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Editor's Choice

Original Research Report

Trajectories of Personality Traits Preceding Dementia Diagnosis

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Abstract

Background: Several retrospective studies using informant report have shown that individuals with dementia demonstrate considerable personality change. Two prospective studies, also using informant report, have shown that individuals who develop dementia show some personality changes prior to diagnosis. The current study is the first to assess personality trait change prior to dementia diagnosis using self-report measures from longitudinal data.

Method: This study used data from the Swedish OCTO-Twin Study, a longitudinal panel of 702 twins aged 80 and older. Analysis was restricted to 86 individuals who completed the Eysenck Personality Inventory and received a dementia diagnosis during follow-up occasions. Latent growth curve analyses were used to examine trajectories of extraversion and neuroticism preceding dementia diagnosis.

Results: Controlling for sex, age, education, depressive symptoms, and the interaction between age and education, growth curve analyses revealed a linear increase in neuroticism and stability in extraversion. Individuals who were eventually diagnosed with dementia showed a significant increase in neuroticism preceding diagnosis of dementia.

Discussion: Personality change, specifically an increase in neuroticism, may be an early indicator of dementia. Identification of early indicators of dementia may facilitate development of screening assessments and aid in early care strategies and planning.

Keywords: Dementia—Extraversion—Longitudinal—Neuroticism—Older adults—Personality change

Personality trait levels were originally thought to be quite stable across the life span (Costa & McCrae, 1988). However, more recent research provides evidence for individual change and variation in personality across the life span (Allemand, Zimprich, & Hertzog, 2007; Berg & Johansson, 2014; Mroczek & Spiro, 2003; Small, Hertzog, Hultsch, & Dixon, 2003). Although the research examining personality in healthy older adults suggests some degree of individual variation in change, several studies indicate a consistent pattern of more substantial personality change in individuals who have been diagnosed with dementia.

The majority of research examining personality changes that are associated with dementia relies mainly on retrospective research based on informant report of current (postdiagnosis) personality and of personality 5 to 10 years prior to dementia onset (temporal range varies between studies). The findings from this research suggest that patients with dementia demonstrate substantial personality change, including increases in neuroticism (Dawson,

Welsh-Bohmer, & Siegler, 2000), decreases in extraversion (Dawson, Welsh-Bohmer, & Siegler, 2000; Rankin et al., 2003; Torrente et al., 2014) and decreases in conscientiousness (Dawson et al., 2000; Torrente et al., 2014) relative to premorbid personality traits. Furthermore, although Lykou and associates (2013) did not examine the timing of personality change, their research found a similar pattern of personality change for individuals with mild cognitive impairment and patients with Alzheimer's disease (AD), suggesting that personality change may occur as early as the mild cognitive impairment disease stage.

A small number of studies (Balsis, Carpenter, & Storandt, 2005; Smith-Gamble et al., 2002) have also examined the timing of informant-reported personality change using a prospective research design to examine within-person change. Findings from these studies suggest that personality may change prior to measureable cognitive decline. Smith-Gamble and associates (2002) used data from the Indianapolis Ibadan Dementia Project, which recruited cognitively healthy participants (N = 3,021) aged 65 years or older. The study investigated personality change and dementia in two culturally and socioeconomically different samples: African American participants living in Indiana, United States (n = 937), and Yoruba participants living in Ibadan, Nigeria (n = 2,084). Trained medical clinicians assessed participants for dementia using the Clinical Dementia Rating (CDR) scale (Morris, 1993) at two occasions. A family member informant completed an assessment evaluating personality change, based on six questions from the Cambridge Examination for Mental Disorders of the Elderly (CAMDEX; Roth et al., 1986), such as "Have you noticed any change in his/her personality?" Personality change was operationalized as an affirmative answer to any item, whereas no personality change was operationalized as a negative response to every item. Only participants who did not receive a dementia diagnosis at the first testing occasion were included in analyses. Although there were some differences in baseline measurements between the two population-based samples, analyses revealed that, for both samples, individuals with informant-rated personality change at baseline were approximately two times more likely to be diagnosed with dementia at the follow-up occasion 2 years later suggesting that informant-rated personality change is a significant predictor of dementia.

Similarly to Smith-Gamble and associates, Balsis and colleagues (2005) recruited cognitively healthy individuals (N = 108) between 1979 and 2001 to examine the timing of personality change in people with neurological deterioration. Participants were assessed annually for presence and severity of dementia using the CDR scale (Morris, 1993). Participants who received a clinical diagnosis of dementia during follow-up assessment were defined as receiving a score of 0.5 or greater out of 3 on the CDR scale and included participants with very mild symptoms (n = 68). Several participants who were not diagnosed while alive received a neuropathological diagnosis of AD at autopsy (n = 14). The remaining participants did not receive a clinical or neuropathological dementia diagnosis at death (n = 26). At each annual assessment, the family informant of each participant completed eight items from the Blessed Dementia Scale (Blessed, Tomlinson, & Roth, 1968) to measure specific personality change. Informant reports regarding the individuals who received a clinical diagnosis indicated substantial personality changes prior to dementia diagnosis, including increased rigidity, growing apathy, increased egocentricity, and impaired emotional control. Informant reports also indicated similar personality changes in the individuals who received a neuropathological dementia diagnosis at death. The individuals who did not receive a dementia diagnosis, in contrast, were seen as having relatively little change in personality. Balsis and colleagues (2005) showed, therefore, that observable personality changes may occur prior to measurable cognitive loss, in particular because the dementia group was defined as any individual who showed even very mild symptoms on the CDR scale.

