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Identification of the healthy neurotic: Personality traits predict smoking after disease onset

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ABSTRACT

Personality traits are known predictors of health behaviors and health status. However, most of this work focuses exclusively on how personality influences health outcomes rather than how personality influences response to disease. Using a large, national study ($N = 7051$), we investigated whether conscientiousness and neuroticism were associated with smoking behavior after the onset of a disease. After the onset of a major chronic disease, high levels of neuroticism predicted less smoking when paired with high levels of conscientiousness, a combination described as healthy neuroticism. Healthy neuroticism only predicted smoking behavior after the onset of disease, not before, suggesting that the relationship between personality and responses to health problems differs from the relationship between personality and the onset of health problems.

1. Introduction

In the study of health, personality traits have been identified as one of the best psychosocial predictors of both general health status and specific outcomes (Hampson, 2012). Personality traits predict self-rated health (Hampson, Goldberg, Vogt, & Dubanoski, 2007), physician-rated health (Chapman, Lyness, & Duberstein, 2007), biomarkers of health as far as 30 years in the future (Hampson, Edmonds, Goldberg, Dubanoski, & Hillier, 2013), disease onset (Goodwin & Friedman, 2006; Weston, Hill, & Jackson, submitted for publication), and mortality (Jokela et al., 2013; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). However, few studies investigate the role personality plays in the response to disease. The current study examines the association of personality traits with smoking after a diagnosis of a major disease, such as lung disease or a heart condition.

1.1. The relationship of conscientiousness and neuroticism with physical health

The personality traits conscientiousness and neuroticism are among the most frequently and strongly connected to health outcomes and health behaviors (Hampson, 2012). Individuals high in conscientiousness experience better health, as they live longer and are at a lower risk for a variety of illnesses (Chapman, Roberts, & Duberstein, 2011; Kern & Friedman, 2008). This relationship is due to the fact that individuals high in conscientiousness are more likely to engage in positive health behaviors, such as exercise, and less likely to engage in risky health behaviors (Bogg & Roberts, 2004; Hill & Roberts, 2011). Individuals high in neuroticism, on the other hand, are at greater risk for developing illness and have shorter life spans (Hampson, 2012; Roberts et al., 2007). Neuroticism is thought to influence health through both physiological and behavioral pathways. Individuals high in neuroticism experience more anxiety and stress (Bolger & Schilling, 1991), which in turn disrupts immune functioning (Sutin et al., 2010). As a means to cope with this stress, individuals high in neuroticism are also more likely to turn to unhealthy behaviors, such as smoking or drinking (Contrada, Cather, & O'Leary, 1999; Terracciano & Costa, 2004; Turiano, Whiteman, Hampson, Roberts, & Mroczek, 2012).

However, some have argued that high levels of neuroticism can benefit health under certain circumstances (Friedman, 2000). Such arguments of a healthy neuroticism rest on the premise that neuroticism could lead to vigilance and concern about germs, symptoms, and treatments. This potentially positive response to stress and uncertainty is less studied than the typical negative pathway where worry and concern is considered harmful. That is, neuroticism may potentially be both beneficial and/or harmful for health depending on how individuals deal with their anxiety and worries. For example, increased vigilance towards one's health could result in less participation in risky behaviors and attentiveness to physical symptoms, ultimately leading to better health. Rather than turning to negative behavioral outlets to relieve stress (e.g., smoking), individuals instead may choose to confront their stressors head-on and attempt to manage or decrease the source of stress.

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A small number of studies have already provided evidence for the beneficial side of neuroticism by demonstrating that neuroticism may be associated with increased vigilance of somatic symptoms, evidenced by increased reporting of such symptoms (Costa & McCrae, 1987), though this potential pathway is mostly unexplored and undocumented.

An intriguing context where this healthy form of neuroticism may arise is when high levels of neuroticism are paired with high levels of conscientiousness. Individuals high in neuroticism are likely to be concerned about their health (Friedman, 2000), whereas conscientious individuals would do something about these concerns, such as by changing their health behaviors (Bogg, 2008), scheduling visits with their physician, and adhering to their physician's recommendations (Hill & Roberts, 2011). Some evidence suggests that this pairing of neuroticism and conscientiousness is effective for the health process. For example, in a study which examined personality types based on combinations of Big Five traits, those styles which included both high neuroticism and high conscientiousness showed the least frequency of smoking and lower mean consumption of cigarette and were more restrained drinkers (Vollrath & Torgersen, 2002). Additionally, current smokers scored lowest on a combination of high neuroticism and high conscientiousness but scored highest on the combination of high neuroticism and low conscientiousness (Terracciano & Costa, 2004). A final study showed that high neuroticism was protective against increased drinking when paired with high conscientiousness, although this study failed to find the interaction when examining smoking behaviors (Turiano et al., 2012). While these findings are in support of the healthy neurotic, some studies create categories to represent healthy neuroticism while others use continuous variables. This inconsistency of methods may account for inconsistency of results. Ideally, research on personality and health would use continuous variables to examine these interactions. These healthy neurotic individuals should recognize symptoms of health problems sooner and take steps – such as dieting and exercising – to address such symptoms or underlying problems, slowing the progression of disease and having healthier immune systems. In support of this idea, low levels of interleukin-6, an inflammatory biomarker negatively associated with immune functioning, occur in healthy neurotics (Turiano, Mroczek, Moynihan, & Chapman, 2013).

