07	.02	.20	.17	.05	.04	.25	.10					
Film house	.14	−.04	.08	.07	.01	.19	.12	.23	.11	.17	.19	.29				
Art gallery	.18	.01	.08	.06	.04	.19	.10	.33	.16	.10	.20	.12	.34			
Museum	.21	.02	.08	.08	.08	.23	.15	.33	.17	.13	.20	.22	.32	.53		
Cultural activity	.26	−.03	.16	.12	.06	.52	.43	.48	.32	.47	.36	.57	.58	.61	.69	

Note. O = openness; C = conscientiousness; A = agreeableness; ES = emotional stability. Cultural activity items are on a scale of 0–4. Cultural activity is the sum score of all cultural activity items.

cultural activity can be considered as a single latent construct.[4] Total cultural activity participation and breadth of cultural activity participation were highly correlated ($r = .95$). That is, when participants indicated that they participated more frequently in cultural activities, it was almost entirely because they participated in new cultural activities, rather than participating in the same activities more frequently. We present the means, standard deviations, and zero-order correlations between cultural activity items and Big Five personality traits in Table 1. Of the Big Five trait domains, openness had the strongest concurrent associations with cultural activity ($r = .26$) and each of the cultural activity items.

Control variables. We included log-transformed monthly household income, which was assessed annually from 2009 to 2014, as a time-variant covariate control in analyses where we specified that we controlled for income. We split participants into college-educated and not college-educated groups by maximum level of education completed, which was assessed annually from 2008 to 2014, in analyses where we specified that we tested effects across education groups.

Analyses

We conducted structural equation model analyses in Mplus version 7.31 (Muthén & Muthén, 2010) unless otherwise noted. We handled missing data using Full Information Maximum Likelihood estimation. We used the cluster function in Mplus to account for the nested structure of the data (individuals were nested within households) in all analyses. It was especially important to account for this in our analyses because cultural activity may often be a shared experience between members of one household.

Measurement invariance. We first tested whether our measures were invariant across time and age using the R package lavaan (Rosseel, 2012; R Core Team, 2016). To do this, we first created item parcels by running a one-factor confirmatory factor analysis on the 10 openness items and sorting them into three parcels by descending factor loading so that parcels would load as equivalently as possible on a latent openness factor (two parcels had three items each; one parcel had four items). We used parcels because they are more normally distributed than single items and they decrease model complexity (Little, Cunningham, Shahar, & Widaman, 2002). We then estimated two measurement invariance models. To test invariance across study waves, we estimated a latent openness factor from the three parcels for each of the study waves, and we tested invariance across participants. To test invariance across age, we estimated a latent openness factor from the three parcels for the first wave of the study for each age group. We created seven age groups by dividing participants based on what decade of life they were in during the first study wave (max group $N = 1{,}608$, min group $N = 389$). Because relatively few participants began the study in their 80s and 90s ($N = 95$), participants in these age groups were grouped together with participants in their 70s in these models.

We then tested increasingly restricted versions of these across-time and across-age groups models for measurement invariance, noting change in confirmatory fit index (CFI), root mean square

[4] In addition to the 10-item cultural activity scale that we used in this study, the LISS social integration and leisure survey also includes a 28-item leisure behavior questionnaire which contains five items that assess cultural activity. We sought to conceptually replicate primary analyses using this ad hoc five-item cultural behavior scale. This scale demonstrated low internal consistency ($\alpha = .31$), and we could not establish measurement invariance for this scale across age groups (CFI $< .793$, ΔCFI $> .09$). Nevertheless, we conducted additional longitudinal analyses using this scale. ARCL model results replicated the pattern of rank-order codevelopment found in our primary analyses. Bivariate LGC model results mostly replicated the pattern of mean-level codevelopment found in our primary analyses. Specifically, although people scoring higher on openness decreased less in cultural activity over time, there were fewer individual differences in change in this measure of cultural activity over time compared with our focal measure of cultural activity, and change in this measure was not correlated with change in openness. We hesitate to draw strong conclusions from these analyses due to psychometric issues with this scale. Full details of these analyses are available in supplemental materials.

error approximation (RMSEA), and χ^2 model fit at each step. In order, we constrained model configuration, factor loadings, and parcel intercepts to be equal across time and across groups. We then repeated this process for cultural activity. Because cultural activity was measured in 2010 and 2012 but openness was not, the measurement invariance models for the former included seven waves of data while models for the latter included five.

Latent growth curve models across the life span. After establishing measurement invariance, in our first set of main analyses, we estimated a second-order LGC model to examine the trajectory of mean levels of openness across the life span. To do this, we estimated a latent openness trait from three parcels. Factor loadings were constrained to be equal across waves based on the results of our measurement invariance tests. We then estimated a life span LGC model using latent openness scores from all participants across all years of life. Although each participant only contributed five waves of openness data at most, a life span trajectory can be estimated using information simultaneously from all participants where slope loadings correspond to a participants' age at measurement (Duncan, Duncan, & Strycker, 2013; Preacher, Wichman, MacCallum, & Briggs, 2008; cf. Orth, Robins, & Widaman, 2012). To facilitate model interpretation, we centered age at 16, the youngest age that provided survey data. We present an illustration of a life span LGC model in Figure 1.

Previous research has characterized openness development across the life span as nonlinear (Roberts et al., 2006; Specht et al., 2011), so we tested an intercept-only growth model up to a cubic growth model, assessing fit empirically at each step using Bayesian Information Criterion (BIC) and χ^2 model fit. Although BIC cannot be used to test absolute model fit, it can be compared between models; the model with a smaller BIC best balances fit and parsimony (Duncan et al., 2013). We then built a second life span LGC model, using the same methodology, to examine life span cultural activity development.

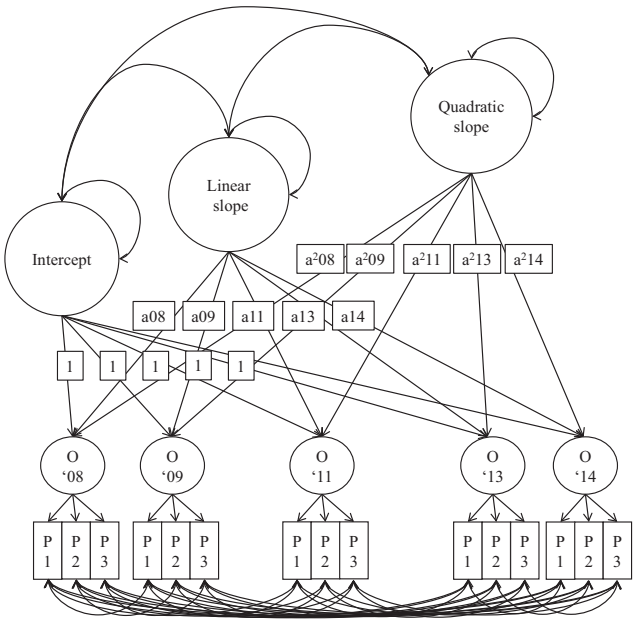

Figure 1. Quadratic life span latent growth curve. O'08–O'14 = latent openness score for each year. P1–P3 = parcel one through parcel three. Small rectangles represent factor loadings: a08–a14 = participant's centered age in each year; $a^2$08–$a^2$14 = participant's centered age squared in each year.