To summarize, the majority of research examining personality change and dementia has been retrospective, using informant report post diagnosis. Two prospective studies measuring personality change prior to dementia also used informant report. Although informant report is reliable (Busch, Balsis, Morey, & Oltmanns, 2015) and also ideal for retrospective assessment of personality for people with dementia, prospectively measured self-report of personality prior to dementia diagnosis would enhance the literature in this area. Furthermore, the measures of personality change in the prospective studies did not distinguish trait change; using a self-report personality trait assessment such as the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964) or the NEO Personality Inventory (NEO PI-R; Costa & McCrae, 1992) may provide more comprehensive information regarding specific personality trait change preceding dementia diagnosis.

The research by Balsis and associates and Smith-Gamble and associates was innovative in providing novel information regarding the timing of personality change in individuals who are eventually diagnosed with dementia. However, a limitation of both studies is use of analyses that compare only whether individuals who were diagnosed with dementia were more likely to have shown personality change at a previous occasion. A review of the literature examining personality change in normal aging suggests that examining trajectories of personality traits using latent growth curve modeling may be the most effective statistical approach for investigation of within-person personality trait change (Berg & Johansson, 2014; Mroczek & Spiro, 2003; Small et al., 2003). Examination of trajectories of personality traits prior to diagnosis in a similar approach to the research examining personality in normal aging may provide valuable information for clinicians and family members of individuals with a possible dementia outcome because identification of a consistent pattern of personality

trait change in individuals who are eventually diagnosed with dementia may facilitate early dementia care strategies and planning. To our knowledge, no research has examined trajectories of personality change preceding dementia diagnosis using trait-based self-report measures of personality. Therefore, the current research includes investigation of the following research question: "Does a consistent pattern of personality trait change precede dementia diagnosis?"

The current research builds on the previous prospective research (Balsis et al., 2005; Smith-Gamble et al., 2002), introducing new analytic techniques and measurement of personality. The analytic strategy used in previous research to examine personality change in normal aging (Berg & Johansson, 2014; Mroczek & Spiro, 2003; Small et al., 2003) informs the data analytic approach applied in the current empirical investigation of personality change preceding dementia diagnosis. The prospective and retrospective research examining the association between personality change and dementia (Balsis et al., 2005; Dawson & Welsh, 1994; Dawson et al., 2000; Lykou et al., 2013; Rankin et al., 2003; Smith-Gamble et al., 2002; Torrente et al., 2014), as well as research examining the neurological basis of personality (Bjørnebekk et al., 2013; Jackson, Balota, & Head, 2011; Knutson, Momenan, Rawlings, Fong, & Hommer, 2001; Wright, Feczko, Dickerson, & Williams, 2007; Xu & Potenza, 2012), informs the rudimentary theoretical explanation for why personality may change prior to diagnosis. Specifically, dementia neuropathology develops for years prior to dementia diagnosis, which requires identification of substantial cognitive decline. Because personality is a result of neurology, dementia neuropathology also impacts personality, and therefore a change in personality may occur preceding diagnosis. Previous research also informs the hypotheses for the current research: (i) that an increase in neuroticism precedes dementia and (ii) that a decrease in extraversion precedes dementia. Latent growth curve analyses were run to examine change in personality trajectories preceding diagnosis of dementia. Additionally, in order to provide further context for the significance of changes occurring in individuals diagnosed with dementia, secondary analyses examined trajectories of personality traits in older adults who were not diagnosed with dementia.

Method

Sample

Data from the longitudinal study Origins of Variance in the Old-Old (OCTO-Twin study) (McClearn et al., 1997) were used. The OCTO-Twin study consists of 351 dizygotic and monozygotic twin pairs (702 individuals) aged 80 years and older. Originally, 737 twin pairs meeting study criteria were identified; response rate, besides individuals who did not respond due to death, was 65%. Baseline interviews began in 1991, with measurement occurring every 2 years thereafter for four additional occasions. Personality was measured at the first four occasions.

The OCTO-Twin study included a clinical conference in which a multidisciplinary team diagnosed individuals with dementia according to the criteria of the DSM-III-R (American Psychiatric Association, 1987) based on a review of medical records, in-person testing protocols, and an informant interview regarding memory and cognitive problems (Pedersen, Gatz, Berg, & Johansson, 2004). Only individuals who were cognitively healthy at baseline, were diagnosed with dementia at a follow-up occasion, and completed and returned personality assessments (n = 86) were included in the analyses investigating personality change prior to dementia diagnosis. Due to individuals only completing self-report assessments when they were cognitively healthy, the subsample of individuals with personality data at the fourth occasion is very limited; therefore, analyses only include data from the first three waves of measurement. Our secondary analyses examined trajectories of personality in individuals who were never diagnosed with dementia and completed and returned personality assessments (n = 367). For consistency, these analyses also only include data from the first three waves of measurement.

Procedure

Licensed nurses interviewed participants in their homes biennially. Testing sessions lasted approximately 3.5 hours. Participants were asked to complete and mail the personality inventories after the testing sessions.

Measures

Outcome Variable: Personality

The EPI (Eysenck & Eysenck, 1964) measures extraversion and neuroticism. Individual variation exists in each personality dimension. High extraversion is characterized by positive affect, optimism, and sociability, whereas low extraversion is characterized by introspection and shyness (Eysenck & Eysenck, 1964). High neuroticism is characterized by emotional instability and anxiety, whereas low neuroticism is characterized by emotional stability and calmness (Eysenck & Eysenck, 1964).