1.2. Personality traits and the response to disease

While numerous studies examine why personality traits may influence health, few studies examine whether personality traits influence reactions to health problems (Chapman et al., 2011; Friedman, 2000). One way to examine this process is to look at how individuals respond to the onset of a major disease. The progression of a chronic illness and the success of its treatment are largely influenced by a patient's coping response, which includes both emotional and behavioral components (Meichenbaum & Turk, 1987; Wiebe & Christensen, 1996). If a patient seeks out a specialist and complies with their recommendations and prescriptions, she is likely to experience fewer physical health problems, fewer negative emotions, and lower economic costs in the long term (Hays et al., 1994; Horwitz & Horwitz, 1993), whereas if the patient fails to change negative health behaviors, such as smoking, then she will naturally experience greater physical, emotional and economic costs. Additionally, different coping responses have different levels of effectiveness; information seeking, for example, leads to better psychological adjustment than fantasizing (Felton & Revenson, 1984), which suggests that individuals who take action to understand and manage their illness will show better emotional health, in addition to better physical health.

Personality traits likely influence responses to health because of their association with behavioral and emotional aspects of the health process. For example, conscientious individuals adhere better to doctors' instructions (Hill & Roberts, 2011), so they are more likely to slow the progression of a major or chronic disease. Personality traits, most notably neuroticism, also likely influence the degree to which a patient effectively copes with the stress and uncertainty that is involved after the onset of a disease (Connor-Smith & Flachsbart, 2007). One review finds support that personality influences the reaction and progression of disease (Wiebe & Christensen, 1996), indicating that high levels of conscientiousness were associated with the most adherence to physician's instructions. Consistent with these findings, in children with Type 1 diabetes, conscientiousness is associated with better regulation of blood sugar levels, known as glycaemic control (Vollrath, Landolt, Gnehm, Laimbacher, & Sennhauser, 2007). However, there is disagreement as to whether low (Christensen et al., 2002), moderate (Wiebe & Christensen, 1996) or high levels of neuroticism (Frasure-Smith, Lesperance, & Talajic, 1995) lead to ideal levels of health behaviors in the post-disease health process.

Despite the numerous studies linking personality traits with mechanisms involved in the health process (e.g., Bogg & Roberts, 2004; Hampson, 2012), the way by which personality influences responses to disease may differ from than the associations between personality and the onset of health. For example, individuals with Type A personality – e.g., ambitious and hostile – typically experience poorer physical functioning, an effect most likely driven by the hostility aspect (Friedman & Rosenman, 1959). However, while Type A personality predicts greater mortality generally, after a heart attack, Type A individuals live longer (Ragland & Brand, 1988), indicating that, in response to disease, personality traits can have a different influence on behavioral choices regarding treatment and recovery. Consequently, this study examines the association between personality and health both before and after a major health event.

1.3. Current study

This study aims to examine how personality influences behavioral responses to chronic disease. Specifically, we examine how the smoking behaviors of older adults are predicted by levels of conscientiousness and neuroticism. We seek to both replicate past findings regarding healthy neuroticism and smoking while extending this research to determine the conditions under which this effect is most likely to be found. To differentiate responses to disease from existing relationships between personality and smoking, we perform three sets of analyses. First, we examine the association between personality traits and smoking behaviors in a broad sample of older adult participants. These first analyses are meant to replicate the general associations found in previous research (e.g., conscientiousness predicts less smoking while neuroticism predicts more; Bogg & Roberts, 2004; Turiano et al., 2012). Second, using a subset of the initial sample, we examine smoking behaviors after the onset of six chronic diseases to examine whether personality traits predict behavioral responses to chronic illness. Third, we examine smoking behaviors before the onset of the diseases to test whether personality trait associations existed before the onset of illness. That is, the third set of analyses tests whether the association between personality and smoking behavior for those who will eventually develop a major illness exists prior to their diagnosis. Together, these analyses test whether personality traits influence a behavioral response after the onset of a major illness.

2. Method

2.1. Participants

Data were taken from the Health and Retirement Study (HRS), a nationwide study of aging adults (Juster & Suzman, 1995; Roberts,

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Jackson, Duckworth, & Von Culin, 2011). Participants in this survey were contacted every two years beginning in 1992 and asked to complete a number of health and finance measures; additionally, each new wave included new participants who had reached retirement age. Personality trait measures were first administered in 2006 to a subset of participants, and a second subset received these personality measures in 2008; HRS participants who were included in either of these subsets and provided health data comprise the sample used in this study ($N = 7051$; 58% Female). Personality measures were included in self-administered questionnaires, which participants returned by mail. The response rate of the self-administered questionnaires was 74% in 2006 and 71% in 2008.

