Trajectories of Personality Preceding Dementia Diagnosis: A Coordinated Analysis

by

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B.A., University of Victoria, 2013

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Supervisory Committee

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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 (Balsis et al, 2005; Smith-Gamble et al 2001). The current study is the first to examine trajectories of personality traits using self-report personality assessment prior to dementia diagnosis.

Methods: This study used data from individuals diagnosed with dementia during the course of two longitudinal studies of older adults (Total $N = 254$). Latent growth curve modelling was used to examine rates of change in each personality trait preceding dementia diagnosis.

Results: Controlling for sex, age, education, the interaction between age and education, and depressive symptoms, growth curve analyses revealed a linear increase in self-reported neuroticism for both datasets. Individuals who converted to dementia showed a significant increase in neuroticism preceding diagnosis of dementia.

Conclusions: Personality change, specifically an increase in neuroticism, may be an early indicator of dementia. Identification of a consistent longitudinal pattern of personality change may facilitate development of screening assessments, and aid in early care strategies and planning.

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Trajectories of Change in Personality Traits and Cognition: A Coordinated Analysis

Introduction

Although some personality change occurs in older adulthood, considerable personality changes may be indicative of underlying neurological disease (Blakemore, 1967; Lautenschlager & Forstl, 2007). Research examining personality change in abnormal aging, in particular in older adults with dementia, consistently documents an association between substantial within-person personality change and dementia (Balsis et al, 2005; Siegler, Dawson & Welsh, 1994; Dawson et al, 2000; Lykou et al, 2014; Mahoney et al, 2011; Rankin et al, 2003; Siegler, Dawson & Welsh, 1994; Smith-Gamble et al 2001; Torrente et al, 2014). This research relies mainly on a retrospective research design however, which is subject to recall bias (Hassan, 2005), and uses informant-report based measures of personality, which may be subject to inaccurate accounts and bias (Balsis et al, 2005). Although the retrospective research has not specified when personality change occurs in people with dementia, two prospective studies (Balsis et al, 2005; Smith-Gamble et al, 2001) found personality change preceding dementia diagnosis. However, these studies also use informant report measures of personality change, specifically six questions from the Cambridge Examination for Mental Disorders (CAMDEX; Roth et al, 1986) and the Blessed Dementia Scale (Blessed, Tomlinson & Roth, 1968), both of which provide a very basic index of personality and of change. Additionally, these studies use a basic statistical approach to deciphering if an individual who shows personality change at a prior occasion is more likely to convert to dementia at a later occasion.

It appears that no study has examined within-person change, assessed by repeated assessment of personality, in relation to dementia using more sophisticated self-report assessment of personality and latent growth curve modelling to examine trajectories of

personality traits over time. Although informant report is an important and rich source of information, investigation of trajectories of personality traits using self-report measurement would enhance the literature in this area and provide novel understanding of the connection between change in personality and dementia.

The aim of this thesis is to empirically examine trajectories of personality using self-report assessment. If the current analyses identify a consistent and specific pattern of personality change preceding dementia diagnosis, that pattern of change in personality may be an early indicator of dementia. 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, for example, by an association between physical exercise and dementia or cognitive decline (see Hamer & Chida, 2008; Lindwall et al, 2012). Beyond this association, there is additional evidence indicating that cognitive integrity can be improved by taking part in physical exercise. For example, a meta-analysis examining 30 randomized controlled trials assessing physical exercise in older adults with dementia found that exercise training increases cognitive function (Heyn, Abreu & Ottenbacher, 2004). Therefore, the sooner that dementia can be identified, the sooner an individual can be educated and hopefully motivated to commit to a healthier lifestyle. Additionally, identification of the early signs of dementia can aid in early treatment strategies, facilitate development of screening assessments, and also assist families in planning of dementia care services.

In order to provide contextual information for the current empirical investigation, this thesis includes a brief history of conceptualizations of personality types, personality traits, and the measurements available to investigate personality. Additionally, this section includes a brief explanation of secondary analysis, which provides further support for the selection of personality

assessments included in the current empirical investigation. Second, this thesis includes a section that reviews the research investigating personality trait change in normal aging in order to contrast personality change that typically occurs in older adulthood with the substantial personality change that occurs for individuals with dementia. The statistical approach used to examine personality change in normal aging provides rationale for the analytic approach of the current research. Third, a review of research that has examined the neurological basis of personality, personality disorders and abnormal behaviour is included. Forth, a brief review of the neurological basis of dementia is included. These sections inform the main hypothesis of the current research, and provide further understanding for why personality change occurs in conjunction with dementia, or, possibly, preceding dementia diagnosis. Fifth, this thesis includes a brief section outlining aging related change, personality trait levels, and health outcomes. This section provides information about the lack of research examining personality longitudinally. Sixth, a comprehensive review of the retrospective and prospective research examining personality change and dementia will be provided. This review establishes what has and has not been examined in previous research, providing rationale for the current empirical investigation and informing the proposed hypotheses. Finally, this thesis reports the results a novel secondary analysis examining trajectories of personality trait change preceding dementia diagnosis using latent growth curve modelling in two samples of older adults.

1.1 Conceptualizations of Personality Types and Personality Traits

Personality psychologists have conceptualized and defined personality in various ways, aiming to predict and explain human behaviour and thought (Carducci, 2009). For centuries, scientists have tried to establish categories of personality types (Drapela, 1987). A history of

these different conceptualizations demonstrates the advances in theories and empirical research that have been made over the years (Carducci, 2009).

The notion of a taxonomy of personality types dates back to the Greek physician Hippocrates (born approximately 460 BC). His temperament theory postulated that moods, behaviours and emotions were caused by a surplus or shortage of four types of body fluids, called "humors" (Kagan, 1994). The Roman physician, Galen (born 129 AD), extended this theory by categorizing four types of individuals based on excess or lack of humors: sanguine individuals as optimistic and energetic; melancholic individuals as being prone to depression; choleric individuals as irritable and hot-tempered; phlegmatic individuals as apathetic (Eysenck & Eysenck, 1987). Although the concepts postulated by Hippocrates and Galen were broad, imprecise, and not substantiated with empirical evidence to meet the standards for modern theories, these conceptions founded the groundwork for more recent conceptualizations of personality types and traits. For example, in 1936, Allport extended personality type theory by emphasizing the uniqueness of individuals, suggesting that individuals could be characterized by a combination of 18000 potential traits, which he attempted to identify and catalogue (Dumont, 2010). Following creation of this list of traits, many scientists attempted to reduce the number of traits to more general categories. Cattell (1943) used factor analysis to systematically identify sixteen personality dimensions. Attempts to replicate Cattell's work resulted in Fiske (1949), Tupes (1957), and Tupes and Christal (1961) finding only five factors of personality. Further research by Norman (1963), Borgatta (1964), and Smith (1967) also resulted in five similar factors of personality. Thus, several independent researchers concluded that personality could effectively be described by five constructs. Although these factors have been labelled differently

depending on the researcher, the most commonly used labels are extraversion, neuroticism, contentiousness, agreeableness, and openness (Costa and McCrae, 1990).

Costa and McCrae (1990) maintain that individual variation exists in level of each personality trait, meaning that an individual is classified on a spectrum of each personality trait, which they define as the following: High extraversion is characterized by positive affect, optimism, and sociability, while low extraversion is characterized by introspection and shyness. High neuroticism is characterized by emotional instability, melancholy, and anxiety, while low neuroticism is characterized by emotional stability and calmness. High conscientiousness is characterized by personal organization, self-discipline, and striving, while low conscientiousness is characterized by lack of persistence and lack of consideration prior to acting or speaking. High agreeableness is characterized by compliance, trust and altruism, while low agreeableness is characterized by tough mindedness and distrust. High openness is characterized by curiosity and active pursuit and appreciation of experiences, while low openness is characterized by reservation and caution. Although most personality traits are not conceptually associated with psychopathology, personality trait neuroticism is the exception because depression, anxiety, and self-reproach (Costa & McCrae, 1990) are sub-facets of neuroticism. For example, previous conceptualizations have theorized (Costa & McCrae, 1990; Eysenck, 1990; Eysenck & Eysenck, 1987) and empirical research has found (Jackson, 1986; Kendler et al, 1993; see Ownby et al, 2006) a connection between levels of neuroticism and depressive symptoms or major depression.

Eysenck also used factor analysis to investigate the structure of personality. Eysenck's theory of personality is based in biology, emphasizing an underlying causal mechanism as the foundation for the expression of certain levels of personality traits (Eysenck, 1990). Although his general conceptualization of personality is consistent with Costa and McCrae's argument for

individual variation in level of each personality trait, Eysenck identified only three basic traits: extraversion, neuroticism, and psychoticism (1968). Although he identified psychoticism as a basic trait, he believed that personality could be mainly characterized by two major dimensions of personality (Carducci, 2009). He theorized that personality can be assessed according to four axes comprised of two bipolar scales: introversion-extraversion and emotional stability-neuroticism (Dumont, 2010). Relating back to Hippocrates and Galen's theory of temperament, Eysenck's personality axes align with the four temperamental categories (melancholic, sanguine, choleric, and phlegmatic) (Dumont, 2010; Eysenck, 1967; Ruch, 1992).

This brief introduction presents only a limited background on the contributions of a small selection of psychologists who have impacted personality theory over the years. However, these conceptualizations of personality provide a foundation for the subsequent research. With several different conceptualizations of personality, there are several measurements available to assess personality. The empirical investigation of personality traits in this thesis includes secondary analysis of previously collected data. A secondary analysis, which is the re-analysis of data that has been previously collected to address novel research questions, is a good way to conduct research because of the lengthy process of collecting original data (Dunn, 2010). However, a limitation of secondary analyses is the inability to control which variables are collected in datasets. Due to the existing variables that were collected in the datasets available for the present research, this thesis will focus on Eysenck's two major personality dimensions, with supplemented information from Costa and McCrae's Five Factor Model of personality.

1.2 Do Personality Traits Change in Older Adulthood?

The question of personality stability or change across the lifespan is complicated and highly debated. Although some personality change seems to occur in older adulthood, substantial

changes in personality may indicate underlying neurological pathology (Blakemore, 1967; Lautenschlager & Forstl, 2007). Considerable personality change in relation to cognitive decline is the focus of this thesis; however, prior to a review of pathological personality change, a brief history of the debate regarding personality change or stability in normal aging, as well as a brief review of available methodology for examining personality change, will be provided to present context and rationale for the current empirical investigation.