The OCTO-Twin study uses a shortened, 19-item, version of the EPI (Floderus-Myrhed, Pedersen, & Rasmuson, 1980), which has been used in several Nordic twin studies (Rose, Koskenvuo, Kaprio, Sarna, & Langinvainio, 1988). Good reliabilities have been reported for the shortened EPI (Read, Vogler, Pedersen, & Johansson, 2006). Furthermore, reliability estimates for the entire sample and the subsample of individuals included in the current analyses are similar for both extraversion (Cronbach's α: entire sample = .62; subsample= .63) and neuroticism (Cronbach's α: entire sample = .74; subsample= .75).

The extraversion scale includes nine items with questions such as "Do you like a lot of activity around you?" and "Do you like to joke and tell funny stories to your friends?" The neuroticism scale includes 10 items with

questions such as "Are you often anxious and feel that you want something but you don't know what?" and "Are you extra sensitive in certain situations?" Consistent with previous research, one item from the neuroticism scale regarding sleep was excluded from the analysis because sleep may be unduly affected by age changes irrelevant to personality. Response alternatives are dichotomous (yes = 1; no = 0) and negatively worded items are reverse-coded prior to scoring. Scores on each scale can range from 0 to 9, with higher scores indicating a higher degree of that personality trait.

Covariates: Education

Education is measured in years. In Sweden, in the early 1900s, 6 years of education was mandatory, and individuals commonly stopped school after 6 years.

Depressive Symptoms

Depressive symptoms measured at the first occasion were included as a covariate in the current analyses. Assessment at baseline was used to minimize missingness due to attrition; within our subsample, many participants did not complete the assessment of depressive symptoms at the third occasion (n = 30). Controlling for depression is important because individuals with dementia may have higher levels of depressive symptoms (Devanand et al., 1996; Nussbaum, 1997), and neuroticism has also been associated with depressive symptoms (Kendler, Neale, Kessler, Heath, & Eaves, 1993).

Depressive symptoms are measured using the self-report Center for Epidemiologic Studies Depressive Scale (CES-D; Radloff, 1977), which was translated to Swedish. The scale includes 20 items rated on a 4-point scale ranging from 0 (*rarely or none of the time*) to 3 (*most or all of the time*). Participants are asked about the frequency of experiences during the past week. Four items are reverse coded prior to summing scores. Total scores range from 0 to 60, with higher scores indicating more depressive symptoms. Good reliabilities have been reported for the OCTO-Twin data set (Cronbach's α = .87–.90; Haynie et al., 2001).

Data Analysis

The focus of our main analyses was investigation of trajectories of personality in individuals eventually diagnosed with dementia. Individual trajectories of change for extraversion and neuroticism were estimated using latent growth curve models in Mplus version 7.1 (Muthén & Muthén, 2013). In order to examine the preclinical onset of cognitive decline, we aligned individuals at the occasion of dementia diagnosis and examined the trajectories of personality traits preceding diagnosis. Therefore, time was specified as "time-to-dementia," with the occasion in which individuals were diagnosed with dementia specified as Time 0 (i.e., the intercept).

Sex was included as a dichotomous variable, with male as the reference group. Age and education were centered at the sample mean (age = 83 years; education = 7 years). Depressive symptoms were centered at zero. Because the analysis is of a maximum of three waves of data per person, we focused on linear trajectories. An α level of .05 was used for all statistical tests.

Secondary analyses investigated individual trajectories of change in personality for individuals never diagnosed with dementia. Because these individuals do not have a dementia diagnosis, time was specified as "time-in-study," where the intercept was specified at study entry (i.e., Wave 1). The same sets of covariates that were used in the "time-to-dementia" models were also included in these models.

Results

For the present analyses, the OCTO-Twin sample included a majority of female participants who were 83 years old on average at the first assessment and had an average of 7 years of education. Demographic information is presented in Table 1.

Univariate Latent Growth Curve Modeling

We fitted univariate growth curve models for personality traits extraversion and neuroticism with and without covariates. The parameter estimates and standard errors

Table 1. Demographic Information of OCTO-Twin Participants

	Individuals diagnosed with dementia	Individuals never diagnosed with dementia
Sample	(n = 86)	(n = 367)
Variable	*M* (*SD*)	*M* (*SD*)
Age at first interview	82.97 (2.56)	83.09 (2.87)
Years of education	6.98 (2.00)	7.38 (2.55)
Time-to-dementia	4.25 (2.68)	—
CES-D	8.71 (7.45)	8.37 (8.14)
Extraversion		
Time 1	4.95 (2.14)	4.88 (2.12)
Time 2	5.02 (2.16)	4.89 (2.11)
Time 3	5.71 (1.71)	4.71 (2.10)
Neuroticism		
Time 1	2.31 (2.21)	2.45 (2.23)
Time 2	2.29 (1.95)	2.30 (2.14)
Time 3	1.76 (1.84)	2.15 (2.10)
	n (%)	*n* (%)
Sex		
Female	55 (63.95%)	135 (63.2%)
Male	31 (36.05%)	232 (36.8%)

Note: CES-D1 = symptoms of depression at Time 1; time-to-dementia = time in years to dementia diagnosis at Time 1.