Latent growth curve models across seven measurement waves. We examined if there were significant individual differences in openness development across three age groups: emerging adulthood (age 16–26; N = 921), middle adulthood (age 27–64; N = 5,445), and old age (age 65–95; N = 987). To do this, we estimated yearly latent scores for openness in the same way as for the life span LGC model. We then estimated a latent intercept and latent linear slope factor for openness across the study period. To assess variability in individual-level change, we examined variance in the linear slope factor of this model across the three age groups (Duncan et al., 2013; Scollon & Diener, 2006).

Next, we examined whether individual-level variability in openness change is associated with individual-level cultural activity change. To do this, we analyzed change in both constructs across the seven measurement waves of the study using a second-order bivariate LGC model (McArdle, 1988; Duncan et al., 2013). Specifically, we estimated a univariate openness LGC model as described in the previous paragraph, and a similar univariate LGC measuring cultural activity. We then correlated latent intercept and slope factors between the two constructs. We were particularly interested in the correlation between openness slope and cultural activity slope, which represents correlated change between the two constructs. To examine whether personality-culture transactions are indeed unique to openness, we repeated these analyses with the other Big Five traits.

To test whether correlated change differed across the life span, we split participants into three age groups as in the univariate openness LGC. We then compared the fit of a restricted model, in which the covariances between intercepts and between slopes were constrained to be equal across groups, with the fits of three less restricted models, in which these covariances were allowed to vary for a single age group and set equal for the other age groups, and with a completely freed model, in which the covariances were estimated separately for each age group (Duncan et al., 2013; cf., Hudson, Roberts, & Lodi-Smith, 2012). In all model comparison tests, comparisons between nested models were done using χ^2 difference tests based on log-likelihood values and scaling correction factors obtained with MLR estimation (Satorra, 2000).

Autoregressive cross-lagged models. Next, we sought to better understand the temporality and directionality of the associations between change in cultural activities and change in openness. To do this, we specified a series of Autoregressive Cross Lagged (ARCL) models to examine bidirectional associations between openness and cultural activities across the seven years of the LISS study. Whereas LGC models measure mean-level change, ARCL models measure rank-order change. Mean-level and rank-order personality change often co-occur, but it is possible to have one type of change without the other (Duncan et al., 2013; Mroczek & Spiro, 2003).

To build the base ARCL model, we first estimated latent scores for openness and cultural activity each year in the same way as the bivariate LGC model. We also estimated an autoregressive structure and correlated change paths. We then tested whether the model fit improved when adding cross-lagged paths across each of the five waves. Finally, we tested whether constraining each of

these paths (autoregressive, correlated change, and cross-lagged) across similar year gaps (1-year and 2-year intervals) significantly decreased model fit.

After estimating the base ARCL model, we examined whether estimated paths differed across age and education groups and when controlling for income. For age groups, we examined if there were age group differences in autoregressive, correlated change, and cross-lagged paths by comparing a series of restricted and unrestricted models in the same way that we tested the bivariate LGC model for age group differences. For education groups, we divided the sample by maximum education reported over the study period into a college-educated group (N = 2,388) and a not college-educated group (N = 4,934). We then tested whether freeing each of the parameters in the restricted model across these education groups in turn significantly increased model fit. To control for the effect of income on growth, we built an autoregressive structure for income and regressed this on growth parameters at each time point.

Results

Attrition Analyses

In total, 2,732 participants (37%) provided study data for all seven waves between 2008 and 2014 (2008 N = 7,360, 2009 N = 5,546, 2010 N = 4,753, 2011 N = 4,202, 2012 N = 3,700, 2013 N = 3,536, 2014 N = 3,301). Some participants did not provide data in a given year but returned to the sample and resumed providing data in later years. Mean-level comparisons indicated that participants who completed all seven waves were, on average, older (M = 50.07 vs. M = 44.03, $t(6038.7) = -16.39$, $p < .001$, $d = 0.40$), but were not different from nonresponders with respect to gender, $\chi^2(1) = 2.64$, $p = .10$, openness (M = 3.50 vs. M = 3.52; $t(5711.5) = 1.51$, $p = .13$, $d = -0.04$), or cultural activity (M = 4.66 vs. M = 4.75; $t(5735.6) = .88$, $p = .38$, $d = -0.02$).

Measurement Invariance

We established measurement invariance for openness to experience (all ΔCFI $< .014$; all ΔRMSEA $< .031$; cf. Cheung & Rensvold, 2002; Kline, 2005). That is, we were able to constrain configuration, factor loadings, and intercepts across measurement occasions (CFI = .996, RMSEA = .025, 95% CI [.020, .030], $\chi^2(66) = 161.62$, $p < .001$), and across age groups (CFI = .984, RMSEA = .058, 95% CI [.046, .070], $\chi^2(21) = 4{,}641.10$, $p < .001$). Measurement invariance for cultural activity was established across measurement occasions (CFI = .997, RMSEA = .020, 95% CI [.017, .024], $\chi^2(129) = 275.58$, $p < .001$). However, we were unable to constrain cultural activity parcel *intercepts* to be equal across decade age groups (CFI = .817, RMSEA = .189, 95% CI [.179, .199], $\chi^2(21) = 4941.45$, $p < .001$). The results of these tests suggest that openness and cultural activity scores can be compared across measurement occasions. Also, scores can be compared across age groups in the case of openness, but caution should be taken when comparing age groups in terms of cultural activity (e.g., our data indicate that younger cohorts are less likely to attend film houses, classical concerts, and cabaret performances, the items that compose parcel 3; for further evidence of cohort effects in cultural activity, see Kraaykamp & van Eijck, 2005). Additional fit indices for all measurement invariance tests are available in supplemental materials (Table S1).

Openness and Cultural Activity Across the Life Span

For openness, model comparison tests indicated that a quadratic-change model best described life span development. Figure 2 shows that openness remained stable between ages 16 and 26. It then declined about four-tenths of a standard deviation between ages 26 and 65. In old age, openness declined increasingly more rapidly, by seven-tenths of a standard deviation between ages 65 and 95.

For cultural activity, model comparison tests indicated that a cubic-change model best described life span development. Figure 3 shows that cultural activity declined about four-tenths of a standard deviation between ages 16 and 40, and then remained stable from age 40 until around age 60. After age 60, cultural activity began to decline precipitously throughout the rest of the life span, by over one standard deviation between ages 65 and 95. Model comparison test results are available in supplemental materials (Table S2).