In the 1980's, Costa and McCrae put forward the hypothesis that personality is fully developed by age 30, and is relatively stable for the remainder of the lifespan. This hypothesis was based on their review of the accumulated personality research over the prior forty years. Their review of developmental personality theories proposed by psychologists such as Freud, Erikson, Levinson, and Neugarten, revealed several opposing theories; however, it led them to argue for a pattern of personality stability across the lifespan, particularly into older adulthood (1980). Costa and McCrae first examined the cross-sectional research to investigate personality trait age trends, concluding that there is evidence for small decreases in extraversion, increases in agreeableness, and stability in neuroticism, conscientiousness and openness (1980). Their discussion of longitudinal personality research, which was quite limited particularly before the 1980's, confirmed evidence of personality stability across the lifespan (1980). This discussion was mainly based on their own research using data from the Normative Aging Study (Costa & McCrae, 1978), which included administration of Cattell's 16 Personality Factor Questionnaire (Cattell, 1970) to approximately 140 men at two occasions in 1965 and 1975. Their findings suggested that for the average participant, the majority of scales showed no difference between testing occasions; however, social independence, which is a facet of extraversion, significantly increased (1980). This apparent change in personality seemed to concern Costa and McCrae, but

further scrutiny of cross sectional and longitudinal research that had investigated the personality facet of social independence led them to attribute this finding to chance (1980).

Although Costa and McCrae put forward evidence from the mid 1900's to suggest that personality remains mostly stable in older adulthood, several other researchers dispute this claim. Roberts and Mroczek (2008) suggest that personality research initiated in 1994 caused psychologists to reassess the assumption that personality traits remain stable into older adulthood. Most importantly, they maintain the value of using multiple indices to track change; specifically, they suggest investigation of personality to focus on both mean-level changes, which reveal changes in traits at the population level, and individual differences in change, which reveal deviations from the mean-level patterns. Roberts and Mroczek's review (2008) of personality change in normal aging predominantly finds empirical evidence to suggest personality change in young adulthood, but also continued change into older adulthood. Although this research has predominantly relied on longitudinal research designs, one more recent cross-sectional study also found significant age-related differences in personality. The rest of this section reviews one cross-sectional and three longitudinal studies examining personality change across the lifespan to provide evidence opposing Costa and McCrae's hypothesis of personality stability. This brief review is by no means exhaustive, but provides a rationale for the analytic strategy undertaken for the current empirical study.

Srivastava and colleagues (2003) administered The Big Five Inventory (BFI) to a large sample (N = 132 515) of self-selected participants aged 21-60 years from North America to investigate how mean levels of personality traits differ by age and gender. Participants were recruited by internet based convenience sampling. Based on the hypothesis that personality is relatively stable after age 30 (Costa and McCrae, 1988), Srivastava and associates calculated

age-based slopes for each of the five personality traits using two theoretically important age ranges: participants less than 30 years old and more than 30 years old. Personality stability was operationalized as the dispersion of scores on each personality dimension preceding and following age 30, calculated as slopes by regressing each of the five personality traits on age to determine how much each trait score increased or decreased per year of age. Taking advantage of the continuous age distribution of the participants in the sample, they concluded that (i) conscientiousness and agreeableness increased through the age range, with the biggest change occurring in the 20s and the 30s respectively, (ii) openness shows small declines with age, and (iii) neuroticism and extraversion declined with age for women, but not as much for men.

Overall, Srivastava and colleagues found a general lack of support for Costa and McCrae's hypothesis of personality stability after age 30. However, because their study used a cross-sectional design, their findings could be attributed to cohort differences. Additionally, the method of sampling that Srivastava and colleagues (2003) utilized is not ideal. Although convenience sampling is the easiest sampling approach, findings derived from this type of sampling are neither entirely generalizable nor representative, and often do not include underrepresented sociodemographic subgroups. The latter issue is a cause for concern: convenience sampling may contribute to inconsistent results due to reduced variability of homogeneous samples (Bornstein, Jager & Putnick, 2013). The idea that sampling can have a very large effect on research findings highlights the importance of random sampling methods. Although most researchers are unable to execute unbiased random sampling, self-selected web-based samples are particularly not representative of the general population. Differential sampling by age is a potential source of confound for internet based recruitment. For example, older internet users are likely a distinct subset of older people; consequently, the age effects reported

by Srivastava and colleagues may be a result of the participants who were likely to end up in their study, rather than true age effects. Thus, generalizations based on the findings from Srivastava and associates may be questionable. The results from the following three longitudinal studies provide more compelling evidence that personality traits can indeed change to some degree in older adulthood.

Small and associates (2003) assessed stability and change in personality measured every three years over six years to develop cross-sectional and longitudinal confirmatory factor models for the NEO-PI. Two samples were recruited, the first sample (N = 474, age range = 55 – 85 years) was tested at baseline, as well as 3 and 6 years later. The second sample (N = 507, age range = 55 – 92 years) was recruited to replicate the cross-sectional findings derived from Sample 1. Personality change was operationalized as latent change based on individual changes in the Big Five personality traits over six years. Confirmatory factor analysis was used to investigate stability of individuals over time, and the stability of factor structure of personality trait factor structure over time. Findings suggested individual differences in change for all five factors across the six year period. Additionally, findings revealed stability in factor structure of personality traits over time. Accompanying cross-sectional analyses replicated previous work by Costa and McCrae (1988). The between-person stability coefficients found by Small and associates were similar to those previously reported by Costa and McCrae, but Small and colleagues went further by examining longitudinal latent change in individual trajectories over time. They discuss that high coefficients are often approached as implying "little or no reliable individual differences in personality change." They go on to explain that this is not the case, namely that despite the high stability coefficients, personality traits returned significant variances in latent change factors; indeed suggesting individual differences in personality change. Small

and colleagues were the first researchers to directly test factor-based individual differences in longitudinal changes in personality. Consistent with Small's research, Mroczek and Spiro (2003) and Berg and Johansson (2013) applied similar approaches by modeling individual change in personality traits using latent growth curve analyses, also finding variability and change in personality trajectories.

Mroczek and Spiro (2003) examined intra-individual differences in stability and change in trajectories of personality traits extraversion and neuroticism. Their analyses used data from the Normative Aging Study, which included data from over 1600 men (initially aged 43 – 91 years) who were followed for 12 years. Unlike Costa and McCrae who concluded longitudinal personality stability based on the same data (1978), Mroczek and Spiro's growth curve analyses revealed significant intra-individual change. Neuroticism was best defined by quadratic decline with age, while extraversion was best defined by a linear decline with age. Further analyses revealed that several variables, including birth cohort, marriage, death of spouse and memory complaints, were significant predictors of variability in level and rate of personality trait change. These findings suggest that although some individuals remain stable, others change to varying degrees, and this variability can be partially accounted for by age-graded and contextual variables.

Berg and Johansson (2013) also investigated intra-individual differences in trajectories of personality traits extraversion and neuroticism in Swedish twins 80 – 98 years old at baseline. Models were fitted for all individuals who completed the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964) at the first occasion (N = 408). Results revealed an age-related linear decrease in extraversion and stability in neuroticism, suggesting that individuals are constant in their level of neuroticism and become less extraverted as they age.

As noted in this section, the debate on personality stability or change may depend on methodology, for example, whether relying on cross sectional versus longitudinal research designs. Cross-sectional designs involve collecting information from one or more groups of individuals to present data of a samples' opinion or state at a point in time (Dunn, 2010). The researchers using cross-sectional designs to examine personality change investigate the association between personality change and chronological age. Cross sectional research emphasizes between-person differences rather than within-person changes; therefore, age-dependent outcomes may be the result of average population age differences, such as cohort differences, instead of individual rates of aging (Hofer & Sliwinski, 2006). Conversely, longitudinal research designs, which include repeated measurement, are better suited for investigation of individual development over time (Baltes, Reese & Nesselroade, 1977; Caspi & Roberts, 2001; Wohwill, 2013). Although longitudinal models more effectively within-person changes, some limitations should be considered. Repeated exposure to assessment instruments and response shift, which is longitudinal bias due to plausible change in measurement calibration, are among the challenges associated with longitudinal research (Bontempo, Grouzet & Hofer, 2011).

Examining the methodology applied to investigate personality change, the requirement for clarity regarding what is meant by personality development becomes apparent. Are we interested in population development or individual development, or, in research design terms, between-person (i.e. cohort) development or within-person development? If the interest is in population development, we should look to research applying cross-sectional designs. Cross-sectional research suggests associations between age and personality trait levels; that is, there may be some mean-level differences in levels of neuroticism, extraversion, and openness (Costa

et al, 1986; Srivastava et al, 2003) across generations or history. If, however, the focus is on the individual and within person change, we should look to research applying longitudinal designs that examine individual trajectories of change.

In summary, research initiated in 2003 has established that there is some degree of individual variation and change in personality traits across the lifespan (Small et al, 2003; Mroczek & Spiro, 2003); nevertheless, Costa and McCrae's research is still highly influential and continues to instigate debate on personality stability or change across the lifespan. In addition, consideration of the methodology applied to investigate personality change is an important factor in deciphering the complexities of personality change or stability. Since the focus of this thesis is within-person rates of change in personality, a longitudinal research design is most suitable for the empirical investigation of personality trait change preceding dementia diagnosis.

The following section will review the literature examining the neurological basis of personality and personality disorders or disturbance, to provide further understanding of why personality change may occur in conjunction with, or prior to, dementia diagnosis.

1.3 A Biological Basis for Personality

Historically, psychologists tended to either take a summary view, in which personality traits are considered descriptive, or a causal view, in which personality traits are based on a neurological causal mechanism (John & Robins, 1993). However, many researchers adhering to the Five-Factor model did not take either view, instead opting to acknowledge that although there is likely a biological basis for personality, understanding of the biology is unnecessary for investigation of personality traits (John & Robins, 1993; Costa & McCrae, 1990). Eysenck suggested the possibility that the extraversion personality dimension may be accounted for by

individual differences in levels of activity in the corticoreticular loop; specifically, introverts may have higher activity than extraverts, with this persistent cortical arousal possibly accounting for a preference for less stimulating environments (Eysenck, 1967). Similarly, the neuroticism personality dimension could possibly be accounted for by individual differences in levels of activity in the visceral brain, which is also known as the emotional brain or limbic circuit, consisting of the hippocampus, amygdala, cingulum, septum, and hypothalamus (Eysenck, 1967). Specifically, Eysenck (1967) postulated that individuals high in neuroticism may have higher levels of visceral brain activation, accounting for emotional instability. Jeffrey Gray extended Eysenck's theory, connecting personality dimensions with much more specific neural structures (1970). Gray suggested that neural structures, such as the ascending reticular activating system, the medial-septal nuclei, the hippocampus, and the orbital-frontal association cortex, may mediate anticipation of negative events, which can account for the underlying mechanism of Eysenck's introversion-extraversion dimension (Gray, 1970).