for the linear models of personality traits preceding dementia diagnosis are presented in Table 2. Results are reported for the model with sex, age, education, depressive symptoms at the first occasion, and the interaction between age and education as covariates of the intercept (centered at time of diagnosis). All covariates were initially included in the model as covariates of the intercept and slope, but were trimmed for follow-up analyses due to the small sample size. This process eliminated the interaction between age and education as well as depressive symptoms to facilitate model interpretation, resulting in inclusion of only sex, age, and education as covariates of the slope. It is important to keep in mind that although the main analyses are based on time-to-dementia, Table 1 reports the mean level of extraversion and neuroticism at each wave. Although the mean level of neuroticism appears to be decreasing over time for the subsample of individuals diagnosed with dementia, this is likely due to individuals closer to diagnosis at study entry already being on an increasing trajectory of neuroticism. Indeed, analyses revealed that individuals higher in neuroticism at Wave 1 are diagnosed at earlier occasions, so their higher values are no longer reflected in the later wave means. There was no association between baseline extraversion and time of diagnosis.

For extraversion (Table 2), neither the unconditional nor the conditional models produced significant mean or variance estimates for linear slopes, indicating that extraversion does not appear to change prior to diagnosis. For neuroticism (Table 2), both the unconditional and conditional models revealed significant mean linear slope estimates ($p < .05$). The results suggest that at the point of diagnosis, the expected average neuroticism score for an 83-year-old man with 7 years of education was 2.0 and it had been increasing by a quarter of a point per year between study entry and diagnosis. It is relevant to note that the slope variance for neuroticism was nonsignificant, suggesting relative consistency of neuroticism increases across individuals.

The covariates for all time-to-dementia models were nonsignificant, except in the linear trajectory model for neuroticism, where depressive symptoms were a significant predictor of the neuroticism intercept. These results suggest that, on average, individuals who endorse more depressive symptoms (at the first occasion) endorse higher levels of neuroticism (at the time of diagnosis) than individuals with lower levels of depressive symptoms (at the first occasion).

Results from the secondary analyses revealed that individuals who have never been diagnosed with dementia did not change over time in either extraversion or neuroticism. Though the unconditional model showed a significant linear decline in extraversion, this effect was no longer significant after adjusting for the set of covariates in the conditional model (Table 3).

Table 2. Parameter Estimates (*SE*) From Growth Curve Models for Time-to-Dementia Metric, With Baseline Age and Education Centered at Sample Mean for Individuals With Dementia

Personality trait	Extraversion		Neuroticism	
Parameter	Unconditional linear	Conditional linear	Unconditional linear	Conditional linear
	ß (*SE*)	ß (*SE*)	ß (*SE*)	ß (*SE*)
Fixed effects				
Intercept	4.616 (0.309)**	5.666 (0.646)**	3.246 (0.428)**	1.970 (0.657)*
Female		−0.722 (0.712)		−0.011 (0.748)
CES-D1		−0.061 (0.037)		0.137 (0.023)**
Age		0.113 (0.162)		−0.239 (0.152)
Education		0.211 (0.365)		−0.404 (0.253)
Age × Education		−0.008 (0.148)		0.016 (0.076)
Time	−0.081 (0.061)	−0.016 (0.102)	0.235 (0.071)**	0.233 (0.100)*
Female		−0.090 (0.133)		−0.040 (0.123)
Age		0.024 (0.045)		−0.050 (0.031)
Education		−0.009 (0.876)		−0.054 (0.032)
Variance components and fit indices				
Intercept	3.987 (1.616)*	3.461 (1.704)*	6.904 (2.181)*	4.388 (1.745)*
Slope	0.030 (0.064)	0.012 (0.058)	0.057 (0.050)	0.034 (0.035)
Cov (IS)	0.174 (0.283)	0.134 (0.279)	0.620 (0.331)	0.381 (0.236)
Residual	1.032 (0.282)**	1.119 (0.202)**	0.942 (0.147)**	0.662 (0.168)**
AIC	613.248	594.597	590.390	526.809
BIC	628.180	628.794	605.185	560.673

Notes: AIC = Akaike information criterion; BIC = Bayesian information criterion; CES-D1 = symptoms of depression at Time 1; Cov (IS) = covariance (intercept-slope).
*$p < .05$. **$p \leq .001$.

Table 3. Parameter Estimates (*SE*) From Growth Curve Models for Time-in-Study Metric, With Baseline Age and Education Centered at Sample Mean for Individuals Never Diagnosed With Dementia

Personality trait	Extraversion		Neuroticism	
Parameter	Unconditional linear	Conditional linear	Unconditional linear	Conditional linear
	ß (*SE*)	ß (*SE*)	ß (*SE*)	ß (*SE*)
Fixed effects				
Intercept	4.849 (0.107)**	5.597 (0.196)**	2.484 (0.145)**	1.096 (0.238)**
Female		−0.345 (0.217)		0.538 (0.223)*
CES-D1		−0.060 (0.014)**		0.120 (0.012)**
Age		−0.005 (0.036)		−0.011 (0.037)
Education		−0.039 (0.045)		0.027 (0.047)
Age × Education		−0.009 (0.017)		−0.011 (0.015)
Time	−0.066 (0.030)*	−0.068 (0.048)	−0.013 (0.034)	0.017 (0.056)
Female		−0.025 (0.062)		
Age		−0.021 (0.014)		
Education		−0.006 (0.011)		
Variance components and fit indices				
Intercept	3.036 (0.392)*	2.698 (0.367)*	3.503 (0.454)**	2.454 (0.329)**
Slope	0.018 (0.025)	0.006 (0.027)	0.014 (0.023)	0.016 (0.024)
Cov (IS)	−0.061 (0.081)	−0.014 (0.079)	−0.083 (0.094)	−0.071 (0.078)
Residual	1.450 (0.141)**	1.485 (0.149)**	1.510 (0.510)**	1.515 (0.110)**
AIC	3,312.871	3,208.429	3,344.617	3,162.423
BIC	3,336.683	3,263.406	3,368.414	3,217.363

Notes: AIC = Akaike information criterion; BIC = Bayesian information criterion; CES-D1 = symptoms of depression at Time 1 Cov (IS) = covariance (intercept-slope). *$p < .05$. **$p \leq .001$.