Do Openness and Cultural Activity Codevelop Across the Life Span?

The univariate openness LGC model fit the data well (CFI = .993, RMSEA = .021, 95% CI [.018, .023], $\chi^2(315) = 33791.11$, $p < .001$). Slope variance estimates indicated that there was significant variance in individual-level openness development across the seven years of the study in each age group: emerging adulthood ($s^2 = 0.54$, 95% CI [0.26, 0.82], $p < .001$), middle age ($s^2 = 0.38$, 95% CI [0.28, 0.48], $p < .001$) and old age ($s^2 = 0.17$, 95% CI [0.03, 0.32], $p = .02$). To follow up on this finding, we conducted likelihood ratio tests in a multiple-groups framework to examine if this slope variance parameter differed by age group, in the same way that we tested age group differences in culture-openness transactions. Results from these tests indicated that there was less variance in change in old age than in emerging adulthood or middle adulthood, $\chi^2(1) = 6.69$, $p = .01$. Additional parameter estimates for the univariate openness LGC model are available in supplemental materials (Table S3). We present a visualization of individual-level openness trajectories in Figure 4.

The bivariate culture-openness LGC model fit the data well (CFI = .993; RMSEA = .013, 95% CI [.012, .014], $\chi^2(539) = 1{,}187.31$, $p < .001$). We report the parameter estimates for this model in Table 2 and present the model in Figure 5. In this model, the intercepts of openness and cultural activity covaried positively (b = 18.57, 95% CI [16.70, 20.43], $p < .001$), indicating that participant's openness scores were positively related to their cultural activity scores at the first measurement occasion. Both the cultural activity slope factor mean ($M = -0.31$, 95% CI [−0.36, −0.29], $p < .001$) and the openness slope factor mean ($M = -0.17$, 95% CI [−0.20, −0.13], $p < .001$) were negative, indicating that the average participant became less open and participated in fewer cultural activities participant over the course of the study period, although there was significant variance around those mean trajectories (s^2 openness = 0.36, 95% CI [0.28, 0.44], $p < .001$; s^2 cultural activity = 0.41, 95% CI [0.33, 0.48], $p < .001$). Levels of openness were negatively associated with the

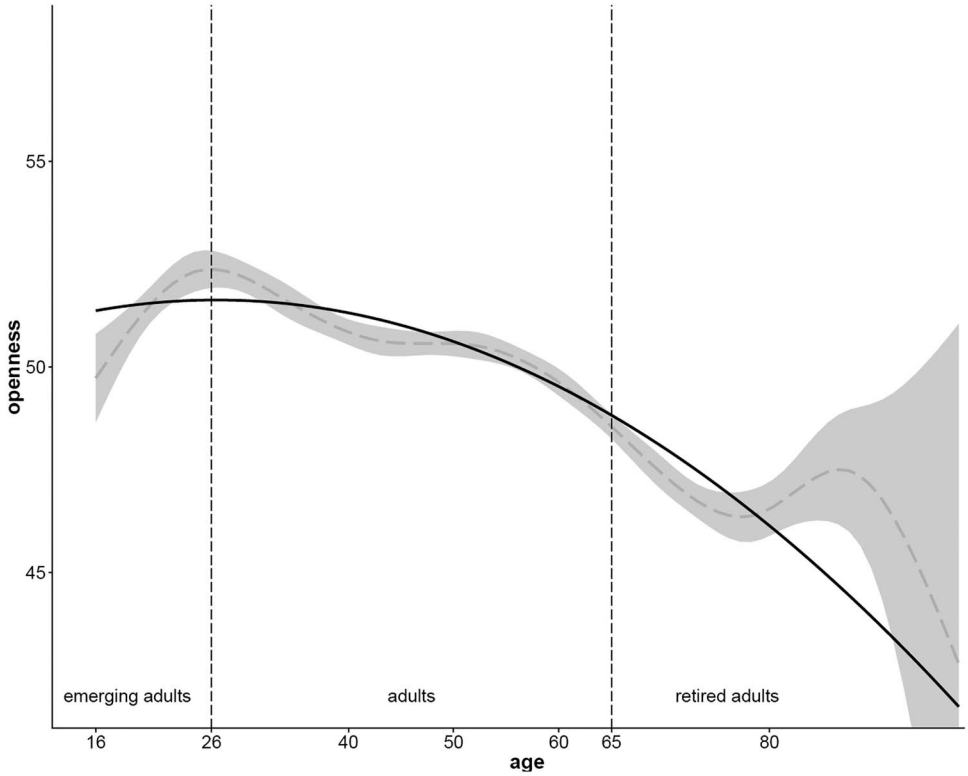

Figure 2. Development of openness across the life span. The black line shows the best-fitting quadratic growth trajectory. The dashed gray line shows the loess-smoothed mean trajectory based on individual data points, including standard error. *y* axis scores are standardized to *t* scores.

openness slope ($b = -0.93$, 95% CI [−1.29 −0.58], $p < .001$) and cultural activity slope ($b = -0.57$, 95% CI [−0.83, −0.31], $p < .001$). These associations suggest that people scoring higher on openness were less likely to decrease in openness and cultural activity over time. Levels of cultural activity were negatively correlated with the cultural activity slope ($b = -1.55$, 95% CI [−1.92, −1.17], $p < .001$) but not the openness slope ($b = -0.24$, 95% CI [−0.48, 0.01], $p = .06$). These associations suggest that people who participated in more cultural activities at the first measurement occasion were less likely to decrease in cultural activity over time. The slopes of openness and cultural activity were positively associated ($b = 0.04$, 95% CI [0.01, 0.08], $p = .02$), indicating that participants who decreased in openness also tended to decrease in cultural activity, and vice versa. Results of the multiple-group model suggested that correlated change did not differ by age group (max $\Delta\chi^2(2) = 0.31$, $p = .86$). More detailed results of multiple group comparison tests are available in the supplemental materials (Table S4).

Associations With Other Personality Traits

To more fully understand longitudinal associations between personality and cultural activity, we examined longitudinal associations between the other Big Five traits and cultural activity. These analyses allowed us to identify which other traits, if any, codeveloped systematically with cultural activity across the life span. Results of these tests suggested that conscientiousness and extraversion were longitudinally related to cultural activity, but that emotional stability and agreeableness were not. Specifically, we found a significant negative covariance between the positive conscientiousness intercept and the negative cultural activity slope ($b = -0.31$, 95% CI [−0.58, −0.03], $p = .03$). This indicates that participants who scored higher on conscientiousness at the first measurement occasion were less likely to decrease in cultural activity over time. We also found a positive covariance between the positive conscientiousness slope and the negative cultural activity slope ($b = 0.04$, 95% CI [0.00, 0.08], $p = .04$). This indicates that participants who increased in conscientiousness over the study period were less likely to decrease in cultural activity over the study period. Second, there was a significant negative association between the positive extraversion intercept and negative cultural activity slope ($b = -0.39$, 95% CI [−0.62, −0.15], $p = .001$). This indicates that participants who scored higher on extraversion at the first measurement occasion were less likely to decrease in cultural activity over the study period. Full results of all bivariate growth curve models for all Big Five traits are available at osf.io/h7apv.