Eysenck's theory is based not only on theoretical conceptualizations, but also on experimental research. For example, Eysenck examined individuals high in extraversion or introversion, finding that extraverts raise their levels of arousal by moving around in sensory deprivation studies whereas introverts tend to stay still (Eysenck & Eysenck, 1987), and that extraverts and introverts demonstrate better conditioning under different circumstances (Eysenck, 1967). However, this research only postulates neural networks by investigating behaviour, rather than investigating neural activity or structures directly.

More recent research extends the theory of a neurological basis of personality using more sophisticated technology, such as brain imagining. Prior to reviewing this literature, there are two concepts that are important to keep in mind. Firstly, this research mainly examines between-

person, cross-sectional differences. Secondly, when considering neurological regions, it is important to recognize the interconnectivity of the brain. In Damasio's (2000) commentary on a neural basis for sociopathy, he briefly reviews the research examining the connection between specific lesions in the prefrontal lobe and inappropriate social behaviour. He suggests that any interpretation of the contribution of specific brain regions to personality must be understood in context of the multicomponent nature of the brain; that is, the brain is a multifaceted system, and any neural region is connected to other neural regions (Damasio, 2000). This more recent research has mainly tried to uncover individual differences in brain regions, while still acknowledging the connections between neural regions, examining individuals high or low in certain personality traits. For example, Knutson and associates (2001) completed brain scans using a Magnetic Resonance Imaging Scanner on healthy volunteers aged 19 to 45 years (N = 86). Participants also completed the NEO- Personality Inventory Revised (Costa & McCrae, 1992). Their analyses revealed that for both male and female participants, neuroticism was negatively associated with cerebrospinal fluid and brain ratio volume for both gray or white matter; that is, individuals with higher levels of neuroticism had significantly reduced brain volume. Further analyses examining the facets of neuroticism revealed a significant association between reduced brain volume and neurotic facets anxiety and self-consciousness, but not for neurotic facets angry hostility, depression, impulsiveness and vulnerability to stress. The researchers (Knutson et al, 2001) also estimated the maximal lifetime brain volume by measuring the intracranial volume of the skull to infer reduction since peak brain volume. Their analyses revealed that brain ratio measures were not dependent on intracranial volume, suggesting that the association between neuroticism and brain ratio develops in middle and late adulthood, after the brain has already reached maximum volume. However, they suggest that this finding may not be

generalizable. Specifically, there may be an association between high levels of neuroticism and reductions in maximum intracranial volume (suggesting that the maximum brain volume is diminished from onset due to high levels of neuroticism) that they were not able to detect due to the relatively homogeneous sample, which included mostly individuals who scored reasonably low in neuroticism and had not suffered psychological trauma. Knutson and associates' (2001) between-person research demonstrates that neuroticism is significantly associated with brain ratio volume, certainly providing further evidence to support a biological basis for personality. These findings are consistent with Jackson, Balota, and Head (2009), who also found that higher neuroticism was associated with decreased volume in the prefrontal and medial temporal brain regions. However, Jackson and associates (2009) extended Knutson and associates (2001) findings by examining brain volume decreases since peak brain volume using measurement of intracranial fluid. Jackson and colleagues found that higher neuroticism was associated with greater decreases in brain volume with increasing age, suggesting that individuals who are more neurotic may be more vulnerable to structural degeneration.

In a comprehensive empirical examination of personality and brain structures in healthy volunteers (N = 265), Bjørnebekk and colleagues (2012) examined personality traits, assessed by the NEO-PI-R (Costa & McCrae, 1992), and cortical thickness, surface area and subcortical volumes, assessed using a 1.5T Magnetic Resonance Imaging Scanner. Consistent with Knutson and colleagues (2001) and Jackson and colleagues (2009), Bjørnebekk and colleagues (2012) also found that neuroticism was the personality trait most clearly related to neurology, with high levels of neuroticism being significantly associated with diminished brain volume, decreased white matter microstructure, and lesser frontotemporal surface area. However, these reductions in brain volume were related to neuroticism facets anxiety, vulnerability to stress, and depression

(Bjørnebekk et al, 2012) in contrast to the relationship with anxiety and self-consciousness found by Knutson and associates (2001). Although a consistent relationship between the neuroticism facet of anxiety and decreased brain volume was found, the inconsistencies could be due to Knutson and associates investigating a smaller, perhaps more homogeneous sample, or due to Bjørnebekk and associates using advanced neuroimaging techniques. Either way, the finding that neuroticism is reliably related to a reduction in brain volume (Bjørnebekk et al, 2012; Jackson et al, 2009; Knutson et al, 2001; Wright et al, 2007; Xu & Potenza, 2011) is particularly important for the theoretical basis and main hypothesis of this research, which will be discussed in the following sections.

Extraversion has also been linked to neurology using magnetic resonance imaging techniques. For example, high extraversion has been associated with perfusion in the thalamus, basal ganglia, cerebellum, and inferior frontal gyrus (O'Gorman et al, 2006) and cortical thickness in the right superior frontal cortex and in the left middle frontal cortex (Wright et al, 2007). High extraversion has also been negatively associated with gray and white matter volume (Forsman et al, 2012). These findings suggest a relationship between high extraversion and neural integrity.

Another method of examining the neural or biological correlates of personality is to examine individuals who have suffered brain injury. Blakemore (1967) hypothesized that substantial changes to the central nervous system should result in behavioural and personality changes, which he then supported with a small body of empirical research, particularly research examining the association between brain injury and reaction time, and brain injury and vigilance. Importantly, he discusses the imprecision or generality of identifying brain damage in an individual; he notes that there is vast variability in behaviour and intellectual change as a result

of brain damage, which is dependent on the specific location of the injury. Moreover, he suggests that a noteworthy characteristic of brain injured individuals is substantial variability in behaviour compared to individuals who have not suffered brain injury.

Research examining the involvement of specific brain regions in abnormal behaviour, personality disorders, and personality dysfunction is also relevant for distinguishing a biological basis for personality. For example, Raine and associates (2000) examined the impact of damage to gray and white matter in the prefrontal cortex. Their review of the research prior to the year 2000 indicates a connection between deficient prefrontal functioning, assessed through brain imaging, and antisocial personality disorder in individuals from prisons, forensic settings, and psychiatric hospitals. They extended this research by examining brain functioning using structural magnetic resonance imaging for volumetric assessment of prefrontal white gray matter by controlling for psychosocial risk factors, such as substance abuse and psychiatric comorbidity. They recruited healthy controls (N = 34), controls with a lifetime of substance dependence (N = 27), and individuals from the community with antisocial personality disorder (N = 21). Their analyses revealed significant differences in brain functioning in individuals with antisocial personality disorder compared to the controls, specifically reduced prefrontal gray matter volume and less autonomic activity during a social stress condition. They conclude that the structural brain deficit in individuals with antisocial personality disorder may be an underlying mechanism that results in the characteristics of antisocial behaviour, such as diminished arousal and conscience, and deficient fear conditioning (Raine et al, 2000). Consistent with this, Barkataki and associates (2006) found that individuals with antisocial personality disorder (N = 13) have larger putamen volume, and smaller whole brain volume and temporal lobe volume compared to healthy controls (N = 15). The links between neural deficiencies or abnormalities and personality

deficiency or abnormality (Barkataki et al, 2006; Hazlett et al, 2005; Lyoo et al, 2004; Raine et al, 2000; Schulze et al, 2015; Yang et al, 2005) provide cross-sectional evidence for a biological basis for personality.

This non-exhaustive review indicates that individuals with abnormal behaviour, personality disorders, and personality dysfunction have measureable structural brain differences compared to healthy controls. In combination with the limited review of research examining the neural correlates of personality, this research, utilizing sophisticated neuroimaging techniques, provides robust evidence that there is indeed a biological, namely neurological, basis for personality. In particular, high levels of neuroticism have consistently been linked to diminished brain volume or reduced cortical thickness (Bjørnebekk et al, 2012; Jackson et al, 2009; Knutson et al, 2001; Wright et al, 2007; Xu & Potenza, 2011). This research has mainly examined cross-sectional between-person differences, so cannot clearly identify whether neuroticism has a moderating effect on age-related decline, or if changes in brain structure result in personality differences. The research examining intracranial fluid, which allows researchers to evaluate the amount of brain degeneration since maximum lifetime brain volume, provides a glimpse into within-person differences. This research reveals inconsistent findings, with Jackson et al (2009) reporting neuroticism being associated with greater decreases in brain-ratio volume compared to Knutson et al (2001) reporting that neuroticism was not associated with greater decreases in brain-ratio volume. However, as discussed, this could be due to the sample recruited by Knutson and associates having low scores on the neuroticism scale. Overall, this section presents evidence for a neurological basis of personality and provides a theoretical background for why personality change, specifically an increase in neuroticism, may be associated with neurodegeneration.

1.4 Neurology and Dementia

A further body of research has examined neurology of individuals who have been, or are eventually, diagnosed with dementia. Neurological changes characteristic of dementia develop progressively for several years prior to clinical manifestation or diagnosis of dementia (Iancono et al, 2008). For example, the brains of individuals with Alzheimer disease commonly include amyloid beta deposits, neuritic plaques, neurofibrillary tangles, neuropil threads, and degeneration of vulnerable neurons and synapses (Iancono et al, 2008). Therefore, a large body of research focuses on identification of neurological changes common to individuals with dementia. Due to the extensive research in this area and because the purpose of this section is to provide a brief background of the neuropathology involved in dementia, this section will focus primarily on findings from systematic reviews. Numerous researchers have examined immunological and pathological changes associated with different types of dementia. Findings from a systematic review suggest that immunological changes associated with frontotemporal lobar degeneration include 29 unique antibodies, including 10 of these reported several times in the literature (see Goosens et al, 2015). Findings from another systematic review suggest that changes associated with Alzheimer's disease include reduced cerebrospinal fluid levels of amyloid beta 42 compared to healthy controls (see Breno et al, 2008; see Mo et al, 2015), retinal nerve fibre thinning compared to healthy controls and individuals with mild cognitive impairment (see Thomson et al, 2015), and increased total and phosphorylated tau compared to healthy controls (see Breno et al, 2008).