2.2. Measures

Personality was assessed using the MIDI personality scales (Lachman & Weaver, 1997), in which adjectives are used as markers of the Big Five personality traits. Participants rated themselves on five items for conscientiousness (*organized*, *responsible*, *hard-working*, *careless* (reverse scored), and *thorough*) and four items for neuroticism (*moody*, *worrying*, *nervous*, and *calm* (reverse scored)) using a 4-point rating scale to indicate how well each adjective described them (1 = not at all, 4 = a lot). The scales have good construct validity and adequate reliability for a short measure (conscientiousness: $\alpha_{2006} = .66$, $\alpha_{2008} = .66$; neuroticism: $\alpha_{2006} = .71$, $\alpha_{2008} = .72$) and have been used previously in the study of personality and health (Hill, Turiano, Mroczek, & Roberts, 2012). Because the study began in 1992 and personality assessments were not given until 2006/2008, the length of time between diagnosis and personality assessment is anywhere from 0 to 16 years. Thus we control for the interval between assessment and diagnosis when considering smoking in relation to disease diagnosis.

2.2.1. Disease description

Diseases included high blood pressure or hypertension; diabetes or high blood sugar; cancer or malignant tumor, excluding minor skin cancer; chronic lung disease, such as bronchitis or emphysema; a heart condition, including a heart attack, coronary heart disease or congestive heart failure; and stroke. Participants were asked, "Has a doctor ever told you that you have [specific illness]?" Responses were coded as either *yes* (1) or *no* (0).

Health measures were collected at each wave (every two years) through telephone interviews. At each wave, participants were asked to rate their health on a scale from 1 (poor) to 5 (excellent).

Participants were also asked about their smoking behaviors. The answers to these questions were coded to reflect the average number of cigarettes smoked per day. For example, participants who responded no to "Have you ever smoked cigarettes?" or "Do you smoke cigarettes now?" were coded as smoking 0 cigarettes per day. Participants who currently smoked at the time of the interview were allowed to respond with number of cigarettes/packs/cartons per day/week/month/year. Packs were considered to hold 20 cigarettes and cartons were considered to hold 200. Responses were adjusted to reflect number of cigarettes per day and censored above 100.

2.3. Data restructuring

Given the form of the HRS data collection and the semi-random nature of disease onset, data were restructured so as the onset of disease served as Wave 0. Smoking behaviors were then restructured around Wave 0. For example, if a participant first reported high blood pressure in 2002, then his smoking behavior as reported in 2000 was inserted into the variable "Smoking at Wave −1" and his behavior reported in 2004 was inserted into the variable "Smoking at Wave 1." Both the variables "cigarettes per day" and "self-rated health" were restructured in this way. Similarly, age at the time of onset was calculated by subtracting the participant's year of birth from the first year he or she reported the chronic disease. For the analyses, smoking behaviors and self-rated health were taken from the wave before onset (Wave −1) and the wave after onset (Wave 1). All predictor variables were centered in all analyses to interpret interactions. Table 1 provides the sample size for each disease data set, the percent of those individuals who report smoking prior to the diagnosis, the age of the participants, and the average length of time between diagnosis and personality assessment.

2.4. Analyses

All analyses were done using R (R Core Team, 2013). The majority of the analyses use the base package and stats package included in R, and the psych package (Revelle, 2013) was used to quickly find descriptive statistics of all predictor and outcome variables and estimate alpha reliabilities of the personality variables. A series of linear regression models were used to examine the relationship between personality and smoking behavior. In the first of these models, each participant's average number of cigarettes per day was predicted by conscientiousness and neuroticism. In the second model, the interaction of conscientiousness and neuroticism was added, to examine whether the healthy neurotic effect could be found for smoking in this sample. In the third model, demographic variables (age, gender, education) were included, to determine whether the effects of conscientiousness and neuroticism could be partially explained by demographic factors.[1] In the final model, average self-rated health was added to the model, to examine whether personality predicted above and beyond a marker of physical health. When predicting smoking after the onset of disease, the model also included smoking behaviors at the wave prior to disease onset, to control for any habits or behaviors established before the health event.

To investigate interactions, graphs of the response surfaces were created using the persp function in R. In addition to response surfaces, density distributions for the personality variables were created from the normal distribution and mapped onto the graph using the trans3d function. Axis labels and tick marks were also added to the graphic using the trans3d function.

3. Results

First, we examined the relationship between personality traits and smoking habits for the entire sample. Multiple regression models were used to predict number of cigarettes per day, averaged across all waves, by personality trait. Table 2 includes the models which predict smoking behaviors from personality traits, demographic variables, and self-rated health. In the baseline model, a one unit increase in conscientiousness is associated with smoking 0.65 fewer cigarettes per day ($b = -0.65$, 95% CI [−0.98, −0.32]), while a one unit increase in neuroticism is associated with smoking 0.58 more cigarettes per day ($b = 0.58$, 95% CI [0.32, 0.83]). In model 2, an interaction between conscientiousness and neuroticism did not predict cigarette use ($b = -0.42$, 95% CI [−0.91, 0.06]). When demographic variables were added to the model 3, both conscientiousness and neuroticism continued to predict smoking. However, when self-rated health was added to model 4 ($b = -0.82$, 95% CI [−1.02, −0.62]), conscientiousness and

[1] All analyses were run with age^2 and race as additional covariates. The inclusion of these covariates did not affect the significance of any predictors in the model and did not change any of the estimates of the coefficients of the model more than .07 units. The models presented do not include these as covariates to simply interpretation.