Discussion

The primary aim of the current study was to examine whether change in personality traits precede dementia diagnosis. Using latent growth curve modeling, we identified a consistent longitudinal pattern of personality change prior to diagnosis of dementia according to the DSM-III-R (American Psychiatric Association, 1987). Supporting our first hypothesis, the analyses indicate that individuals from the OCTO-Twin data set show a significant increase in self-report measures of neuroticism preceding dementia diagnosis. These findings are particularly noteworthy in the context of our secondary analyses, which examined personality traits over time in individuals who were not diagnosed with dementia. The results revealed personality stability for these individuals, suggesting that trajectories of personality are markedly different for a general sample of individuals compared with a subgroup of individuals who were cognitively healthy at baseline and received a dementia diagnosis at a later testing occasion.

Our results do not support our second hypothesis that extraversion decreases preceding dementia diagnosis. This hypothesis was based on retrospective research that found decreases in extraversion in individuals who currently have dementia (Dawson et al., 2003; Rankin, Kramer, Mychack, & Miller, 2003; Torrente et al., 2014). This lack of agreement with previous research could be due to a variety of reasons, most notably due to the timing of personality measurement in previous research. For example, the brain regions responsible for extraversion may not be implicated until the later stages of dementia. Because our focus is change in personality traits prior to dementia diagnosis, changes in extraversion may not yet be measurable. Beyond neurology, behaviors or beliefs about oneself that are associated with extraversion may be less specific to the changes experienced by individuals who are in the process of dementia progression than behaviors and beliefs associated with neuroticism. Namely, the items on the extraversion scale may be less sensitive to the types of changes experienced by individuals who are later diagnosed with dementia than the items on the neuroticism scale.

A further possibility for not finding a decrease in extraversion could be due to the consistent use of informant report personality assessment in the previous research; caregivers of people with dementia have higher rates of depression and anxiety compared with the general population (Nicholas et al., 2009), which may lead to caregivers providing more pessimistic recollections than informants who are not caregivers. As such, the caregiver situation may contribute to variability between informant report versus self-report; namely, informant caregivers may either perceive their loved ones to be more introverted than the individuals perceive themselves to be, or perceive their loved ones to have been more extraverted prior to diagnosis.

In the case of individuals who are eventually diagnosed with dementia, a concern arises regarding accuracy of

self-report in the earliest stages of dementia. To our knowledge, no research has specifically examined self-awareness of personality preceding dementia diagnosis; however, Rankin, Baldwin, Pace-Savitsky, Kramer, and Miller (2005) investigated self-awareness of personality in individuals currently diagnosed with dementia, examining individuals with frontotemporal dementia (n = 12), individuals with AD (n = 10), and older adults controls (n = 11). Their findings indicated significant differences in self-awareness between the groups with different types of dementia. Individuals with frontotemporal dementia showed the greatest error in self-assessment of personality, whereas individuals with AD showed mostly accurate self-awareness in all personality dimensions. However, Rankin and associates showed that the postmorbid self-report assessment from both groups of individuals with dementia more closely matched their premorbid rather than current personality (which showed postmorbid changes), suggesting that these individuals may be unable to update their self-image after measureable cognitive decline. These findings suggest that if the individuals in the current study were already impacted by the disease, the analyses would have likely revealed no change in personality, inconsistent with the current findings.

Baseline depressive symptoms, assessed by the CES-D (Radloff, 1977), were the only significant predictor of neuroticism, and only of level, not rate of change. Depressive symptoms were included based on previous reports of an association between dementia and depressive symptoms (Butters et al., 2008; Byers & Yaffe, 2011; Halperin & Korczyn, 2007; Korczyn & Halperin, 2009; Richard et al., 2013; van den Kommer et al., 2013) and previous conceptualizations and research examining the connection between neuroticism and depressive symptoms or major depression (McCrae & Costa, 1990; Eysenck, 1990; Eysenck & Eysenck, 1987; Kendler et al., 1993).

Our findings are consistent with expectations based on neurological research that finds an association between heightened levels of neuroticism and diminished brain volume (Bjørnebekk et al., 2013; Jackson et al., 2011; Knutson et al., 2001; Wright et al., 2007; Xu & Potenza, 2012). However, this prior brain volume research mainly examines between-person differences, so could not clearly identify whether neuroticism has a moderating effect on age-related decline, or whether changes in brain structure result in personality changes. Indeed, Jackson and associates (2011) found that neuroticism was associated with greater increases in intracranial fluid, suggesting that individuals who were originally more neurotic tended to experience more brain degeneration since maximum lifetime brain volume. Although this provides a glimpse into within-person differences, the findings of Jackson and associates (2011) are inconsistent with similar research by Knutson and associates (2001), who reported that levels of neuroticism were not associated with greater decreases in brain-ratio volume. However, this could be due to the relatively homogeneous sample recruited by Knutson and associates, which included individuals with relatively low scores on the neuroticism scale.