Several post-mortem studies have examined individuals who were diagnosed with Alzheimer's disease prior to death using immunohistochemical staining to detect antigens in brain tissue. A systematic review suggests substantial amyloid beta accumulations in autopsy research as well as finding that blood brain barrier functioning interacts with amyloid beta

accumulations, accelerating neurodegeneration in Alzheimer's disease (see Burgmans et al, 2013). Additionally, dementia is associated with neuritic plaques (Savva et al, 2009; Wilcock & Esiri, 1982) and neurofibrillary tangles (Hurle et al, 2014).

In addition to examining dementia-related immunological characteristics and neuropathology, the literature includes investigation of brain regions that are implicated by pathology in individuals with dementia. In a systematic review, Debette and Markus (2010) found that cognitive decline (19 studies) and dementia (17 studies) are consistently associated with lesions in neural white matter, appearing as hyperintensities when assessed by magnetic resonance imaging. In addition to white matter lesions predicting cognitive decline and dementia, research has found decreased reactivity and atrophy in neural grey matter. For example, Rombouts and associates (2007) examined face encoding ability, assessed by functional magnetic resonance imaging, in individuals with Alzheimer's disease (N = 18), mild cognitive impairment (N = 28), and healthy controls (N = 41). Tensorial probabilistic modelling revealed that grey matter neural networks, such as the thalamus, motor cortex, caudate nucleus, putamen, hippocampus, cingulum, bilateral parietal cortex, parahippocampal gyrus and precuneus, show diminished reactivity in individuals with Alzheimer's disease and mild cognitive impairment (Rombouts et al, 2007). Likewise, Jagust and colleagues (2007) found cortical gray matter volume atrophy and diminished hippocampal volume associated with Alzheimer's disease (Jagust et al, 2007).

This very brief review of the literature examining pathology associated with dementia suggests that neuropathology develops in both white and grey matter of individuals with dementia, characterized by concentration of brain lesions, diminished neuro reactivity, or decreased brain volume. Notably, neuropathology develops for years prior to clinical

manifestation of dementia, suggesting that there may be alternative measureable symptoms prior to cognitive decline that may indicate progression to dementia.

1.5 Aging-related Changes and Personality

As discussed, the influence of Costa and McCrae's hypothesis of personality stability across the lifespan is demonstrated by many longitudinal studies having measured personality only once; several longitudinal studies include measurement of personality at baseline and not at follow up occasions, suggesting an assumption of personality as a time-invariant covariate. However, personality measurement at baseline occasion of longitudinal research studies has allowed researchers to investigate specific health outcomes associated with baseline levels of personality traits. Baseline personality trait levels have been associated with walking speed decline (Tolea et al, 2013), change in reaction time (Hagger-Johnson et al, 2012), change in gray matter volume (Taki et al, 2013), and change in motor function (Buchman et al, 2013).

Specific personality traits assessed at baseline have also been found to be associated with cognitive decline. A systematic review and meta-analysis examining personality trait levels and the risk of dementia (see Low, Harrison & Lackerteen, 2012) found a consistent pattern of results in longitudinal (N = 12) and case-control studies (N = 5) suggesting that higher levels of neuroticism are associated with greater risk of dementia and mild cognitive impairment. In contrast, higher levels of conscientiousness were consistently found to be protective against dementia and to reduce risk of mild cognitive impairment (Low, Harrison & Lackerteen, 2012). For example, Chapman and associates (2012) investigated the association between baseline personality trait levels and general cognitive decline, assessed by biannual repeated measurement of the Modified Mini-Mental State Examination over seven years, in individuals who were cognitively healthy at baseline (N = 602). Their results indicate that higher neuroticism at

baseline is associated with a greater rate of cognitive decline, while higher levels of conscientiousness at baseline are associated with a slower rate of cognitive decline (Chapman et al, 2012). More recently, Hock and associates (2014) examined originally healthy participants (*N* = 561), also finding that higher neuroticism at baseline is associated with greater cognitive decline, assessed by repeated measurement of the Mini-Mental State Examination, while higher conscientiousness is associated with increased cognitive functioning. While this research indicates that higher levels of neuroticism may be a risk factor for cognitive decline, this research does not investigate the pattern of trajectories of change in personality trait levels. Furthermore, although the research examining outcomes associated with baseline levels seem to suggest that particular personality trait levels may increase risk of or protection against certain health outcomes, baseline levels could also reflect changes that have already been initiated in these individuals.

In addition to investigating associations between baseline personality trait levels and various health outcomes, limited research studies have also examined personality change and health outcomes, specifically in older adults with dementia. As discussed, although longitudinal designs are the best way to investigate within-person change, the research examining personality change and dementia has typically relied on retrospective research designs. Retrospective research aims to investigate within-person change; however, measurement occasions occur simultaneously, that is, present and past assessments are made at the same time point, instead of in real time as is the case with true longitudinal research designs. The following section will review the retrospective research investigating personality and dementia, as well as two prospective studies investigating personality change prior to dementia.

1.6 Personality Change in Individuals with Dementia

Although the research examining personality in healthy older adults suggests some degree of individual variation in change, several studies indicate that more substantial personality change occurs in people who have been diagnosed with dementia. Most research examining changes that occur as a result of cognitive deterioration is retrospective using informant report of current (post-diagnosis) personality, and of personality five to ten years prior to dementia onset (temporal range varies between studies). Findings based on informant report suggest that patients with dementia demonstrate substantial personality change, including increases in neuroticism (Dawson, Welsh-Bohmer & Siegler, 2000; Williams, Briggs & Coleman, 1995), decreases in extraversion (Dawson, Welsh-Bohmer & Siegler, 2000; Rankin et al, 2003; Torrente et al, 2014; Williams, Briggs & Coleman, 1995) and decreases in conscientiousness (Dawson, Welsh-Bohmer & Siegler, 2000; Torrente et al, 2014; Williams, Briggs & Coleman, 1995) relative to premorbid personality traits. Although efficient in terms of time and resources (Euser et al, 2009), several limitations are associated with retrospective designs. Confounding and bias are more prevalent, and bias can jeopardize validity. For example, internal validity can be threatened due to recall bias (Hassan, 2005), which may be particularly salient due to the caregiver situation. Compared to the general population, caregivers of people with dementia have higher rates of depression and anxiety (Nicholas et al, 2009), which may lead to caregivers providing more pessimistic recollections.

Several retrospective studies have examined associations between types of dementia and specific changes in personality, finding that patients with Alzheimer's disease demonstrate increases in neuroticism (Lykou et al, 2014; Siegler, Dawson & Welsh, 1994; Torrente et al, 2014), as well as decreases in extraversion (Siegler, Dawson & Welsh, 1994; Torrente et al, 2014), openness (Siegler, Dawson & Welsh, 1994) and conscientiousness (Siegler, Dawson &

Welsh, 1994). Patients with frontotemporal dementia were found to demonstrate decreases in conscientiousness (Lykou et al, 2014; Mahoney et al, 2011; Torrente et al, 2014), agreeableness (Mahoney et al, 2011), openness (Mahoney et al, 2011; Torrente et al, 2014), and extraversion (Mahoney et al, 2011; Torrente et al, 2014). Torrente and associates (2014) argue for a pattern of generalized personality change after dementia onset, as opposed to disease-specific personality changes.

The goal of such research is to provide understanding of the underlying disease-specific neurological processes and the presentation of different types of dementia, potentially to use specific personality changes as clinical markers to assist in distinguishing type of dementia. Studies of disease-specific personality changes are difficult to compare due to examination of inconsistent types of dementia, inconsistent use of a control group, and inconsistent inclusion of personality traits. Additionally, the issue of small sample size is particularly salient in the research examining disease specific outcomes because each group only includes approximately 15 to 20 participants. Consequently, the uniqueness of the individuals in each group may be due to chance rather than disease. Small samples result in a greater possibility that the participants in each group are not representative of the general population.

Overall, although the patterns regarding disease-specific changes in personality are inconclusive, the retrospective research in this area consistently suggests that substantial personality change occurs in people who have been diagnosed with dementia. Although this research does not examine the timing of personality change, Lykou and associates (2013) found a similar pattern for patients with Mild Cognitive Impairment and patients with Alzheimer's disease, suggesting that personality change occurs as early as or prior to the Mild Cognitive Impairment disease stage.

In contrast to the retrospective research, Smith-Gamble and colleagues (2001) and Balsis and colleagues (2005) prospectively examined the timing of personality change in individuals who converted to dementia. Prospective research requires a substantially larger sample size than retrospective research to ensure that the outcome will be observed during follow-up waves. In this research area, older adults who are cognitively healthy are recruited to participate in a study. Particular attention is paid to the participants who change over time; for example, the individuals who are diagnosed with dementia at a follow-up occasion. In addition to examination of personality change, prospective research is able to capture different types of information, in this case, *when* personality change occurs in the disease process. Informant report was also used for both of these prospective studies, however, due to informants completing the personality measures in real time, the issue of recall bias may be diminished.

Smith-Gamble and associates (2001) used data from the Indianapolis Ibadan Dementia Project, which included participants (N = 3,021) age 65 years or older. The study investigated personality change and dementia in two culturally and socioeconomically different samples: African American participants living in Indiana, USA (N = 937), and Yoruba participants living in Ibadan, Nigeria (N = 2,084). Trained medical clinicians assessed participants for dementia using the Clinical Dementia Rating Scale (CDR; 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, while 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 chi-square analyses. There were

some differences in baseline measurements between the two population-based samples, such as concern for others and stubbornness, however, for both samples, individuals with personality change at baseline were approximately two times more likely to convert to dementia at the follow up occasion two years later. This research suggests 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. Participants were assessed annually for presence and severity of dementia using the Clinical Dementia Rating Scale (CDR; Morris, 1993). Participants who received a clinical diagnosis of dementia during follow-up assessment (N = 68) were labelled "converters," and had been followed for an average of 3.68 years preceding clinical dementia diagnosis. The converter group included individuals receiving a score of 0.5 or greater out of 3 on the Clinical Dementia Rating Scale, which suggests very mild symptoms. Participants who were not diagnosed while alive, but received a neuropathological diagnosis of Alzheimer's disease at autopsy (N = 14), were labelled "preclinical," and had been followed for an average of 7.97 years. The remaining participants, clinically and neuropathologically non-demented at death (N = 26), had been followed for an average of 4.12 years. At each assessment a family informant of each participant completed 8 items from the Blessed Dementia Scale (Blessed et al, 1968) to measure personality change. For example, the clinician listed specific changes such as "increased rigidity," and informants were asked if the change was present or absent. Analyses revealed that 47% of individuals showed at least some informant rated personality change prior to dementia diagnosis. According to informant report, both the converter and preclinical groups showed personality changes including increased rigidity, growing apathy, increased egocentricity, and impaired emotional control prior

to dementia diagnosis. The non-demented group, in contrast, showed relatively little change in personality.