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Table 1
Sample sizes and proportion of participants who responded to smoking for entire sample and for each chronic illness.

	N	% Smoking	Age	Personality interval
All participants	6978	25.49	60.20 (15.70)	10.63 (4.73)
High blood pressure	3990	21.28	65.03 (18.67)	7.88 (5.35)
Diabetes	1641	17.61	65.42 (25.74)	6.20 (5.28)
Cancer	1193	17.18	68.99 (28.96)	6.16 (5.10)
Lung disease	1239	32.36	66.20 (11.63)	6.85 (5.65)
Heart condition	2364	17.34	69.24 (23.32)	6.47 (5.21)
Stroke	579	22.45	72.23 (36.03)	5.21 (5.12)

Note: Age includes both mean and standard deviation. "Personality interval represents the number of years between the first report of smoking or the onset of disease and the personality assessment, and includes mean and standard deviation". For the row "all participants," *N* represents the number of participants who answered any question regarding smoking at any point in the survey, "% smoking" represented the proportion of those participants who have an average level of smoking greater than 0 cigarettes per week, and age represents age at first report of smoking. For all other rows, *N* represents the number of participants who at any point in the survey report having that chronic illness, "% smoking" represents the proportion of those participants who report smoking more than 0 cigarettes per week at the wave after diagnosis, and age represents age at wave of onset.

Table 2
Mean levels of smoking collapsed across all participants. Smoking is measured as number of cigarettes per day.

	Model 1		Model 2		Model 3		Model 4	
	B	(*SE*)	*B*	(*SE*)	*B*	(*SE*)	*B*	(*SE*)
Conscientiousness	**−0.65**	(0.17)	**−0.62**	(0.17)	**−0.52**	(0.17)	−0.26	(0.17)
Neuroticism	**0.58**	(0.13)	**0.58**	(0.13)	**0.47**	(0.13)	0.23	(0.13)
$C \times N$			−0.42	(0.25)	−0.40	(0.25)	−0.36	(0.24)
Age					**−0.14**	(0.01)	**−0.15**	(0.01)
Gender					**−0.90**	(0.16)	**−0.91**	(0.16)
Education					**−0.16**	(0.03)	**−0.09**	(0.03)
Self-rated health							**−0.82**	(0.10)

Note: All variables are centered at 0. Sample size for all models is 7005. Bold values indicate $p < .05$.

neuroticism no longer predicted smoking behavior ($b_{con} = -0.26$ 95% CI [−0.60, 0.07], $b_{neur} = 0.23$, 95% CI [−0.03, 0.50]).

We next examined whether smoking behaviors changed after the onset of disease. Table 3 depicts the average levels of smoking before and after the onset of disease, the standardized difference between the means, and a 95% confidence interval around the unstandardized difference. For all diseases, average levels of smoking dropped significantly, though not to zero levels, with individuals roughly decreasing on an average of 1.5 cigarettes from pre-disease levels. Effect size estimates ranged from $d = -0.12$ to $d = -0.21$ for all diseases, with the largest decreases occurring for those that developed lung disease.

To examine how personality traits influence the response to disease, we next predicted smoking behavior in the first wave following the onset of a disease. In each of these models we accounted for age, gender, and self-rated health to rule out known influences on smoking behaviors. Importantly, we also adjusted for levels of smoking prior to the disease, so that we could better examine people's responses to the disease. Table 4 displays the estimates of each regression model. For most diseases, age was associated with lower levels of smoking ($b_{\text{High Blood Pressure}} = -0.06$, 95% CI [−0.09, −0.03]; $b_{\text{Diabetes}} = -0.08$, 95% CI [−0.11, −0.03]; $b_{\text{Lung Disease}} = -0.06$, 95% CI [−0.13, 0.00]; $b_{\text{Heart Condition}} = -0.03$, 95% CI [−0.05, 0.00]; $b_{\text{Stroke}} = -0.06$, 95% CI [−0.11, −0.01]). As expected, levels of smoking prior to disease onset predicted the number of cigarettes individuals smoked after they had been diagnosed with a disease ($b_{\text{High Blood Pressure}} = 0.54$, 95% CI [0.52, 0.56]; $b_{\text{Diabetes}} = 0.49$, 95% CI [0.46, 0.52]; $b_{\text{Cancer}} = 0.51$, 95% CI [0.47, 0.55]; $b_{\text{Lung Disease}} = 0.50$, 95% CI [0.46, 0.54]; $b_{\text{Heart Condition}} = 0.46$, 95% CI [0.43, 0.48]; $b_{\text{Stroke}} = 0.49$, 95% CI [0.44, 0.54]). No main effects emerged for conscientiousness or neuroticism, with the exception of neuroticism significantly predicting smoking for individuals who had a stroke ($b = 0.81$, 95% CI [0.05, 1.56]). Main effects for conscientiousness and neuroticism also did not emerge when demographic variables and the interaction term were removed from the model, suggesting that personality traits did not directly influence the response to disease.[2]

Table 3
Comparisons of average levels of smoking before and after the onset of disease.