Dementia has been distinguished by concentration of brain lesions (Debette & Markus, 2010), diminished neuroreactivity (Rombouts et al., 2009), or decreased brain volume in gray and white matter (Jagust et al., 2008). The neurological characteristics of dementia, in combination with the neurological characteristics of high levels of neuroticism, provide a theoretical background for why personality change, specifically an increase in neuroticism, may be associated with neurodegeneration. Our understanding of personality change, neurology, and dementia would benefit from future research that extends Jackson and associates (2011) by directly measuring personality and brain volume at repeated occasions. Specifically, an investigation may include longitudinal examination of levels of neuroticism and intracranial fluid in an older adult population, paying particular attention to the individuals who eventually convert to dementia. Although our findings hint at this notion, such an investigation may allow researchers to empirically identify whether there is a negative relationship between trajectories of neuroticism and trajectories of brain volume; specifically, whether increases in neuroticism consistently align with decreases in brain volume.

Going beyond the research presented to establish a rationale for why personality change may occur prior to dementia diagnosis, Paul Baltes' (1987) theoretical view of life-span development and aging may provide further support for an explanation of personality change preceding measureable cognitive decline. He proposed that all human development involves both gains and losses, with more losses, and consequently more resources invested and required to minimize losses, occurring in later life. This theory of developmental regulation, called selective optimization with compensation (SOC), is important for successful aging and development and can be automatic or planned; specifically, older adults select by restricting domains and goals, compensate for increasing deficiencies, and optimize by successfully implementing selection and compensation.

Applying the SOC theory to personality change preceding dementia diagnosis could potentially account for measurable personality changes in the early stages of disease onset. For instance, older adults may start to experience cognitive changes in daily life and recognize that changes in cognition may be indicative of impending cognitive decline. Consequently, these individuals may start to engage in an intentional process of compensating for increasing cognitive deficiencies; however, they may not think to deliberately compensate for personality changes. For example, these individuals may start keeping more detailed reminders of scheduled appointments, engaging in habitual routines such as keeping medication in a daily pill container or ensuring that car keys are always put in the same place when returning home, or even practicing the questions that are expected to be asked during administration of the Mini-Mental State Examination (MMSE). In terms of the

informant interview (which was included in the procedure for identifying dementia diagnosis), if an individual had noticed cognitive changes and started adhering to the concepts of SOC, a family informant may not yet have noticed their loved ones' cognitive losses. Likewise, as suggested, an individual in the very early stages of dementia may be able to optimize their performance on the MMSE by preparing to be mentally alert or rehearsing prior to an interview. Accordingly, probable or definite dementia may not be identified until more advanced progression of the disease, whereas self-reported personality may be a more revealing indication of dementia progression.

As far as we know, our research is the first to longitudinally examine preclinical personality change, using self-report measures of personality, in individuals eventually diagnosed with dementia. However, there are some limitations. Our research only included analysis of two traits, extraversion and neuroticism. A more fine-grained measure of personality that captures more detail and is more sensitive to variation, such as the NEO-PI, may broaden the understanding of personality change as an indicator of dementia; perhaps other personality traits also change preceding dementia diagnosis.

The OCTO-Twin data set consists of individuals who were 80 years or older at baseline, leading to considerable missing data, though death accounts for approximately 90% of the attrition. Furthermore, OCTO-Twin is unique because individuals with dementia diagnosis at the first occasion were included in the sample. Personality data were not collected for these individuals; however, because we were only interested in personality change prediagnosis, the data would not have been included in the current analyses. Although the sample size used in the current research is considerably diminished compared with the total individuals in the original data set, the sample is larger than the majority of the previous research examining personality change in individuals with dementia. Future research examining longitudinal data with a more comprehensive self-report measure of personality at more occasions would advance the understanding of personality change preceding dementia diagnosis.

Our study contributes novel empirical findings that provide further understanding of the trajectories of change in personality and emphasize the importance of including repeated measures of personality in longitudinal research. The current analyses suggest that personality change, specifically an increase in neuroticism, may be an early indicator of dementia. Identification of the early signs of dementia can aid in early treatment strategies and planning of dementia care services and facilitate development of screening assessments. Most importantly, although there is not yet a cure for dementia, there is mounting evidence suggesting that progression to dementia may be slowed by adherence to a healthy lifestyle. Therefore, the sooner that dementia can be identified, the sooner individuals can be educated and hopefully motivated to commit to a healthier lifestyle.

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References

Allemand, M., Zimprich, D., & Hertzog, C. (2007). Cross-sectional age differences and longitudinal age changes of personality in middle adulthood and old age. *Journal of Personality*, **75**, 323–358. doi:10.1111/j.1467-6494.2006.00441.x

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed.). Washington, DC: American Psychiatric Association.

Balsis, S., Carpenter, B. D., & Storandt, M. (2005). Personality change precedes clinical diagnosis of dementia of the Alzheimer Type. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **60**, 98–101. doi:10.1093/geronb/60.2.P98

Baltes, P. B. (1987). Theoretical propositions of life-span developmental psychology: On the dynamics between growth and decline. *Developmental Psychology*, **23**, 611.