Balsis and colleagues (2005) showed that observable personality changes may occur prior to measurable cognitive loss, in particular because the dementia converter group was defined as any individual who showed even very mild symptoms on the Clinical Dementia Rating. Their use of a prospective longitudinal design as opposed to a retrospective design facilitates the ability to better capture the timing of changes that occur with dementia onset.

To summarize this section, the majority of research examining personality change and dementia has been retrospective, using informant report measures of personality change post diagnosis. The two prospective studies measuring personality change prior to dementia also use informant report. Although informant report of personality for people with dementia is necessary for retrospective research, prospective research utilizing self-report measures of personality would enhance the literature in this area and provide novel understanding of the connection between trajectories of change in personality in individuals who are eventually diagnosed with dementia. For example, 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 that is indicative of dementia. Furthermore, the measures used to assess personality change in the two prospective studies included only basic questions that did not distinguish personality trait change. The six CAMDEX personality change items administered to informants by Smith-Gamble and associates (2001) and the eight Blessed Dementia Scale (Blessed et al, 1968) items administered by Balsis and associates (2005) measured informant

report of personality change, rather than directly assessing personality characteristics at multiple points in time.

A further limitation of both prospective studies is utilization of relatively simple analyses (chi square) to compare if individuals who later converted to dementia were more likely to show personality change at a previous occasion. The literature examining personality change in normal aging suggests that examining trajectories of personality traits using latent growth curve modelling 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 pathology in a similar way to the research examining personality in normal aging may provide valuable information for clinicians and family members of individuals with a possible dementia outcome. Identification of a consistent pattern of personality trait change in individuals who eventually convert to dementia may facilitate early dementia care strategies and planning.

To my 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 2001) examining personality change preceding dementia diagnosis, introducing different 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. The retrospective research examining the association between personality

change and dementia (Dawson & Welsh, 1994; Dawson et al, 2000; Lykou et al, 2014; Mahoney et al, 2011; Rankin et al, 2003; Siegler et al, 1994; Torrente et al, 2014) and the research examining the neurological basis of personality (Bjørnebekk et al, 2012; Jackson et al, 2009; Knutson et al, 2001; Wright et al, 2007; Xu & Potenza, 2011), informs the main hypothesis for the current research: (i) that an increase in neuroticism precedes dementia. Additionally, the retrospective research (Dawson, Welsh-Bohmer & Siegler, 2003; Mahoney et al, 2011; Siegler, Dawson & Welsh, 1994; Torrente et al, 2014; Rankin et al, 2003; Williams, Briggs & Coleman, 1995) informs a second hypothesis: (ii) that a decrease in extraversion precedes dementia.

The current research includes investigation of two longitudinal samples of older adults, providing the opportunity for immediate replication and comparison of results. Each study includes repeated assessment of personality traits and an indication of definite or probable dementia diagnosis. These measures were used to identify a subset of individuals within each sample for univariate modelling of each personality trait preceding dementia diagnosis. Selection of two datasets allow for conceptual replication within this coordinated analysis, which is important for effective cumulative science (Brandt et al, 2014; Hofer & Piccinin, 2009; Hofer & Piccinin, 2010).

Method

Participants and Procedures

2.1 Origins of Variance in the Old-Old Participants (Sweden). This study used data from the longitudinal study Origins of Variance in the Oldest-Old (OCTO-Twin; McClearn et al, 1997). The OCTO-Twin study consists of 351 dizygotic and monozygotic twin pairs (702 individuals). OCTO-Twin participants were twin pairs in which both twins were still alive and aged 80 years or older at the first occasion of data collection in 1991. Participants were recruited from the Swedish Twin Registry, which is a record of all cases of multiple births in Sweden (Lichtenstein et al, 2002). Longitudinal data were collected at two year intervals for a maximum of five waves; however, personality data was only collected at the first four occasions. Due to a variety of factors including participant dropout, not all participants mailing back personality inventories, and individuals only completing self-report assessments when they were cognitively healthy, the current analyses only include data from the first three waves of measurement.

Licensed nurses interviewed participants in their homes biennially. Testing sessions lasted approximately 3.5 - 4 hours, including several breaks. The researchers requested that the participants complete and mail back the personality inventories after the testing sessions.

The OCTO-Twin study included a clinical conference in which a multidisciplinary team diagnosed individuals with dementia 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) according to the criteria of the DSM-III-R (American Psychiatric Association, 1987). Only individuals who were cognitively healthy at baseline and converted to dementia at a follow-up occasion were included in the current analyses. A total of 86 participants who received a dementia diagnosis after the first wave of testing and completed

personality assessment were included in the present analyses (see Table 1 for demographic information).

2.2 Longitudinal Aging Study Amsterdam Participants (Amsterdam, Zwolle and Oss, the Netherlands). This study used data from the Longitudinal Aging Study of Amsterdam (LASA; Huisman et al, 2011), a population-based cross-sequential longitudinal study consisting of three independent and geographically representative cohorts of older adults between 55 and 85 years old recruited from the Netherlands. Testing intervals were scheduled every three years following recruitment into the study and participants were recruited for each cohort at ten year intervals. Cohort 1 was recruited in 1992-1993 (N = 3107), Cohort 2 in 2002-2003 (N = 1002), and Cohort 3 in 2012-2013 (N = 1023).

Participants were visited in their homes every three years by trained interviewers, who completed a main interview and a medical interview at each occasion. Participants were also asked to complete questionnaires, such as the Neuroticism scale, in the presence of the interviewer.

The LASA study includes a composed variable of probable dementia, determined by taking into account the Mini Mental State Examination (MMSE) score, a telephone administered MMSE, or an Informant Questionnaire on Cognitive Decline in the Elderly.

Data from the first four waves of measurement of Cohort 1 were used in the current analyses, as these waves of measurement include repeated personality assessment. A total of 167 participants who received a probable dementia diagnosis after the first wave of testing and completed repeated assessment of personality were included in the current analyses (see Table 1 for demographic information).

Measures

Both the OCTO-Twin and the LASA studies included a large battery of measures including assessment of health, functional and mental capacity, well-being, personality, depressive symptoms, and social network. A subsample of these assessments is used in the present analyses.

3.1 Personality measures. Personality traits were evaluated using self-report measures of personality traits. Repeated measurement of personality traits extraversion and neuroticism (Eysenck Personality Inventory; Eysenck & Eysenck, 1964) is included in the OCTO-Twin study, while repeated measurement of neuroticism (The Neuroticism Subscale; Luteijn et al, 2000) is included in the LASA study.

3.1.1 Eysenck Personality Inventory (OCTO-Twin). The self-report Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964) measures extraversion and neuroticism, two independent factors of personality. The OCTO-Twin study uses a shortened, 19-item, version of the EPI (Floderus-Myrhed et al, 1980), which has been used in several Nordic twin studies (Rose et al, 1988). Good reliability has been reported previously for the OCTO-Twin dataset for both extraversion (Cronbach's alpha = .65 - .66) and neuroticism (Cronbach's alpha = .74 - .75) in the three measurement occasions (Read et al, 2006).

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 ten 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 were reverse-coded prior to scoring. Scores on the Extraversion scale can range from 0 – 9, with higher scores indicating a higher degree of extraversion. Scores on the Neuroticism scale can range from 0 – 9, with higher scores indicating a higher degree of neuroticism.

3.1.2 The Neuroticism Scale (LASA). The Neuroticism subscale is derived from the Dutch Personality Questionnaire (DPQ; Luteijn et al, 2000). High neuroticism is characterized by negative moods, such as fear, anxiety, depression, guilt, and self-dissatisfaction, while low neuroticism is characterized by emotional stability. The Neuroticism Scale contains 15 items with three response options: *applicable, do not know, not applicable*. Scores on the Neuroticism scale can range from 0 – 30, with higher scores indicating a higher degree of neuroticism. A good reliability of the Neuroticism Scale has been reported previously by Steunenberg and associates (2010) for the LASA dataset (Cronbach's alpha= .85).

3.2 Covariates.

3.2.1 Depressive symptoms. Depressive symptoms measured at the first occasion are included as a covariate in the current analyses. Baseline assessment was used to minimize missingness due attrition. 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 (Jackson, 1986; Kendler et al, 1993; see Ownby et al, 2006).

Both OCTO-Twin and LASA studies measured depressive symptoms using the self-report Center for Epidemiologic Studies Depressive Scale (CES-D; Radloff, 1977), which was translated to Swedish and Dutch, respectively. 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

were asked about the frequency of particular experiences during the past week. Four items are reverse coded prior to summing scores. Total scores can range from 0 to 60, with higher scores indicating elevated levels of depressive symptoms. Good reliabilities have been previously reported by Haynie and associates (2001) for the OCTO-Twin dataset (Cronbach's alpha = .87 - .90) over three waves and by Pronk and associates (2011) for LASA (Cronbach's alpha = .85), indicating good internal consistency.

Data Analytic Approach

The nature of a longitudinal research design makes the use of latent growth curve modelling (LGM) desirable. For each study and personality trait, a sequence of models was run in Mplus version 7.3 (Muthen & Muthen, 2014) examining individual trajectories of change in extraversion and neuroticism preceding dementia diagnosis with and without controlling for covariates. Time was specified as "time-to-dementia" with the occasion in which individuals were diagnosed with dementia specified as time zero. Results are reported for the model with sex, age, education, the interaction between age and education, and depressive symptoms at the first occasion as covariates of the intercept. For LASA, these terms were also included as covariates of the slope. For OCTO-Twin, all covariates were originally included in the model, but trimmed for follow-up analyses due to the small sample size. This process eliminated the non-significant interaction between age and education and depressive symptoms to facilitate model interpretation, resulting in inclusion of only sex, age, and education as covariates of the slope for OCTO-Twin analyses.

For all models, age and education were included as continuous variables mean centered for each study; the means for baseline age and education were subtracted from the baseline values for each individual. For OCTO-Twin, age was centered at 83 years and education was

centered at 7 years. For LASA, age was centered at 74 years and education was centered at 9 years. Centering age and education across samples at a common value may have facilitated interpretability; however, because the mean age is substantially different for each sample and particularly because OCTO-Twin does not include individuals less than 80 years old, centering at a common value would result in extensive extrapolation. Sex was included as a dichotomous variable, with male as the reference group. An alpha level of < 0.05 was used for all statistical tests.

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. The LASA sample included a majority of male participants who were 74 years old on average at the first assessment and had an average of almost 9 years of education. Demographic information is presented in Table 1.

Table 1. Demographic information of participants.