	Smoking before disease onset	Smoking after disease onset	Cohen's *d*	95% CI
High blood pressure	5.94	4.25	−0.16	[1.48, 1.92]
Diabetes	4.67	3.54	−0.12	[0.80, 1.45]
Cancer	4.53	3.39	−0.12	[0.75, 1.53]
Lung disease	9.30	6.61	−0.21	[2.18, 3.19]
Heart condition	5.03	3.39	−0.17	[1.36, 1.92]
Stroke	4.99	3.47	−0.16	[1.04, 2.00]

Note: Smoking measured in number of cigarettes per day. 95% CI around difference in unstandardized means.

A significant conscientiousness by neuroticism interaction occurred for individuals who developed diabetes ($b = -0.90$, 95% CI [−1.73, −0.07]), lung disease ($b = -1.44$, 95% CI [−2.82, −0.05]), and a heart condition ($b = -1.15$, 95% CI [−1.84, −0.46]).[3] No conscientiousness by neuroticism interaction was found for individuals who developed high blood pressure ($b = -.47$, 95% CI [−1.05, 0.11]), cancer ($b = -0.98$, 95% CI [−2.00, 0.04]) or stroke ($b = -0.49$, 95% CI [−1.65, 0.68]). To better understand the form of this interaction, Fig. 1 shows the predicted amount of smoking at levels of

[2] Main effects for personality did not emerge when demographic variables were removed, nor did they emerge when the interaction between conscientiousness and neuroticism was removed. Thus, these demographic variables and the interaction were not limiting the predictive power of conscientiousness and neuroticism.

[3] Removing demographic variables, self-rated health and prior smoking behaviors did not affect the statistical significance of these interactions. These various models suggest that the interaction of neuroticism and conscientiousness cannot be explained by other background variables.

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Table 4
Smoking after onset of disease. Smoking is measured as number of cigarettes per day.

		High blood pressure	Diabetes	Cancer	Lung disease	Heart condition	Stroke
Age	*B*	**−0.06**	**−0.08**	−0.03	**−0.06**	**−0.03**	**−0.06**
	SE	0.01	0.02	0.02	0.03	0.01	0.02
Gender	*B*	0.15	−0.24	0.27	0.69	0.22	0.30
	SE	0.20	0.29	0.38	0.51	0.24	0.46
Education	*B*	**−0.07**	0.02	−0.09	−0.07	−0.01	−0.12
	SE	0.03	0.05	0.06	0.09	0.04	0.07
Self-rated health	*B*	0.11	−0.10	−0.31	−0.22	0.05	0.20
	SE	0.10	0.15	0.18	0.25	0.12	0.21
Smoking before	*B*	**0.54**	**0.49**	**0.51**	**0.50**	**0.46**	**0.49**
Onset of disease	*SE*	0.01	0.02	0.02	0.02	0.01	0.03
Conscientiousness	*B*	−0.13	0.00	−0.11	0.39	0.14	0.02
	SE	0.21	0.29	0.38	0.54	0.25	0.42
Neuroticism	*B*	0.22	0.13	0.08	0.50	0.24	**0.81**
	SE	0.17	0.25	0.32	0.41	0.20	0.38
Con × Neur	*B*	−0.47	**−0.90**	−0.98	**−1.44**	**−1.15**	−0.49
	SE	0.30	0.42	0.52	0.71	0.35	0.59
Sample size		3990	1641	1193	1239	2364	579

Note: All variables are centered at 0. Bold values indicate $p < .05$. Additionally, these models include time between assessment of personality and onset of disease as a control variable.

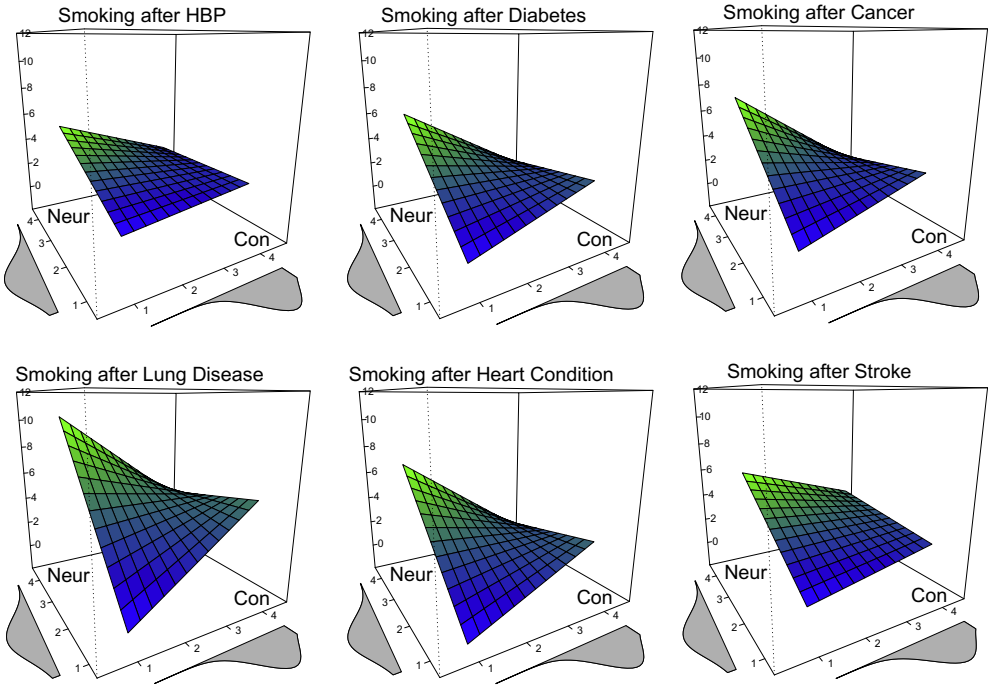

Fig. 1. Response surfaces representing the interaction between neuroticism and conscientiousness on smoking after the onset of disease.