Berg, A. I., & Johansson, B. (2014). Personality change in the oldest-old: Is it a matter of compromised health and functioning? *Journal of Personality*, **82**, 25–31. doi:10.1111/jopy.12030

Bjørnebekk, A., Fjell, A. M., Walhovd, K. B., Grydeland, H., Torgersen, S., & Westlye, L. T. (2013). Neuronal correlates of the five factor model (FFM) of human personality: Multimodal imaging in a large healthy sample. *Neuroimage*, **65**, 194–208. doi:10.1016/j.neuroimage.2012.10.009

Blessed, G., Tomlinson, B. E., & Roth, M. (1968). The association between quantitative measures of dementia and of senile change in the cerebral grey matter of elderly subjects. *British Journal of Psychiatry*, **114**, 797–811. doi:10.1192/bjp.114.512.797

Busch, A. J., Balsis, S., Morey, L. C., & Oltmanns, T. F. (2015). Gender differences in borderline personality disorder features in an epidemiological sample of adults age 55–64: Self versus informant report. *Journal of Personality Disorders*, 1–14, doi:10.1521/pedi_2015_29_202

Butters, M. A., Young, J. B., Lopez, O., Aizenstein, H. J., Mulsant, B. H., Reynolds, C. F., III, … Becker, J. T. (2008). Pathways linking late-life depression to persistent cognitive impairment and dementia. *Dialogues in Clinical Neuroscience*, **10**, 345–357.

Byers, A. L., & Yaffe, K. (2011). Depression and risk of developing dementia. *Nature Reviews Neurology*, **7**, 323–331. doi:10.1038/nrneurol.2011.60

Costa, P. T., & McCrae, R. R. (1988). Personality in adulthood: A six-year longitudinal study of self-reports and spouse ratings on the NEO Personality Inventory. *Journal of Personality and Social Psychology*, **54**, 853–863. doi:10.1037/0022-3514.54.5.853

Costa, P. T., & McCrae, R. R. (1992). *Neo Pi-R. The Revised NEO Personality Inventory*. Odessa FL: Psychological Assessment Resources.

Dawson, D. V., Welsh-Bohmer, K. A., & Siegler, I. C. (2000). Premorbid personality predicts level of rated personality change in patients with Alzheimer disease. *Alzheimer Disease and Associated Disorders*, **14**, 11–19.

Debette, S., & Markus, H. S. (2010). The clinical importance of white matter hyperintensities on brain magnetic resonance imaging: Systematic review and meta-analysis. *British Medical Journal*, 341–350. doi:10.1136/bmj.c3666

Devanand, D. P., Sano, M., Tang, M. X., Taylor, S., Gurland, B. J., Wilder, D., Stern, Y., & Mayeux, R. (1996). Depressed mood and the incidence of Alzheimer's disease in the elderly living in the community. *Archives of General Psychiatry*, **53**, 175–182. doi:10.1001/archpsyc.1996.01830020093011

Eysenck, H. J. (1990). *Biological dimensions of personality research*. New York, NY: Guilford.

Eysenck, H. J., & Eysenck, S. G. G. (1964). *Manual of the Eysenck Personality Inventory*. London: University of London Press.

Eysenck, H. J., & Eysenck, M. W. (1987). *Personality and individual differences*. New York, NY: Plenum.

Floderus-Myrhed, B., Pedersen, N., & Rasmuson, I. (1980). Assessment of heritability for personality, based on a short-form of the Eysenck Personality Inventory: A study of 12,898 twin pairs. *Behavior Genetics*, **10**, 153–162.

Halperin, I., & Korczyn, A. D. (2007). Late-life depression as a risk factor for dementia. *Future Neurology*, **2**, 201–208, doi:10.2217/14796708.2.2.201

Haynie, D. A., Berg, S., Johansson, B., Gatz, M., & Zarit, S. H. (2001). Symptoms of Depression in the Oldest Old A Longitudinal Study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **56**, 111–118. doi:10.1093/geronb/56.2.P111

Jackson, J., Balota, D. A., & Head, D. (2011). Exploring the relationship between personality and regional brain volume in healthy aging. *Neurobiology of Aging*, **32**, 2162–2171. doi:10.1016/j.neurobiolaging.2009.12.009

Jagust, W. J., Zheng, L., Harvey, D. J., Mack, W. J., Vinters, H. V., Weiner, M. W., … Chui, H. C. (2008). Neuropathological basis of magnetic resonance images in aging and dementia. *Annals of Neurology*, **63**, 72–80, doi:10.1002/ana.21296

Kendler, K. S., Neale, M. C., Kessler, R. C., Heath, A. C., & Eaves, L. J. (1993). A longitudinal twin study of personality and major depression in women. *Archives of General Psychiatry*, **50**, 853–862. doi:10.1001/archpsyc.1993.01820230023002.

Knutson, B., Momenan, R., Rawlings, R. R., Fong, G. W., & Hommer, D. (2001). Negative association of neuroticism with brain volume ratio in healthy humans. *Biological Psychiatry*, **50**, 685–690. doi:10.1016/S0006-3223(01)01220-3

Korczyn, A. D., & Halperin, I. (2009). Depression and dementia. *Journal of the Neurological Sciences*, **283**, 139–142. doi:10.1016/j.jns.2009.02.346

Lykou, E., Rankin, K. P., Chatziantoniou, L., Boulas, C., Papatriantafyllou, O., Tsaousis, I., … Papatriantafyllou, J. D. (2013). Big 5 personality changes in Greek bvFTD, AD, and MCI patients. *Alzheimer Disease and Associated Disorders*, **27**, 258–264. doi:10.1097/WAD.0b013e31826e5504

McCrae, R. M., & Costa, P. T. (1990). *Personality in adulthood*. New York, NY: Guilford.