		OCTO-Twin	LASA
		Participants (n = 86)	Participants (n = 167)
		M (SD)	M (SD)
Age at first interview		82.97 (2.56)	74.36 (6.86)
Years of education		6.98 (2.00)	8.96 (2.37)
Time to Dementia		-4.25 (2.68)	-7.99 (3.30)
CES-D		8.71 (7.45)	8.82 (7.52)
		n (%)	n (%)
Sex			
	Female	55 (63.95%)	62 (32.13%)
	Male	31 (36.05%)	105 (62.87%)

Notes. Time to Dementia = Time in Years to Dementia Diagnosis at Time 1; CES-D1 = Symptoms of Depression at Time 1.

4.1 Univariate latent growth curve modelling.

For each study, latent growth curve models for each personality trait were fitted with and without covariates to examine rates of change in personality traits preceding dementia diagnosis. For OCTO-Twin, linear trajectories of extraversion and neuroticism were examined. For extraversion, both the unconditional and conditional models revealed non-significant linear slope

means and variances. For neuroticism, both the unconditional and conditional models revealed significant mean linear slopes ($p<0.05$). The results suggest that at point of diagnosis, a man who entered the study at age 83 with seven years of education had an average score of 2.0 on the neuroticism scale, and 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 non-significant, suggesting relative consistency of neuroticism increases across individuals. For OCTO-Twin, the parameter estimates and standard errors for the linear models of personality traits are presented in Table 2 (extraversion) and Table 3 (neuroticism). Figure 1 and Figure 2 display a random selection of individual observed trajectories of extraversion and neuroticism, respectively, for OCTO-Twin data.

Table 2. Parameter Estimates (and Standard Errors) for OCTO-Twin study from Growth Curve Models for Time-to-Dementia Metric, with Baseline Age and Education Centered at Sample Mean for Personality Trait Extraversion.

	Unconditional Linear ß (SE)	Conditional Linear ß (SE)
Fixed effects		
Intercept	4.616 (0.309)**	5.666 (0.646)**
Female		-0.722 (0.712)
CES-D1		-0.061 (0.037)
Age		0.113 (0.162)
Education		0.211 (0.365)
Age x education		-0.008 (0.148)
Time	-0.081 (0.061)	-0.016 (0.102)
Female		-0.090 (0.133)
Age		0.024 (0.045)
Education		-0.009 (0.876)
Variance Components and fit indices		
Intercept	3.987 (1.616)*	3.461 (1.704)*
Slope	0.030 (0.064)	0.012 (0.058)
Cov (IS)	0.174 (0.283)	0.134 (0.279)

Residual	1.032 (0.282)**	1.119 (0.202)**
AIC	613.248	594.597
BIC	628.180	628.794

Notes. AIC = Akaike information criterion; BIC = Bayesian information criterion; OCTO-Twin = Origins of Variance in the Oldest-Old (sample mean = 83 years, education = 7 years); CES-D1 = Symptoms of Depression; *p < .05, **p ≤ .001

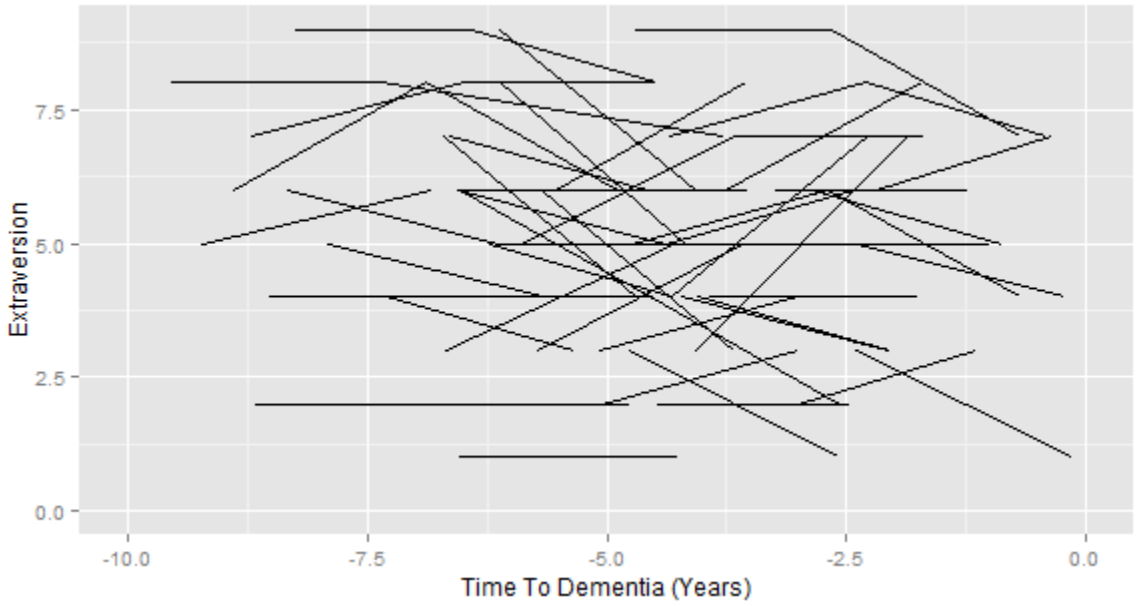

Figure 1. Individual observed trajectories of extraversion aligned according to the occasion of dementia diagnosis for OCTO-Twin.

The covariates for all OCTO-Twin models were non-significant, except in the linear trajectory model for neuroticism. As discussed, depressive symptoms were originally included as a covariate of the slope, but eliminated due to non-significance and small sample size; however, the trajectory model for neuroticism revealed depressive symptoms as a significant predictor of the intercept of neuroticism. 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.

Table 3. Parameter Estimates (and Standard Errors) for OCTO-Twin study from Growth Curve Models for Time-to-Dementia Metric, with Baseline Age and Education Centered at Sample Mean for Personality Trait Neuroticism.

	Unconditional Linear ß (SE)	Conditional Linear ß (SE)
Fixed effects		
Intercept	3.246 (0.428)**	1.970 (0.657)*
Female		-0.011 (0.748)
CES-D1		0.137 (0.023)**
Age		-0.239 (0.152)
Education		-0.404 (0.253)
Age x education		0.016 (0.076)
Time	0.235 (0.071)**	0.233 (0.100)*
Female		-0.040 (0.123)
Age		-0.050 (0.031)
Education		-0.054 (0.032)
Variance Components and fit indices		
Intercept	6.904 (2.181)*	4.388 (1.745)*
Slope	0.057 (0.050)	0.034 (0.035)
Cov (IS)	0.620 (0.331)	0.381 (0.236)
Residual	0.942 (0.147)**	0.662 (0.168)**
AIC	590.390	526.809
BIC	605.185	560.673

Notes. AIC = Akaike information criterion; BIC = Bayesian information criterion; OCTO-Twin = Origins of Variance in the Oldest-Old (sample mean = 83 years, education = 7 years); CES-D1 = Symptoms of Depression;*$p < .05$, **$p \leq .001$

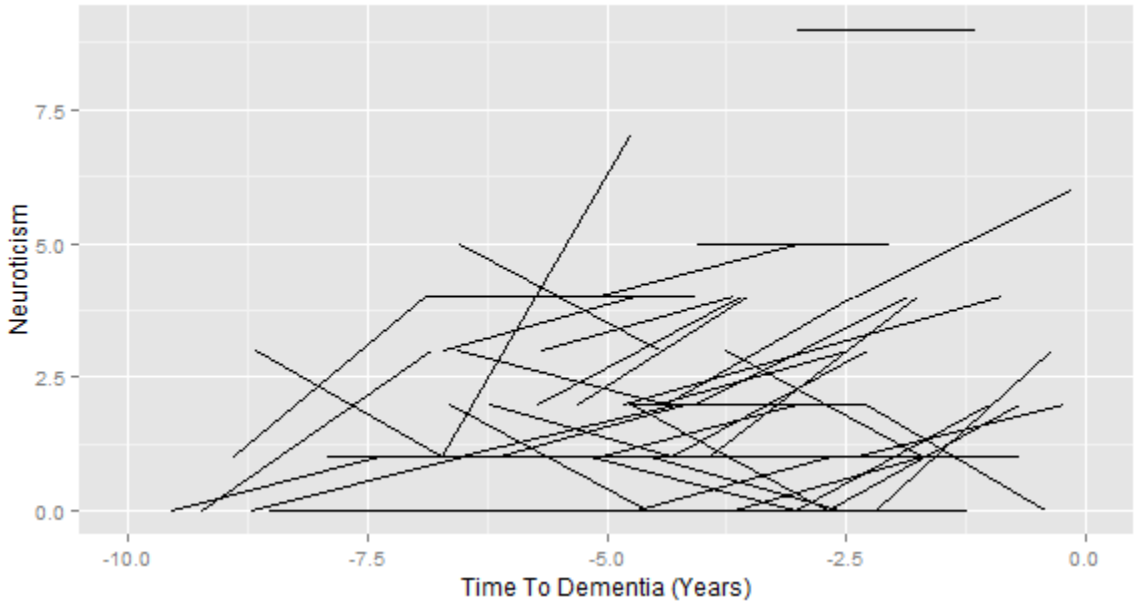

Figure 2. Individual observed trajectories of neuroticism aligned according to the occasion of dementia diagnosis for OCTO-Twin.

For LASA, only trajectories of neuroticism were examined, as this was the only personality assessment that was administered at repeated occasions. However, because there were four waves of repeated personality data, quadratic trajectories of neuroticism were examined in addition to linear trajectories to determine the most appropriate model for trajectory shape. The conditional and unconditional models examining quadratic trajectories revealed non-significant mean quadratic slope estimates. Although the unconditional linear model revealed non-significant mean slope estimates, the conditional model revealed significant mean linear slopes ($p<0.05$). The AIC and BIC were smaller for the linear model, suggesting that the linear model afforded a better fit of the data.

Based on the conditional linear model, the results suggest that at the point of diagnosis, a man who enrolled in the study at age 74 year with 9 years of education scores an average of 5.2 on the neuroticism scale, and had been increasing by just over a quarter of a point per year

between study entry and diagnosis. Like OCTO-Twin, the slope variance for neuroticism was non-significant, suggesting relative consistency of neuroticism increases across individuals. LASA parameter estimates and standard errors for the linear and quadratic models of neuroticism are presented in Table 4. Figure 3 displays individual observed trajectories of neuroticism for LASA data.

For LASA, the linear trajectory model for neuroticism revealed depressive symptoms as a significant predictor of the intercept of neuroticism. Again, 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.