Does Cultural Activity Change Predict Openness Change Across the Life Span?

The best fitting ARCL model is shown in Figure 6; we report parameter estimates for this model in Table 3. This model fit the data well (CFI = .992, RMSEA = .015, 95% CI [.014, .016],

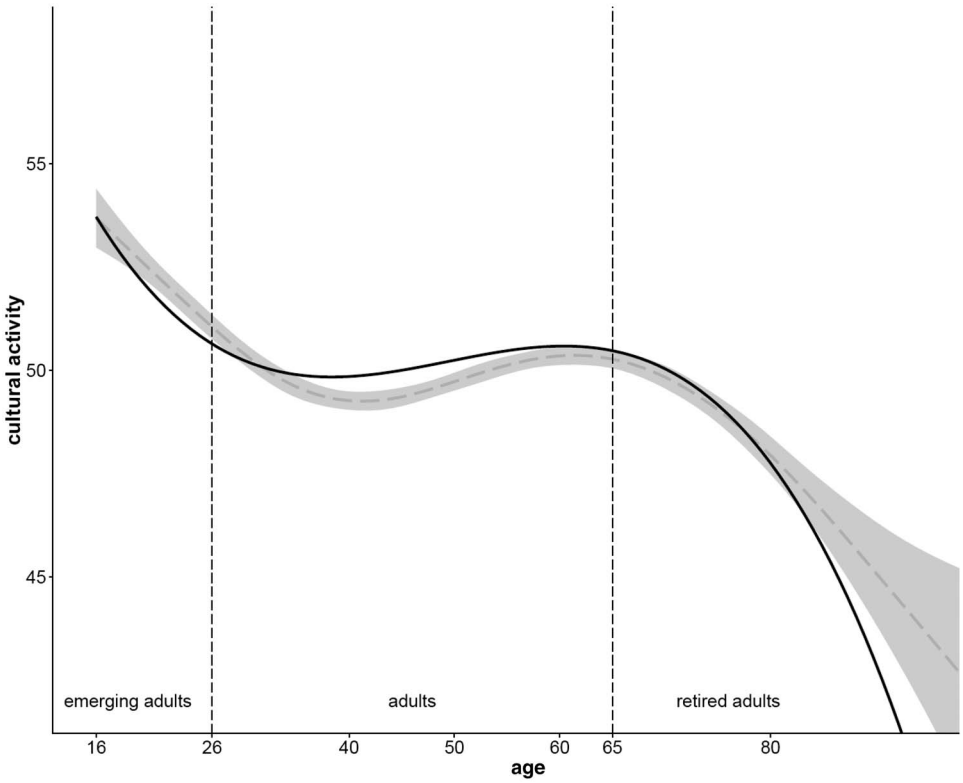

Figure 3. Development of cultural activity across the life span. The black line shows the best-fitting cubic growth trajectory. The dashed gray line shows the loess-smoothed mean trajectory based on individual data points, including standard error. *y* axis scores are standardized to *t* scores.

$\chi^2(349) = 919.35$, $p < .001$). Results suggest that the stability of both openness (*b*s of .90-.93, *p*s $< .001$) and cultural activity (*b*s of .88–.94, *p*s $< .001$) was high across the study period. Openness and cultural activity were moderately associated at the first measurement occasion ($b = 18.59$, 95% CI [16.61, 20.56], $p < .001$).

Model comparison tests revealed that the model fit improved when including the cross-lagged paths (1) from openness to cultural activity ($\Delta\chi^2(4) = 22.49$, $p < .001$), and (2) from cultural activity to openness ($\Delta\chi^2(4) = 21.88$, $p < .001$). More specifically, lagged effects across one year intervals were significant but small in both directions, from openness to cultural activity ($b = 0.03$, 95% CI [0.01, 0.04], $p = .002$) and from cultural activity to openness ($b = 0.03$, 95% CI [0.01, 0.05], $p = .01$). Lagged effects across two year intervals were significant, but with smaller point estimates, from cultural activity to openness ($b = 0.02$, 95% CI [0.00, 0.04], $p = .03$), but not significant from openness to cultural activities ($b = 0.01$, 95% CI = [−0.00, 0.03], $p = .10$). This suggests that changes in an individual's openness prospectively predict changes in their cultural activity one year in the future but not two years in the future, and changes in an individual's cultural activity prospectively predict changes in their openness both one and two years in the future.[5] Full results of model comparison tests are available in supplemental materials (Table S5). Full results of all ARCL models for all Big Five traits are available at osf.io/h7apv.

Controlling for Age, Education, and Income

Cultural Activity and Openness may codevelop differently depending on a person's age, education, or income. However, results of multiple-groups models for education groups and age groups did not reveal group differences for any sets of ARCL parameters besides cultural activity auto-regressive paths. Specifically, rank-order cultural activity was less stable in emerging adults than in the other two age groups ($\Delta\chi^2(4) = 13.18$, $p = .01$), and less stable among those who do not have a college degree ($\Delta\chi^2(4) = 16.92$, $p = .002$). Results of all multiple-groups model tests are available in supplemental materials (Tables S6 and S7). We also controlled for age in a more powerful, less nuanced manner by regressing openness and cultural activity growth factors on age in 2008 and on age and age^2 in 2008. This did not affect point estimates or the significance of any cross-lagged paths.

[5] Although not discussed elsewhere in the manuscript, we also examined longitudinal associations between openness and time spent reading. Levels of the two constructs were not highly correlated ($r = .09$), and cross-lagged paths did not improve model fit (Figure S1; Table S6). We hesitate to draw conclusions from this because we do not believe that time spent reading is a strong indicator of exploratory behavior (i.e., people may be reading for work or school).