conscientiousness and neuroticism for all six diseases included in the study. Conscientiousness and neuroticism are on the *X* and *Y* axis, respectively, and smoking, measured in number of cigarettes per day, is on the *Z* axis. Along the *X* and *Y* axes are density distributions, representing distributions of personality trait scores in our sample. For all diseases, individuals high in neuroticism and low in conscientiousness smoke substantially more cigarettes per day, consistent with previous findings for the main effect of conscientiousness and neuroticism with smoking. However, in line with the idea of the healthy neurotic, individuals both high in conscientiousness and high in neuroticism smoke the fewest cigarettes. That is, healthy neurotics smoke less than individuals high in conscientiousness and low in neuroticism.

To rule out whether it is something unique about individuals who eventually develop a disease that leads to the conscientiousness by neuroticism interaction, smoking behavior in the wave before the onset of disease was examined. Table 5 displays the estimates of these models. The interaction of conscientiousness and neuroticism was not significant in any of these models, consistent with the lack of interaction in the entire sample. Thus, it appears that the conscientiousness by neuroticism interaction only occurs as a response to the onset of disease. Conscientiousness predicted lower levels of smoking in participants about to develop high blood pressure ($b = -0.50$, 95% CI $[-1.22, -0.14]$), diabetes ($b = -0.89$, 95% CI $[-1.60, -0.17]$) and lung disease ($b = -2.27$, 95% CI $[-3.56, -0.98]$). Neuroticism predicted higher levels of smoking in participants about to develop high blood pressure ($b = 0.50$, 95% CI $[0.08, 0.92]$), diabetes, ($b = 0.67$, 95% CI $[0.09, 1.25]$), and cancer ($b = 0.97$, 95% CI $[0.28, 1.66]$). Notably, these effects are in the same direction and size as the first set of analysis, which examined average smoking behaviors collapsed across all subjects, suggesting that personality evidences a similar relationship with smoking

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Table 5
Smoking before onset of disease. Smoking is measured as number of cigarettes per day.

		High blood pressure	Diabetes	Cancer	Lung disease	Heart condition	Stroke
Age	*B*	**−0.18**	**−0.17**	**−0.20**	**−0.30**	**−0.18**	**−0.25**
	SE	0.02	0.02	0.02	0.04	0.02	0.03
Gender	*B*	**−1.10**	**−1.14**	0.14	**−1.91**	−0.58	−0.32
	SE	0.25	0.35	0.43	0.63	0.33	0.60
Education	*B*	**−0.15**	0.01	**−0.26**	−0.23	**−0.16**	**−0.32**
	SE	0.04	0.06	0.07	0.11	0.06	0.10
Self-rated health	*B*	**−0.64**	**−0.66**	−0.08	0.43	**−0.39**	−0.17
	SE	0.13	0.18	0.20	0.30	0.16	0.27
Conscientiousness	*B*	**−0.68**	**−0.89**	−0.64	**−2.27**	−0.72	−0.41
	SE	0.28	0.36	0.43	0.66	0.35	0.56
Neuroticism	*B*	**0.50**	**0.67**	**0.97**	0.23	0.34	0.87
	SE	0.22	0.29	0.35	0.50	0.28	0.50
Con × Neur	*B*	−0.77	−0.34	−1.11	−1.30	−0.66	−0.63
	SE	0.40	0.54	0.59	0.85	0.48	0.79
Sample size		5307	2145	1519	1529	2764	726

Note: All variables are centered at 0. Bold values indicate $p < .05$.

for the participants who eventually develop a disease. The effect sizes in this model are similar to the estimates found in the first analyses (roughly half a cigarette more with every 1-unit increase in neuroticism and decrease conscientiousness).

4. Discussion

Our study examined the relationship between conscientiousness and neuroticism in the prediction of smoking behaviors after the onset of a disease. In general, results indicate personality traits are associated with how one responds to disease in terms of health behaviors. More specifically, healthy neurotics – individuals high in both neuroticism and conscientiousness – smoked the least after the onset of a major chronic disease. This healthy neurotic pattern was only found in response to disease, not prior to onset or in the overall sample.