Table 4. Parameter Estimates (and Standard Errors) for LASA study from Growth Curve Models for Time-to-Dementia Metric, with baseline Age and Education Centered at Sample Mean for Personality Trait Neuroticism.

	Unconditional Linear	Conditional Linear	Unconditional Quadratic	Conditional Quadratic
	ß (SE)	ß (SE)	ß (SE)	ß (SE)
Fixed effects				
Intercept	7.545 (0.617)**	5.214 (1.157)**	7.669 (0.856)**	6.050 (1.559)**
Female		-0.113 (1.180)		-2.130 (1.891)
CES-D1		0.346 (0.099)**		0.270 (0.138)
Age		-0.0.15 (0.087)		0.174 (0.141)
Education		0.167 (0.176)		0.016 (0.375)
Age x Education		-0.030 (0.025)		-0.003 (0.040)
Linear	0.074 (0.070)	0.258 (0.126)*	0.127 (0.225)	0.608 (0.384)
Female		-0.116 (0.142)		-0.047 (0.035)
CES-D1		-0.010 (0.013)		0.089 (0.037)*
Age		0.004 (0.010)		0.006 (0.002)
Education		-0.018 (0.021)		-0.007 (0.006)
Age x Education		-0.001 (0.003)		0.001 (0.001)
Quadratic			0.004 (0.015)	0.030 (0.026)
Female				-0.032 (0.032)
CES-D1				-0.003 (0.002)
Age				0.006 (0.002)*
Education				-0.007 (0.006)
Age x Education				0.001 (0.001)

Variance Components				
Intercept	31.616 (8.200)**	24.824 (7.987)*	33.251 (19.783)	38.226 (14.628)*
Linear Slope	0.042 (0.120)	0.066 (0.123)	0.292 (4.032)	0.703 (0.667)
Quadratic Slope			0.001 (0.027)	0.002 (0.002)
Cov (IS)	0.634 (0.926)	1.062 (0.938)	1.306 (8.417)	4.563 (3.087)
Cov (IQ)			0.043 (0.015)	0.222 (0.157)
Cov (SQ)			0.015 (0.329)	0.034 (0.034)
Residual	12.151 (2.511)**	11.517 (2.520)**	11.975 (2.747)**	10.498 (2.110)**
Fit Indices				
AIC	2215.747	2117.025	2223.615	2120.722
BIC	2234.382	2166.426	2254.674	2197.912

Notes. AIC = Akaike information criterion; BIC = Bayesian information criterion; LASA = Longitudinal Aging Study of Amsterdam (sample mean = 70 years, education = 9 years); CES-D1 = Symptoms of Depression;*p < .05, **p ≤ .001

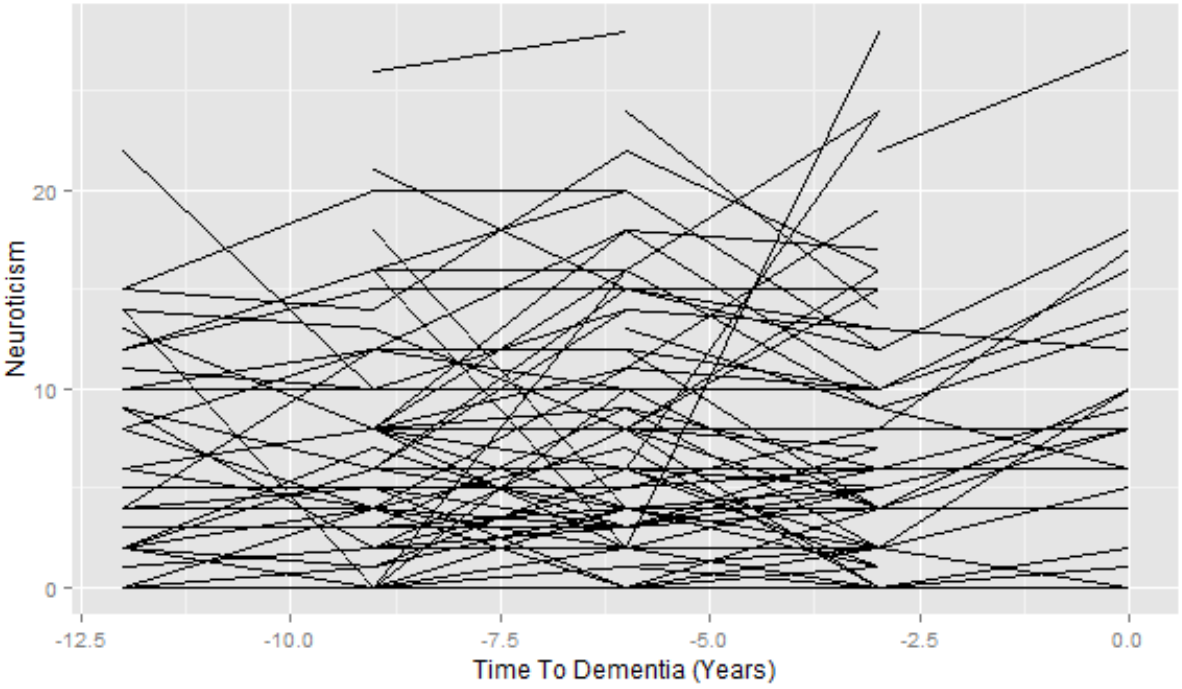

Figure 3. Individual observed trajectories of neuroticism aligned according to the occasion of dementia diagnosis for LASA.

In summary, the conditional models for both studies revealed significant linear increases in levels of neuroticism preceding dementia diagnosis (all $P < .05$). Additionally, baseline

depressive symptoms were consistently the only significant predictor of neuroticism, and only of level, not rate of change (all $P < .05$).

Discussion

The primary aim of the current study was to examine whether change in personality traits precede dementia diagnosis. To examine the preclinical onset of cognitive decline, individuals were aligned according to the occasion of dementia diagnosis, and trajectories of personality traits were examined preceding diagnosis. This study conducted analyses using data from two longitudinal studies: Origins of Variance in the Old-Old (OCTO-Twin) and Longitudinal Aging Study Amsterdam (LASA). These studies were selected based on their repeated measurement of personality traits, as well as indication of conversion to dementia at each occasion. Using latent growth curve modelling, a consistent longitudinal pattern of personality change prior to diagnosis of dementia was identified. Supporting the main hypothesis, the analyses indicate that individuals from both the OCTO-Twin and LASA datasets show a significant increase in self-report of neuroticism preceding dementia diagnosis. A longitudinal design utilizing two diverse samples of older adults who were assessed using different measurements of neuroticism provides the opportunity for conceptual replication within this coordinated analysis. The consistent results across these studies contribute to cumulative science.

The findings from OCTO-Twin are particularly noteworthy in the context of previous research investigating personality change in normal aging, also using the OCTO-Twin study. As discussed in section 1.2, Berg and Johansson (2013) fitted models for all individuals from the OCTO-Twin dataset who completed the Eysenck Personality Inventory at the first occasion (N = 408), finding an age-related linear decrease in extraversion and stability in neuroticism. Berg and Johansson's findings coupled with the findings from the subset of individuals included in the current analyses, suggest that trajectories of personality change are markedly different for a general sample of older individuals compared to a subgroup of individuals who were cognitively

healthy at baseline and received a dementia diagnosis at a later testing occasion. An idea for further analysis includes examination of personality trajectories in the subset of individuals from OCTO-Twin who did not convert to dementia. An expectation is that the stability in neuroticism found by Berg & Johansson may be impacted by their analyses including the individuals who converted to dementia.

The results of the current study do not support the second hypothesis, that extraversion decreases prior to dementia diagnosis. This hypothesis was based on retrospective research that consistently found decreases in extraversion in individuals who currently have dementia (Dawson, Welsh-Bohmer & Siegler, 2003; Rankin et al, 2003; Torrente et al, 2014). This inconsistency could be due to a variety of reasons, perhaps most notably to the timing of personality measurement in previous research. For example, the brain regions more responsible for extraversion may not be implicated until the later stages of dementia. Since our focus is change in extraversion prior to dementia diagnosis, changes in extraversion may not yet be measureable. 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. As discussed, caregivers of people with dementia have higher rates of depression and anxiety compared to the general population (Nicholas et al, 2009), which may lead to caregivers providing a more pessimistic recollection than an informant who is not a caregiver. 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 loves ones to have been more extraverted prior to diagnosis.

Depressive symptoms, assessed by the CES-D (Radloff, 1977), were included as a covariate in the current analyses based on two associations found in previous research. The first association involves 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). Although an association is well established, the pathway between depression and dementia is unclear. For example, it has been suggested that depressive symptoms may increase the risk of developing dementia (Devanand et al, 1996) or may be an early symptom of dementia (Smith-Gamble et al, 2001). The second reason for including depressive symptoms in the current analyses involves previous conceptualizations and research examining the connection between neuroticism and depressive symptoms or major depression (Costa & McCrae, 1990; Eysenck, 1991; Eysenck & Eysenck, 1987; Jackson, 1986; Kendler et al, 1993). In his book, *Melancholia and Depression: From Hippocratic Times to Modern Times* (1986), Stanley Jackson wrote the first comprehensive history of depression, presenting the idea that a cluster of symptoms or syndromes documented over the past 2,500 years describe a construct we now define as major depression. He suggests that the connection between depression and neuroticism originated with the theoretical conceptualizations of personality by Hippocrates and Galen, whose theories categorized four types of individuals based on excess or lack of humors. Melancholic individuals, who were later identified as individuals high in neuroticism, were classified as being prone to depression (Eysenck & Eysenck, 1987, p 42). More recent empirical research has also identified an association between depression and neuroticism. For example, Kendler and associates (1993) examined major depression and personality traits extraversion and neuroticism in 1,733 female twins at two occasions separated by 15 months. Findings suggested that high levels of neuroticism were significantly associated

with a major depression diagnosis during their lifetime. Additionally, their analyses revealed that higher levels of neuroticism at the first testing occasion predicted major depression at the second testing occasion, 15 months later.

Consistent with the research examining depression and neuroticism as well as depression and dementia, our findings suggest that although depressive symptoms are associated with neuroticism and cognitive decline, depressive symptoms do not impact the trajectory of neuroticism. The present analyses revealed that level of neuroticism was significantly higher for individuals with depressive symptoms at the first wave of assessment; specifically, on average, for every unit increase on the CES-D, individuals scored .137 and .346 higher on the respective neuroticism scales at the occasion of diagnosis in OCTO-Twin and LASA, respectively. Although our findings suggest a link between level of depressive symptoms and level of neuroticism, the slope of neuroticism was not associated with depressive symptoms at the first occasion in either dataset. These findings are similar to findings by van den Kommer and associates (2013), who examined depressive symptoms and cognitive functioning in all individuals from the LASA study. Their findings revealed that although the trajectory of cognitive functioning was not significantly associated with the trajectory of depressive symptoms, baseline depressive symptoms predicted cognitive decline.