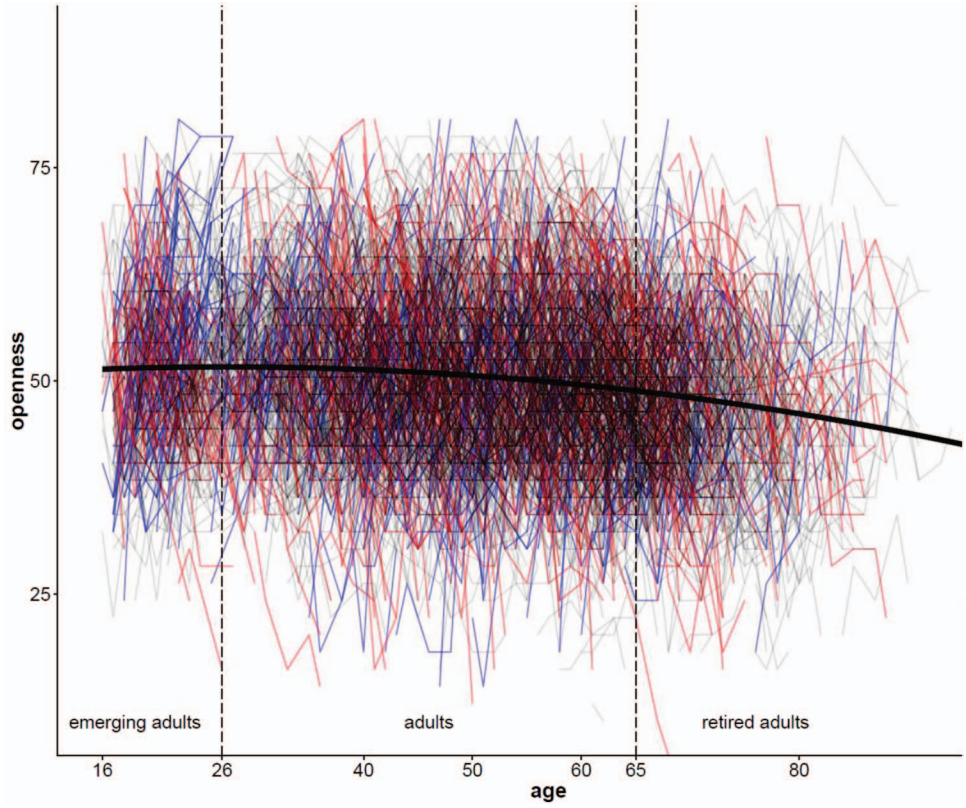

Figure 4. Individual-level openness trajectories across the life span. The black line shows the best-fitting quadratic growth trajectory. Individual lines show individual participant trajectories. Blue lines show participants who increased one standard deviation or more (10 *t* score points) over the study period; red lines show participants who decreased over one standard deviation or more over the study period.

All significant parameters remained significant at the $p < .05$ level after controlling for income as a time-variant control variable. Specifically, point estimates for autoregressive and cross-lagged parameters across single-year gaps were unaffected, and cross-lagged parameters across two year gaps from cultural activity to openness were slightly reduced but remained significant. Regressions of all income parameters on growth factors were nonsignificant. An illustration of this model is available in supplemental materials (Figure S3), and we report parameter estimates before and after controlling for income in Table 3. These findings suggest that culture-openness transactions are robust across age and education groups and not affected by income.

Discussion

In this study, we sought to better understand the development of openness across the life span. We found that mean levels of openness remained relatively unchanging in emerging adulthood before declining in midlife and beyond. In addition, we found significant individual differences in openness development throughout all stages of life. Furthermore, we found that changes in cultural activity over time were associated with individual differences in openness change. Moreover, rank-order changes in cultural activity predicted subsequent rank-order changes in openness, and vice versa. These culture-openness transactions held across age and education groups and when controlling for changes in income. In contrast, there were few longitudinal associations between cultural activity and the other Big Five traits.

Openness Across the Life Span

Past studies have yielded different estimates of how openness develops across the life span. Although the results from a single study cannot definitively establish any developmental trajectory, we analyzed a large, multiwave representative sample using second-order latent growth curve analysis (Bollen & Curran, 2006), which allowed us to provide a powerful estimate of openness development from ages 16 to 95 in the Dutch population.

We found that mean levels of openness remain relatively stable in emerging adulthood (ages 16–26; Arnett, 2000); the trait increased by only one-tenth of a standard deviation during this time. Stability of openness in emerging adulthood has also been demonstrated in longitudinal samples of Australians (Wortman et al., 2012) and Germans (Lucas & Donnellan, 2011; Specht et al., 2011). Meta-analytic results, however, suggested that openness increases by four-tenths of a standard deviation during ages 18–22 (Roberts et al., 2006). There are a few differences between these studies and our study that might explain these discrepancies. One is sample composition. Different nations, different subsamples of the population, such as college students, and different age cohorts

Table 2
Openness and Cultural Activity Parameter Estimates from the Bivariate Growth Curve Model (Standard Errors in Parentheses; N = 7,353)

Parameter estimate	*B*	*r*	95% CI	*p*
O → Parcel 1	1.00	—	—	—
O → Parcel 2	.85 (.02)	—	[.81, .88]	<.001
O → Parcel 3	.90 (.02)	—	[.87, .93]	<.001
O intercept	55.03 (.59)	—	[53.90, 56.20]	<.001
O intercept variance	54.28 (1.64)	—	[51.09, 57.54]	<.001
O slope	−.17 (.02)	—	[−.20, −.13]	<.001
O slope variance	.36 (.04)	—	[.28, .44]	<.001
CA → Parcel 1	1.00	—	—	—
CA → Parcel 2	1.07 (.03)	—	[1.02, 1.13]	<.001
CA → Parcel 3	1.03 (.03)	—	[.98, 1.09]	<.001
CA intercept	49.11 (.75)	—	[47.64, 50.57]	<.001
CA intercept variance	42.86 (1.78)	—	[39.48, 46.23]	<.001
CA slope	−.31 (.02)	—	[−.36, −.29]	<.001
CA slope variance	.41 (.04)	—	[.33, .48]	<.001
Covariances				
O intercept and O slope	−.93 (.18)	−.21	[−1.29, −.58]	<.001
CA intercept and CA slope	−1.55 (.19)	−.37	[−1.92, −1.17]	<.001
O intercept and CA intercept	18.57 (.95)	.39	[16.70, 20.43]	<.001
CA intercept and O slope	−.24 (.13)	−.06	[−.48, .01]	.06
O intercept and CA slope	−.57 (.13)	−.12	[−.83, −.31]	<.001
O slope and CA slope	−.04 (.02)	.11	[.01, .08]	.02

Note. O = openness to experience. CA = cultural activity.

may have different life span openness trajectories (Bleidorn et al., 2013; Bleidorn & Schwaba, 2016; Löckenhoff et al., 2008; but see King, Weiss, & Sisco, 2008, and McCrae et al., 2000, for similar patterns of openness change across species and cultures). Additionally, different studies have measured openness using different instruments. This study used an intellect-centered openness questionnaire while other studies used abbreviated openness questionnaires that put greater emphasis on aesthetic openness and imagination. Roberts and colleagues (2006) were even more inclusive by operationalizing a variety of questionnaires such as sentence-completion tasks and workplace creativity measures as assessments of openness. As such, the latent openness construct being measured may have differed between studies. Taken as a whole, the results of this study and others utilizing large longitudinal national samples (Lucas & Donnellan, 2011; Wortman et al., 2012) suggest that mean levels of openness are relatively unchanging among emerging adults living in today's Western world.