These results find that personality traits are associated with the behavioral response to a disease, which likely influence the overall markers of physical health. It is not surprising that the strongest effect of healthy neuroticism was found when examining those diseases – diabetes, lung disease, and heart conditions – with specific, narrow behavioral influences. While all the diseases are influenced by behavior, diseases like diabetes, lung disease and heart conditions are more specifically linked to unhealthy behaviors, as smoking is one of the leading risk factors of lung and cardiovascular diseases and cancer (US Department of Health, 2004). For those patients with the most to gain from behavioral changes, healthy neuroticism was associated with the healthiest behavior. While there exists a large of body of literature examining how personality traits impact health behaviors in the maintenance of positive health, few studies have examined the impact of personality after the onset of a disease (e.g., Ragland & Brand, 1988; Vollrath et al., 2007). Even though smoking behavior has obvious negative consequences for health, many other processes are likely involved in the management of health after a disease. Developing a chronic disease often necessitates the participation in novel behaviors, routines and contexts. Diabetics, for example, must monitor their blood sugar levels throughout the day. Cancer patients often undergo treatments such as chemotherapy, which cause great stress and discomfort for the patients; involve a number of the patient's friends and family, thus generating new or intense social situations; and may require the patient to take a significant amount of time off work, disrupting finances and daily routines. Our findings suggest that part of the reason personality traits are related to broad measures of health such as mortality or self rated health is that personality traits influence the ability to effectively manage diseases. Even though this finding was statistically significant for only three of the six diseases studied, the results for high blood pressure and cancer both trend in the same direction as other models, suggesting this pattern is more widespread. Future studies should continue to identify these potential novel pathways that emerge after the onset of a disease.

One possible explanation for these results is that the relationship between personality traits and health processes may take on a different meaning after the onset of a disease. Smoking to a teenager, for example, may be seen as a way to rebel or a way to demonstrate their independence and maturity, but to an adult with emphysema, smoking becomes an uncomfortable reminder of poor health and addiction. While this serves as an extreme example, it could be the case that before a person had emphysema they may have taken their health for granted, and it took the onset of a major disease for them to realize the consequences smoking had on them in particular. Similarly, it may be easier for a person who is low in conscientious to remember to take a pill to control their high blood pressure than it was for them to remember a pill to prevent it. Given the different relationship between personality and smoking pre- and post-disease, it is necessary for future research to test whether the many proposed pathways between personality in health (e.g., Hampson & Friedman, 2008; Smith, 2006) vary according to disease status.

These results also provide evidence of the "healthy neurotic," an individual high in both neuroticism and conscientiousness who experiences improved health due to the combination of these traits (Friedman, 2000; Turiano et al., 2013). Theoretically, these individuals experience increased anxiety from both their neuroticism and the onset of the disease. Because conscientiousness is associated with greater success accomplishing everyday tasks (Jackson et al., 2010), these individuals should be more successful at channeling their anxiety towards managing their disease and making healthier choices, such as closely adhering to physicians' instructions (Hill & Roberts, 2011). This study replicates previous findings that healthy neurotics smoke less (Terracciano & Costa, 2004; Vollrath & Torgersen, 2002). However, one behavioral consequence does not necessarily translate into better overall health. Perhaps this is the reason that, to our knowledge, no study has shown that healthy neurotics experience better physical health or longevity.

The interactive effect of neuroticism and conscientiousness is far from established, as this particular combination of traits is not always found to be associated with health processes or physical health. For example, conscientious neurotics are no more or less likely to use illegal drugs (Turiano et al., 2012), and we did not find that conscientious neuroticism predicts overall smoking levels prior to disease onset. A reason for the elusiveness of the healthy neurotic may be that it only occurs under certain circumstances. It has been hypothesized that some behaviors relevant to a trait

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(or in this case, a combination of traits) only manifest in specific contexts (Funder, 1995; Reeder & Brewer, 1979). The onset of a chronic disease is a novel situation, which greatly impacts the stress levels of the patient (e.g., Horowitz et al., 1980, 1983). While in most contexts the negative effects of stress and worry associated with neuroticism outweigh the possible benefits of vigilance concerning health, in this more extreme context of chronic disease, there are likely increased benefits to vigilance. That is, it is important to be especially vigilant towards one's health after a disease given the heightened consequences involved. As a result, this stressful and extreme context may tip the scales for neuroticism in a positive direction, rather than the general negative relationships with health, when paired with high levels of conscientiousness.

Further research should examine other contexts or behaviors that may be uniquely approached or utilized by healthy neurotics. While the healthy neurotic was not found in the healthy adults of this sample who had not been diagnosed with a chronic disease, healthy neuroticism may still be present in some healthy adults. We expect healthy neuroticism to be more likely to occur in relatively healthy populations when health concerns become especially prominent such as with advanced age or when one's family member experiences poor health. These contexts will likely hinge on the ability of vigilance outweighing the negative aspects of neuroticism. One context where the awareness of health may be important is becoming older and being in poorer health. Much like after the onset of a disease, older adults have more reasons to be vigilant about their health compared to young adults, and thus healthy neuroticism may be more beneficial. Another context where neuroticism would be beneficial is when the negative consequences are outsourced to someone else. For example, spouses can reap the potential benefits of their romantic partner's healthy neuroticism without any of the effects of stress on their immune system (Roberts, Smith, Jackson, & Edmonds, 2009). A spouse can be vigilant about their partner's health – as well as conscientious so as they put the vigilance in effect – by scheduling doctors appointments, making sure health behaviors are completed; as such, the partner's healthy neuroticism may help out their spouse more than it does themselves. Additionally, this study examines only the objective event of a disease diagnosis. Current research on the perception of situations (e.g., Sherman, Nave, & Funder, 2012), should be an especially useful tool in predicting how individuals will act in different contexts. Such methods may inform how perceptions of situations drive behavioral responses, thus highlighting potential mechanisms which may explain the association between personality and health.