McClearn, G. E., Johansson, B., Berg, S., Pedersen, N. L., Ahern, F., Petrill, S. A., & Plomin, S. (1997). Substantial genetic influence on cognitive abilities in twins 80 or more years old. *Science*, **276**, 1560–1563. doi:10.1126/science.276.5318.1560

Morris, J. C. (1993). The Clinical Dementia Rating (CDR): Current version and scoring rules. *Neurology*, **43**, 2412–2414.

Mroczek, D. K., & Spiro, A. (2003). Modeling intraindividual change in personality traits: Findings from the normative aging study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **58**, 153–165. doi:10.1093/geronb/58.3.P153

Muthén, L. K., & Muthén, B. O. (2013). *Mplus user's guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.

Nicholas, H., Moran, P., Foy, C., Brown, R. G., Lovestone, S., Bryant, S., & Boothby, H. (2009). Are abnormal premorbid personality traits associated with Alzheimer`s Disease?—A care-control study. *International Journal of Geriatric Psychiatry*, **25**, 345–351. doi:10.1002/gps.2345

Nussbaum, P. D. (1997). Late life depression: A neuropsychological perspective. In P.D. Nussbaum (Ed.). *Handbook of neuropsychology and aging: Critical issues in neuropsychology* (pp. 260–270). New York, NY: Plenum.

Pedersen, N. L., Gatz, M., Berg, S., & Johansson, B. (2004). How heritable is Alzheimer's disease late in life? Findings from Swedish twins. *Annals of Neurology*, **55**, 180–185. doi:10.1002/ana.10999

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, **1**, 385–401, doi:10.1177/014662167700100306

Rankin, K. P., Kramer, J. H., Mychack, P., & Miller, B. L. (2003). Double dissociation of social functioning in frontotemporal dementia. *Neurology*, **60**, 266–271, doi:10.1212/01.WNL.0000041497.07694.D2

Rankin, K. P., Baldwin, E., Pace-Savitsky, C., Kramer, J. H., & Miller, B. L. (2005). Self awareness and personality change in dementia. *Journal of Neurology, Neurosurgery, and Psychiatry*, **76**, 632–639. doi:10.1136/jnnp.2004.042879

Read, S., Vogler, G. P., Pedersen, N. L., & Johansson, B. (2006). Stability and change in genetic and environmental components of personality in old age. *Personality and Individual Differences*, **40**, 1637–1647. doi:10.1016/j.paid.2006.01.004

Richard, E., Reitz, C., Honig, L. H., Schupf, N., Tang, M. X., Manly, J. J., … Luchsinger, J. A. (2013). Late-life depression, mild cognitive impairment, and dementia. *JAMA Neurology*, **70**, 383–389. doi:10.1001/jamaneurol.2013.603

Rombouts, S. A., Damoiseaux, J. S., Goekoop, R., Barkhof, F., Scheltens, P., Smith, S. M., & Beckmann, C. F. (2009). Model-free group analysis shows altered BOLD FMRI networks in dementia. *Human Brain Mapping*, **30**, 256–266. doi:10.1002/hbm.20505

Rose, R. J., Koskenvuo, M., Kaprio, J., Sarna, S., & Langinvainio, H. (1988). Shared genes, shared experiences, and similarity of personality: Data from 14,288 adult Finnish co-twins. *Journal of Personality and Social Psychology*, **54**, 161–171. doi:10.1037/0022-3514.54.1.161

Roth, M., Tym, E., Mountjoy, C. Q., Huppert, F. A., Hendrie, H., Verma, S., & Goddard, R. (1986). CAMDEX: A standardised

instrument for the diagnosis of mental disorder in the elderly with special reference to the early detection of dementia. *The British Journal of Psychiatry*, **149**, 698–709. doi:10.1192/bjp.149.6.698

Small, B. J., Hertzog, C., Hultsch, D. F., & Dixon, R. A., (2003). Stability and change in adult personality over 6 years: Findings from the Victoria Longitudinal Study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **58**, 166–176. doi:10.1093/geronb/58.3.P166

Smith-Gamble, V., Baiyewu, O., Perkins, A. J., Gureje, O., Hall, K. S., Ogunniyi, A., & Hendrie, H. C. (2002). Informant reports of changes in personality predict dementia in a population-based study of elderly African Americans and Yoruba. *The American Journal of Geriatric Psychiatry*, **10**, 724–732. doi:10.1097/00019442-200211000-00011

Torrente, F., Pose, M., Gleichgerrcht, E., Torralva, T., López, P., Cetkovich-Bakmas, M., & Manes, F. (2014). Personality changes in dementia: Are they disease specific and universal? *Alzheimer Disease and Associated Disorders*, **28**, 261–268. doi:10.1097/WAD.0000000000000030

van den Kommer, T. N., Comijs, H. C., Aartsen, M. J., Huisman, M., Deeg, D. J., & Beekman, A. T. (2013). Depression and cognition: How do they interrelate in old age? *The American Journal of Geriatric Psychiatry*, **21**, 398–410, doi:10.1016/j.jagp.2012.12.015

Wright, C. I., Feczko, E., Dickerson, B., & Williams, D. (2007). Neuroanatomical correlates of personality in the elderly. *Neuroimage*, **35**, 263–272. doi:10.1016/j.neuroimage.2006.11.039

Xu, J., & Potenza, M. N. (2012). White matter integrity and five-factor personality measures in healthy adults. *Neuroimage*, **59**, 800–807. doi:10.1016/j.neuroimage.2011.07.040