In young and middle adulthood (ages 27–64), we found that mean levels of openness decline slowly, about four-tenths of a standard deviation, over nearly 40 years of the life span. This finding replicates longitudinal studies of Australians (Wortman et al., 2012), Americans (Terracciano et al., 2005), and Germans (Lucas & Donnellan, 2011; Specht et al., 2011), which found mean-level declines in openness of four-tenths, one half, and seven-tenths of a standard deviation, respectively, across midlife. Again, this finding conflicts with meta-analytic results (Roberts et al., 2006), which found that openness remained stable over this part of the life span. We believe that, given this evidence, the most accurate conclusion for openness development in midlife is that levels of the trait decline, albeit very gradually, in the majority of the population.

In old age (ages 65–95), we found that mean levels of openness declined in an increasingly rapid manner. All other longitudinal studies including this age range (Lucas & Donnellan, 2011; Specht et al., 2011; Terracciano et al., 2005; Wortman et al., 2012) as well as a meta-analysis (Roberts et al., 2006) have also shown evidence for declines. Thus, late-life trait openness declines appear to be normative in Western nations, and to be increasingly prominent as age increases.

Beyond mean-level development, we also found significant individual differences in openness development (see Figure 4), in accordance with past studies (Allemand et al., 2007; Robins et al., 2001; Small et al., 2003; Terracciano et al., 2005). Although there was significant heterogeneity in development across all stages of life, we found that those in old age (65 + years) varied less in their development than the two younger age groups.

Why might older adults tend to develop more similarly in their openness? It may be that the environmental contingencies that affect openness in late life tend to push development in similar directions, toward commitment rather than exploration (Sutin et al., 2013). Evidence for socioemotional selectivity theory supports this: older adults are less likely to explore and focus more on existing and close relationships (Carstensen, 1995).

Culture-Openness Transactions Across the Life Span

In our second set of analyses, we examined whether changes in cultural activity (Kraaykamp & Van Eijck, 2005; Jackson, 2011) were associated with some of these observed individual differences in openness change. Replicating past research, we found that levels of cultural activity and openness were correlated (Chamorro-Premuzic et al., 2009; Furnham & Chamorro-Premuzic, 2004; Jackson, 2011). We also found correlated mean-level change between openness and cultural activity over the seven years of the study. This suggests that individuals who invested in cultural activity tended to become more open, and individuals who divested from cultural activity

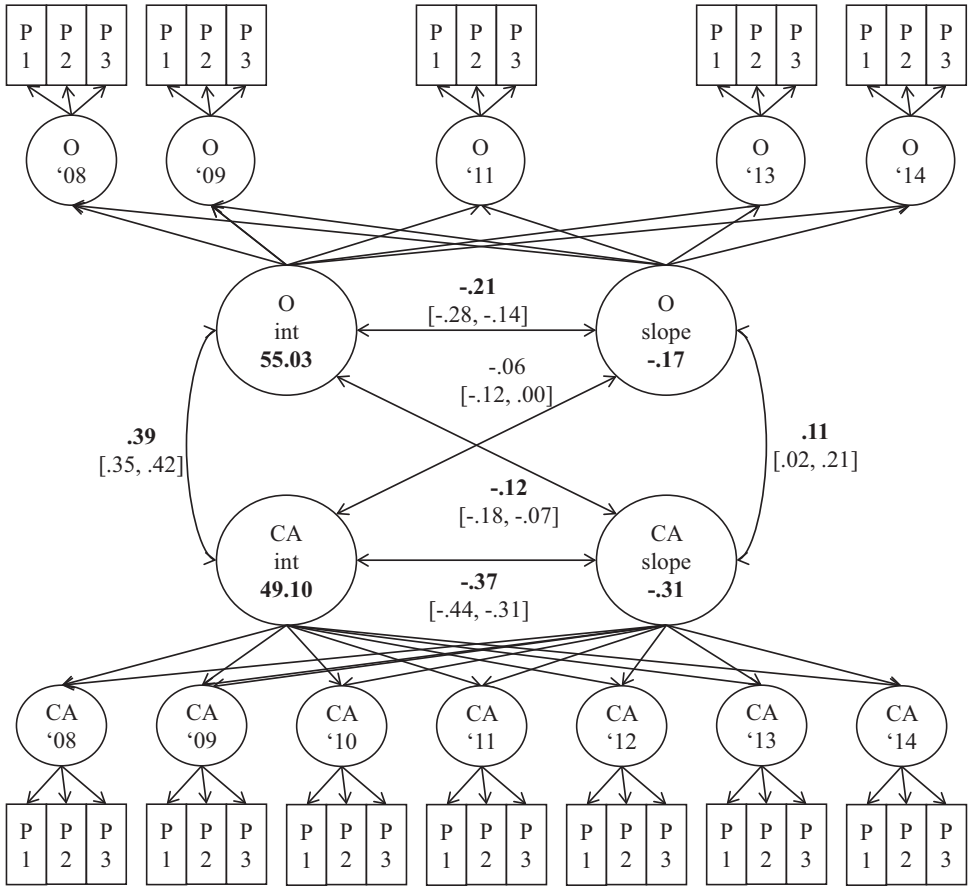

Figure 5. Bivariate latent growth curve. O'08–O'14 = latent openness score for each year. CA'08–CA'14 = latent cultural activities score for each year. O int = openness intercept. O slope = openness linear slope. CA int = cultural activities intercept. CA slope = cultural activities linear slope. P1–P3 = parcel one through parcel three. Numbers in brackets are 95% confidence intervals. Not in figure: parcel residuals were allowed to correlate across time.

tended to become less open. In subsequent tests of rank-order codevelopment, we found that changes in openness predicted subsequent changes in cultural activity (selection effects), and changes in cultural activity predicted subsequent changes in openness (socialization effects). Especially important to note here is that our openness measure was intellect-centered, which means that change in cultural activity was associated with openness trait change beyond change in the openness facet of aesthetic sensitivity. Our results also suggest that these changes were mutually reinforcing, which means that small initial changes in cultural activity and openness may snowball into larger, lasting trait change (Roberts & Jackson, 2008).

Results also indicated that culture-openness transactions were smaller in magnitude across 2-year gaps than 1-year gaps. Specifically, cultural activity was less related to changes in openness two years in the future than one year into the future, and openness was not related to changes in cultural activity two years into the future (see Figure 6). These results underscore how frequent and well-timed personality assessments are necessary to understand how trait changes unfold in the context of experiences and life events (Bleidorn, Hopwood, & Lucas, 2016; Luhmann, Orth, Specht, Kandler, & Lucas, 2014).

In summary, the pattern of longitudinal results we found supports our hypothesis that cultural activity and openness codevelop over time. We thus posit that changes in cultural activity can be added to the taxonomy of experiences associated with openness change across the life span.