Future research should also expand beyond the realm of behavioral responses and examine how personality traits influence emotional and cognitive processes after the onset of a disease. For example, an individual high in agreeableness may find more social support from loved ones and consequently less stress during the treatment of a disease. Additionally, emotion regulation may greatly influence the course of a disease, as they may buffer individuals from feeling increased stress (Chen & Miller, 2013). More specifically, some individuals may find meaning from an adversarial event, like the diagnosis of a major disease, and these individuals will not experience increased immune activation due to stress. Furthermore, coping processes may also play a role, as a person has to deal with the physical and mental consequences of their disease (Connor-Smith & Flachsbart, 2007). Likely, the strategies used by individuals with major health issues differ depending on the severity of the illness and their ultimate prognoses. Furthermore, coping may influence behavioral changes or vice versa. Beliefs that a particular health behavior will be beneficial predicts engagement in that behavior (Carpenter, 2010). Thus an individual whose coping strategy leads him to believe either that he is helpless or that he is fine and not in need of preventative behaviors will not engage in them. Similarly, behavioral changes may eliminate the need for emotional coping strategies. A diabetic who successfully manages her blood sugar may not need to rely on social support or reframing. The extent to which an individual engages in both emotional coping and behavioral changes, as well as the effectiveness of those strategies, should be predicted by their personality before the onset of disease.

Greater precision in predicting outcomes may be achieved through the use of facets. Individual components of these traits should aid not only in the prediction of which individuals will have healthy or unhealthy responses to disease but also in the understanding of why such individuals respond in these ways. For example, a meta-analysis of conscientiousness-related traits demonstrated that the facet lack of self-control was a bigger predictor of tobacco use than the facets order and responsibility (Bogg & Roberts, 2004). Thus, we may expect that individuals specifically low on self-control are less likely to reduce smoking after a diagnosis.

While this study provides a unique insight into the association of personality with behaviors after a major health episode, a few limitations must be considered. First, the study began in 1992, but personality traits were only measured starting in 2006, resulting in personality measurements anywhere from two years before to 16 years after the onset of disease. This may be problematic if personality traits change along with changes in health (e.g., Takahashi, Edmonds, Jackson, & Roberts, 2013). Ideally, personality traits would have been measured just before the onset of disease. However, while mean changes in health may occur during the course of this study, rank order on personality should remain stable (Roberts & DelVecchio, 2000). As such, we expect that the associations hold true: as one increases on both conscientiousness and neuroticism compared to others, one smokes less after the onset of disease. This study is further limited by the amount of time between smoking assessments as habits and behaviors are likely to change, perhaps multiple times, within the two years between disease onset and smoking measurement. For example, some individuals may attempt to quit smoking immediately after onset and relapse within a few months. Others may go through repeated attempts and failures to quit. Future studies should include more frequent measurements of health behaviors to track the patterns which emerge after a health episode. Additionally, a number of individuals involved in the panel study passed away before the personality assessments in 2006. These individuals were less likely to have high blood pressure or diabetes, but more likely to be diagnosed with cancer, lung disease, a heart condition or a stroke. As such, disease status may be confounded with taking a personality assessment in this study.[4]

Future studies should include other health behaviors. Smoking is a fairly straightforward health behavior in that it has negative consequences at all levels. Other behaviors, such as drinking or exercise, have a curvilinear relationship with health, such that moderate amounts of drinking may be beneficial to health (Gaziano et al., 2000) and extreme amounts of exercise can weaken immune systems (Smith, 2003). Personality traits may lead to optimal levels of these health behaviors, but perhaps the same anxiety that drives down smoking in this study leads to extreme and unhealthy levels of other behaviors, such as dieting. Additionally,

[4] *T*-tests were used to determine whether those individuals who passed were more or less likely to have specific diseases. Individuals who died were less likely to have high blood pressure, $t(37{,}928) = -17.88$, $p < .05$ and diabetes, $t(37{,}938) = -4.03$, $p < .05$, but more likely to have been diagnosed with cancer, $t(37{,}938) = 8.23$, $p < .05$, lung disease, $t(37{,}938) = 9.79$, $p < .05$, a heart condition, $t(37{,}938) = 12.56$, $p < .05$, and stroke, $t(37{,}938) = 16.88$, $p < .05$. It should be noted that the standardized difference in disease status is fairly small, ranging in size from a Cohen's *d* of .04 to .18.

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the inclusion of other health behaviors may uncover whether individuals are truly improving their health or if they have simply transferred their unhealthy behavior to another domain, for example by replacing their cigarette with a bag of potato chips. Finally, all measurements in this study were self-report. Future studies should incorporate other methods of measurement, such as physician-rated health, daily observations of health behaviors, and informant-reports of personality to reduce mono-method assessments.

In conclusion, the present study is among the first to demonstrate the unique associations between personality and health behaviors after the onset of a disease, including the presence of a healthy neurotic effect on smoking. These associations suggest that major health events constitute unique contexts, in which traditional relationships between personality and behaviors may change.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jrp.2014.04.008.

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