Our research, examining within-person changes, indicates that individuals who are eventually diagnosed with dementia demonstrate consistent increases in self-reported levels of neuroticism. These 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, 2012; Jackson et al, 2009; Knutson et al, 2001; Wright et al, 2007; Xu &

Potenza, 2011). However, this prior brain volume research mainly examined between-person differences, so could not clearly identify whether neuroticism has a moderating effect on age-related decline, or if changes in brain structure result in personality changes. Indeed, Jackson and associates (2009) 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 research provides a glimpse into within-person differences, Jackson and associates (2009) findings are not consistent with similar research by Knutson and associates (2001), who did not find that levels of neuroticism were associated with greater decreases in brain-ratio volume. However, this could be due to the 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 neuro reactivity (Rombouts et al, 2007), or decreased brain volume in grey and white matter (Jagust et al, 2007). 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 (2009) 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 if there is a negative association between trajectories of

neuroticism and trajectories of brain volume; specifically, if increases in neuroticism consistently align with decreases in brain volume.

5.1 Further Theory: Selective Optimization with Compensation

Beyond the research presented throughout this thesis to establish a rationale for why personality change may occur prior to dementia diagnosis, Paul Baltes' 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 (1987). 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 older adults exhibiting measurable personality changes in the early stages of disease onset. For instance, older adults may start to experience cognitive changes occurring in their daily life, and recognize that changes in cognition may be indicative of impending cognitive decline. Consequently, older adults 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, avoiding more difficult social engagements such as chess, or even practicing the questions that are expected to be asked during administration of the MMSE. The procedure for identifying probable or definite diagnosis of dementia in both OCTO-Twin and LASA included an interview with a family informant and consideration of MMSE score. In terms of the informant interview, 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.

5.2 Clinical Significance of Findings

Although the analyses for both studies revealed significant increases in neuroticism over time, the average increase was approximately only a quarter of a point per year between study entry and dementia diagnosis. The rather small average increase may lead some readers to wonder about the extent to which this research is clinically significant. This line of thinking is justified, and arguments for the clinical significance of the findings are presented.

As discussed in section 1.6, previous prospective research has measured premorbid personality changes using relatively basic measurement to assess *any* personality change: Smith-Gamble and associates (2001) administered six CAMDEX personality change items, while Balsis and associates (2005) administered eight Blessed Dementia Scale items (Blessed et al, 1968). The current research used personality trait scores from the EPI (Eysenck & Eysenck,

1964) and the Neuroticism Scale, a subscale derived from the Dutch Personality Questionnaire (DPQ; Luteijn et al, 2000). The EPI scale administered to OCTO-Twin participants included nine items measuring neuroticism, with dichotomous response alternative (yes = 1; no = 0). The Neuroticism Scale administered to LASA participants included fifteen items with three response options: *applicable, do not know, not applicable*. Although the personality assessments used in the current research are more detailed than the assessments used in previous studies, the EPI and DPQ neuroticism scales are still relatively rudimentary. Consequently, a question arises in regards to these assessments*: if change is occurring in real life, to what degree should we expect these assessments to capture that change?*

Firstly, the self-report nature of the assessments is incredibly important, because, arguably, an individual is typically thought to be the best agent to answer personality questions about them self. In the case of individuals who are eventually diagnosed with dementia, a concern arises regarding accuracy of self-report involved in self-awareness in the earliest stages of dementia. To my knowledge, no research has examined self-awareness of personality preceding dementia diagnosis; however, Rankin and associates (2005) investigated self-awareness of personality in individuals *currently* diagnosed with dementia. They examined individuals with frontotemporal dementia (N = 12), individuals with Alzheimer's disease (N = 10), and older adults controls (N = 11), finding significant differences in self-awareness between each group. Individuals with frontotemporal dementia showed the greatest error in self-assessment of personality, while individuals with Alzheimer's disease showed mostly accurate self-awareness in all personality dimensions. Therefore, self-report assessment may not be the best choice of measurement for individuals currently diagnosed with frontotemporal dementia. However, Rankin and associates showed that the post-morbid self-report assessment from both

groups of individuals with dementia most closely matched their premorbid personality, suggesting that these individuals were 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 disease onset, the analyses would have likely revealed no change in personality, inconsistent with the current findings.

Beyond self-report, the magnitude of quantifiable changes is constrained by the properties of the scale. Namely, answers are limited by the restrained nature of the response options. Since there are not common metrics for what constitutes meaningful effect sizes in growth models, interpretation of what constitutes meaningful change is complicated and challenging. Secondly, the items are general, referring to broad characteristics that typically would not change overtime. Again, in their analyses that included the entire OCTO-Twin sample, Berg and Johansson found stability in neuroticism. Therefore, any quantified change seems meaningful. At the very least, this study demonstrates reliable, consistent change in neuroticism preceding dementia, which is meaningfully different from no change.

Certainly, as discussed in the following section, a more detailed personality trait measurement would have enhanced this study. For example, the NEO-Personality Inventory Revised (NEO PI-R; Costa & McCrae, 1992) measures five personality traits, with each trait assessed by 40 items answered on a 5-point scale from *strongly disagree (0)* to *strongly agree (4)*. The NEO PI-R would be a more effective assessment to capture changes in personality traits, and future research using the NEO PI-R would improve the understanding of personality change preceding dementia diagnosis.

Strengths, Limitations, and Future Directions

Previous research examining personality change mainly focuses on the changes that occur after onset of dementia. Due to unreliability of self-report measures completed by people who already have behavioural and psychological symptoms of dementia, the research has typically used retrospective informant-report measures of personality, which may result in inaccurate accounts for many reasons, including biased responses due to caregiver burden. Although Smith-Gamble and colleagues (2001) and Balsis and colleagues (2005) measured personality change prospectively, they also used informant report assessment. Additionally, small sample sizes have provided rationale for further investigation of personality change and dementia. Balsis and colleagues' analyses included 108 individuals, of which 82 converted to probable or possible dementia during follow-up occasions. Although the quantity of individuals who converted to dementia is very similar to the OCTO-Twin sample in the current research (N = 87), Balsis and associates' sample was more heavily weighted with individuals who eventually converted to dementia, which may mean their findings are not as generalizable to a normal aging population. The proportion of individuals who converted to dementia in Smith-Gamble and associates' research (N = 2,084) provides a more realistic picture of conversion rates in the community; however, the individuals who converted to dementia (N = 45) at the follow-up occasion also resulted in their analyses being based on a small sample. Likewise, the retrospective research has also used relatively small total samples (Dawson, Welsh-Bohmer & Siegler, 2000, N = 50; Lykou et al, 2014, N = 47; Mahoney et al, 2011, N = 30; Rankin et al, 2003, N = 45; Torrente et al, 2014, N = 50). Therefore, the data and conclusions from the existing prospective and retrospective research are subject to the limitations common to all small samples; for example, the uniqueness of the individuals who are examined may be due to chance

rather than disease, resulting in questionability regarding the ability to generalize findings. Finally, because a considerable number of research studies have investigated disease-specific patterns of personality change, sample sizes have been further fragmented. The current research extends previous research by examining personality in a substantially larger sample of individuals who converted to dementia (total $N = 254$).

As far as I know, this 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. This research only included analyses for two traits, extraversion and neuroticism, because the protocols for OCTO-Twin and LASA did not include measurement for additional traits. The current research applies secondary analysis, which uses previously collected data to address novel research questions. As discussed, a secondary analysis is a good way to conduct research because of the lengthy process of collecting original data (Dunn, 2010). However, a limitation of secondary analyses is the inability to control which variables are collected in datasets. As discussed in section 1.1, several measurements are available to assess personality, and the previous retrospective research has typically examined Costa and McCrae's Five Factor Model of personality using a version of the NEO-PI; however, for the present research, only extraversion and neuroticism were available for investigation due to the existing variables that were collected in OCTO-Twin and LASA. A more fine-grained measure of personality that captures more detail and is more sensitive to variation, such as the NEO-Personality Inventory, may broaden the understanding of personality change as an indicator of dementia; perhaps other personality traits also change preceding dementia diagnosis. Additionally, the OCTO-Twin procedure of leaving the EPI with participants to

complete and return by mail resulted in a substantial reduction in the number of participants with personality data.

Due to focusing only on participants who converted to dementia after the first occasion, the current analyses only included 87 individuals from three waves of measurement from OCTO-Twin, and 167 individuals from four waves of measurement from LASA. Although the sample size is considerably diminished compared to the total number of individuals in the original datasets, 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. Furthermore, although this study was longitudinal in nature, only three and four waves of measurement were included in analyses for OCTO-Twin and LASA, respectively. For OCTO-Twin, since the analysis is of a maximum of three waves of data per person, only linear trajectories were examined. For LASA, quadratic models were also fitted. The Akaike information criterion (AIC) and Bayesian information criterion (BIC) were higher for the quadratic models than the linear models, suggesting that linear models are a better fit. The finding that a linear pattern rather than a quadratic pattern of personality change is a better fit is consistent with Helmes and associates (2013), who found longitudinal evidence of a linear pattern of personality change with increasing severity of cognitive impairment.

Overall, within the current study, the OCTO-Twin analyses improved upon the LASA analyses by including measurement of two personality traits, neuroticism and extraversion, rather than just neuroticism. Likewise, the analyses for LASA improved upon the analyses for OCTO-

Twin by including an additional wave of measurement and thus, examining quadratic trajectories in addition to linear trajectories. That being said, a more comprehensive assessment of personality traits and additional waves of measurement would improve the understanding of personality change preceding dementia.

A further limitation of the current research includes high attrition rates. Although not necessarily unrepresentative, attrition rate in studies of older adults is often considerable (Harel et al, 2007; Huisman et al, 2011). However, unlike longitudinal studies investigating individuals in midlife or young age in which attrition is most commonly due to participant drop-out, attrition is mainly due to mortality in both OCTO-Twin (Mitchell et al, 2012) and LASA (Huisman et al, 2011). For example, OCTO-Twin consists of individuals 80 years or older at baseline and consequently attrition due to death accounts for approximately 90% of the attrition because mortality after 80 years old is common. Likewise, Huisman and associates (2011) report of survival and participation in LASA, attrition due to death accounts for the majority of attrition at every testing occasion; specifically 73% - 81% of attrition was due to death across all five waves of measurement.

This 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.

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