However, the question remains: what processes underlie culture-openness transactions? We propose that changes in exploratory behavior may drive the culture-openness transactions that we observed. People who are engaging in new cultural activities may frequently be in a highly open state because they are often in novel situations that require them to process new ideas. People who are divesting from cultural activity participation may frequently be in low-openness states because they are participating in fewer cognitively stimulating novel activities. In this way, cultural activity may both signal and constitute the exploratory experiences that precipitate openness change.

Interestingly, a person who attended a variety of cultural activities at initial measurement was no more likely to change in their openness than a person who attended few cultural activities at initial measurement. That is, the cultural activity intercept was not associated with the openness slope. This finding is consistent with our hypothesis that expansions or contractions in breadth of be-

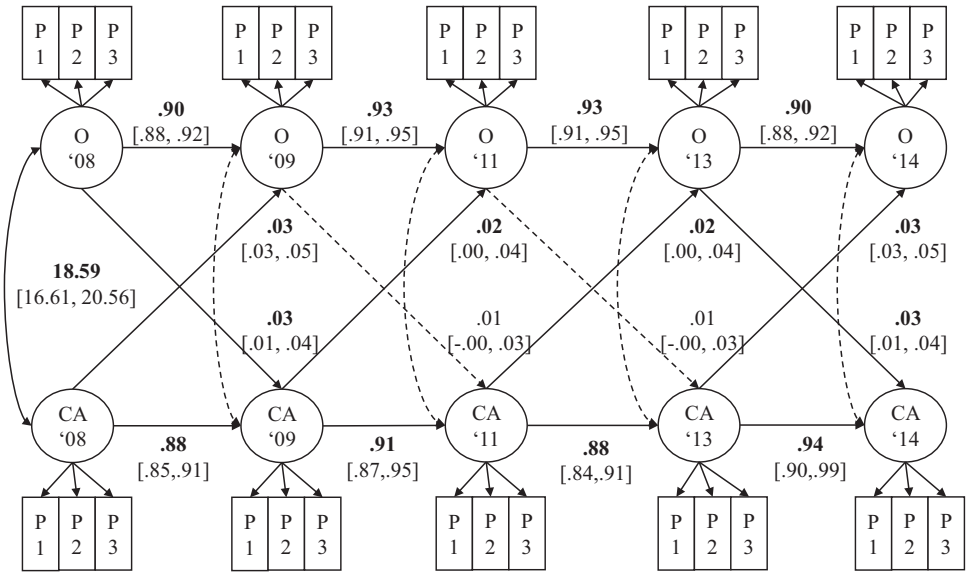

Figure 6. Base autoregressive cross-lagged model. O'08–O'14 = latent openness score for each year. CA'08–CA'14 = latent cultural activity score for each year. P1–P3 = parcel one through parcel three. Numbers in brackets are 95% confidence intervals for initial correlation and cross-lagged paths. Dashed lines represent nonsignificant associations. Not illustrated in this figure: parcel residuals were allowed to correlate across time.

havior, rather than a continuation of preexisting behavioral patterns, is the mechanism behind openness change. If a person attends a variety of cultural activities at initial measurement, and then continues this behavior, they are not experiencing novel situations. Rather than exploring, these people would be continuing their patterns of preexisting behavior.

Although no studies to date have examined how changes in exploration specifically relate to changes in openness across time, we believe that the common threads between this study and past research on openness development may situate exploration as a driving mechanism behind openness change (Bleidorn & Schwaba, 2016). More research on exploratory behavior and change in openness is needed to better understand the processes that underlie the links between cultural investment and openness development. For example, people who expand the breadth of their behavior, even behaviors not related to cultural activity, may also become more open over time.

An additional mechanism that may underlie culture-openness transactions is transcendent moments (Maslow, 1964). Specifically, individuals attending cultural activities may experience extremely intense high-openness states. When these experiences happen often (Roberts & Jackson, 2008) or lead people to reassess and alter their identity (e.g., MacLean et al., 2011), these transcendent moments may translate into lasting openness increases.

We also attempted to rule out some plausible third-variable explanations for culture-openness transactions. Neither selection effects, socialization effects, nor cross-sectional associations differed across age groups, between college and noncollege groups, or when controlling for income. That these effects were similar across different age groups was particularly interesting. Although we found that individual level openness development was less variable in old age, culture-openness transaction effects were not attenuated within this age group. Although we cannot be certain that the mechanism for change is the same across these groups, these results suggest that changes in cultural activity are a robust signal of future openness change across the life span and across various demographic groups.

Although culture-openness transactions are robust across groups, they are not especially strong in magnitude. Both selection and socialization effect sizes ranged around $d = .05$. That effects are small is sensible, because rarely does a person's personality change drastically in a short amount of time. After accounting for trait stability (and reducing random measurement error by measuring the construct at the latent level), there is not much variance left in openness or cultural activity for culture-openness transactions to account for. However, over time, even small changes in personality can have a large impact on life outcomes (Roberts et al., 2007).

Cultural Activity and the Other Big Five Traits

We also found codevelopmental patterns between cultural activity and two other Big Five traits: extraversion and conscientiousness. Individuals who were more extraverted at initial measurement tended to engage in more cultural activity and decreased less rapidly in cultural activity over time. When people visit a museum, or attend a concert, they often do so with others, and this social aspect of cultural activity may explain these codevelopmental patterns. Regarding conscientiousness, we found that individuals who became less conscientious over time also tended to become less invested in cultural activity, although the two constructs were not associated at initial measurement. This finding is in line with past research that has investigated personality change in the context of social engagement; people who disengage from social activities tend to also become less conscientiousness (Lodi-Smith & Roberts, 2012). Although we found that cultural activity

Table 3
Openness and Cultural Activity Parameter Estimates From the Autoregressive Cross-Lagged Model (Standard Errors in Parentheses; N = 7,353)

Parameter estimate	Unstandardized model	95% CI	*p*	Controlling for income model	95% CI	*p*
O → Parcel 1	1.00	—	—	1.00	—	—
O → Parcel 2	.86 (.02)	[.83, .89]	<.001	.86 (.02)	[.83, .89]	<.001
O → Parcel 3	.91 (.02)	[.87, .94]	<.001	.91 (.02)	[.88, .94]	<.001
O'08 → O'09	.90 (.01)	[.88, .92]	<.001	.90 (.01)	[.88, .92]	<.001
O'09 → O'11	.93 (.01)	[.91, .95]	<.001	.93 (.01)	[.91, .95]	<.001
O'11 → O'13	.93 (.01)	[.91, .95]	<.001	.93 (.01)	[.91, .95]	<.001
O'13 → O'14	.90 (.01)	[.88, .92]	<.001	.90 (.01)	[.88, .92]	<.001
CA → Parcel 1	1.00	—	—	1.00	—	—
CA → Parcel 2	1.06 (.03)	[1.00, 1.12]	<.001	1.06 (.03)	[1.00, 1.12]	<.001
CA → Parcel 3	1.07 (.03)	[1.01, 1.13]	<.001	1.07 (.03)	[1.01, 1.12]	<.001
CA'08 → CA'09	.88 (.02)	[.85, .91]	<.001	.87 (.02)	[.89, .93]	<.001
CA'09 → CA'11	.91 (.02)	[.87, .95]	<.001	.90 (.02)	[.88, .93]	<.001
CA'11 → CA'13	.88 (.02)	[.84, .91]	<.001	.88 (.02)	[.89, .94]	<.001
CA'13 → CA'14	.94 (.02)	[.90, .99]	<.001	.94 (.02)	[.91, .95]	<.001
Covariances						
O'08 and CA'08	18.59 (1.01)	[16.61, 20.56]	<.001	18.67 (1.01)	[16.69, 20.65]	<.001
O'09 and CA'09	.13 (.17)	[−.21, .47]	.45	.13 (.17)	[−.22, .47]	.47
O'11 and CA'11	.13 (.17)	[−.21, .47]	.45	.13 (.17)	[−.22, .47]	.47
O'13 and CA'13	.13 (.17)	[−.21, .47]	.45	.13 (.17)	[−.22, .47]	.47
O'14 and CA'14	.13 (.17)	[−.21, .47]	.45	.13 (.17)	[−.22, .47]	.47
Cross-lagged paths						
O'08 → CA'09	.03 (.01)	[.01, .04]	<.001	.03 (.01)	[.01, .04]	<.001
O'09 → CA'11	.01 (.01)	[−.00, .03]	.10	.01 (.01)	[−.00, .03]	.11
O'11 → CA'13	.01 (.01)	[−.00, .03]	.10	.01 (.01)	[−.00, .03]	.11
O'13 → CA'14	.03 (.01)	[.01, .04]	<.001	.03 (.01)	[.01, .04]	<.001
CA'08 → O'09	.03 (.01)	[.01, .05]	.01	.03 (.01)	[.01, .06]	.01
CA'09 → O'11	.02 (.01)	[.00, .04]	.03	.02 (.01)	[.00, .04]	.05
CA'11 → O'13	.02 (.01)	[.00, .04]	.03	.02 (.01)	[.00, .04]	.05
CA'13 → O'14	.03 (.01)	[.01, .05]	.01	.03 (.01)	[.01, .06]	.01
Controlling for income						
Inc'09 → O'09	—	—		.02 (.01)	[−.16, .21]	.79
Inc'11 → O'11	—	—		.14 (.12)	[−.09, .37]	.23
Inc'13 → O'13	—	—		.03 (.12)	[−.21, .26]	.83
Inc'14 → O'14	—	—		.01 (.11)	[−.20, .22]	.89
Inc'09 → CA'09	—	—		.15 (.08)	[−.01, .31]	.05
Inc'11 → CA'11	—	—		.14 (.11)	[−.09, .36]	.23
Inc'13 → CA'13	—	—		.11 (.10)	[−.09, .31]	.29
Inc'14 → CA'14	—	—		.14 (.07)	[−.00, .24]	.05

Note. O = openness; CA = cultural activity; Inc = income.

was longitudinally associated with extraversion and conscientiousness, openness was the sole Big Five trait to demonstrate both cross-lagged associations and correlated change with cultural activity. In addition, the concurrent and longitudinal associations with cultural activity were stronger for openness than for any of the other Big Five traits. This evidence suggests that cultural activity is most strongly related to openness development across the life span.

Limitations and Future Directions

In this study, we used five waves of longitudinal survey data from a nationally representative of more than 7,000 Dutch participants who were followed over 7 years. This allowed us to establish the temporal and directional links between openness and cultural activity over time. However, the correlational nature of the data prevents us from making any causal conclusions. Furthermore, because our study was not genetically informative, we could not disentangle genetic and environmental effects on individual differences in openness development and cultural activity.

Another limitation of this study concerns the nature of our cultural activity measure, which precluded us from investigating how singular experiences (such as one additional visit to the opera) may lead to trait change. We could not examine cultural activity at the item level because the distribution of individual item scores was skewed and some items had low means. However, using a latent cultural activity variable conferred some advantages: it allowed us to examine a latent construct composed of the common variance between items, and it reduced random measurement error. Future work that disentangles which particular cultural activities are associated with change in openness may provide further insight into the mechanisms that may be behind culture-openness transactions.

Finally, although we propose that exploration may be a key mechanism underlying culture-openness transactions, we could not

test which specific mechanism is responsible for change in this study because we were reliant on yearly panel data. To better isolate the mechanism behind culture-openness transactions, or behind any experience's effect on personality, researchers must gather behavioral data as well as in vivo data of thoughts and feelings centered precisely around the experience (e.g., using experience sampling designs or measurement burst designs; Wrzus & Roberts, 2016). Additional insight into underlying mechanisms can be gained by comparing the effects of different types of cultural activity on personality change. For example, making one's own music may be more strongly tied to openness change than passively attending concerts, and such a finding would suggest that one's level of involvement plays a role in culture-openness transactions.

In the last decade, the taxonomy of experiences associated with Big Five trait change has been delineated considerably (Bleidorn et al., 2016). However, the understanding of openness development still lags behind the understanding of the development of other Big Five traits. Indeed, there is no prevailing theory that explains openness development across the life span. Future work is needed to explain development in the last (but not least) of the Big Five traits. One avenue for further research is the impact of other exploratory experiences on openness. One category of experiences that may be particularly exploratory are non-normative events. For example, attending college in one's late teens is a normative event that has not been shown to affect openness (Lüdtke et al., 2011). However, attending college in midlife be an especially intellectually stimulating and novel experience that has a strong effect on openness. Additionally, future research on openness should examine development at the facet level whenever possible. Within the Big Five domains, the facets of openness are the least related to each other (Soto & John, 2016). It is possible that research into facet-level development will uncover differential longitudinal associations for different openness facets. Such differences would have theoretical implications for the structure and development of personality across the life span. For example, change in some cultural activities (e.g., attending film houses) may be more related to the aesthetics facet of openness, whereas change in others (e.g., visiting museums) may be more related to the intellect facet.

Conclusion

Although the personality trait of openness is associated with physical and mental health and well-being (Gregory et al., 2010; Ozer & Benet-Martinez, 2006; Stephan, 2009; Turiano et al., 2012), past research has not presented a clear picture of how openness develops across the life span, nor of the nature and conditions of openness change. In this study, we found that openness remains stable in emerging adulthood, declines across midlife, and declines precipitously in old age. In each of these life stages, there were significant individual differences in openness development, some of which were explained by culture-openness transactions. We believe that increases in cultural activity may catalyze personality change and/or signal that a person is changing in exploratory behavior; these explorers may be especially likely to change in their openness trait in the future. To develop theories of openness change and personality interventions that can improve life outcomes, more research is needed to better understand when, why, and how experiences affect openness development across the life span.

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