Nicotine & Tobacco Research Volume 9, Number 3 (March 2007) 397–404

Personality and smoking status: A longitudinal analysis

Marcus R. Munafò, Stephanie Black

Received 18 August 2005; accepted 26 February 2006

We attempted to clarify the strength and nature of the association between personality and smoking status in early and middle adulthood, using a longitudinal study design. Data from the Medical Research Council National Survey of Health and Development, based on a stratified sample of all single, legitimate births occurring in England, Wales, and Scotland in one week of March 1946 (N=5,362), were analyzed using generalized estimating equations methods to account for the correlation between the smoking status variables for the same individual over time. The unadjusted estimates indicated that the odds of being a current smoker increased with higher personality score for both extraversion ($p<.0001$) and neuroticism ($p<.0001$) traits. Sex was significantly associated with being a current smoker ($p<.0001$), with males more likely than females to be current smokers. Current smoking decreased with increasing age ($p<.0001$). These relationships were maintained in the fully adjusted model. These data indicate that both higher levels of extraversion and higher levels of neuroticism, as measured at age 16, are independently associated with an increased likelihood of subsequently being a current smoker rather than a nonsmoker at all time points, although the observed effect sizes were small. Males also were more likely than females to be current smokers, and increasing age reduced the likelihood of being a current smoker, which is consistent with an attempt by a subset of smokers in the cohort to subsequently stop smoking.

Introduction

Smoking is the major preventable cause of disease worldwide, but despite the well-known associated health risks, smoking prevalence is still increasing. If current trends continue, tobacco use will most likely become the world's leading cause of premature death in less than 30 years (Peto, Chen, & Boreham, 1999). Smoking prevalence has increased among adolescents and young adults in many countries in recent years (Munafò, Drury, Wakley, Chambers, & Murphy, 2003), and the rate of decline among adults (Mendez & Warner, 2004) has shown signs of leveling off (Munafò, Drury et al., 2003), although considerable variation remains between countries (Kubik & Plesko, 1998). Interest is growing in individual differences in smoking behavior and response to treatment (Munafò, Bradburn, Bowes, & David, 2004), but individual differences in smoking initiation also are of potential interest if the increase in smoking prevalence among adolescents and young adults is to be countered.

Disagreement remains about whether a trait approach can be used to adequately conceptualize personality (Cervone, Shadel, & Jencius, 2001), but agreement exists regarding major trait dimensions, with factor analytic models typically describing five major dimensions (e.g., McCrae & Costa, 1997), and causal theorists typically describing mechanisms underlying three major dimensions (e.g., Cloninger, 1987; Eysenck & Eysenck, 1991; Gray, 1970). Both factor analytic and causal approaches have demonstrated strong agreement that the dimensions of extraversion-introversion and neuroticism-stability are fundamental parts of any personality taxonomy, and these dimensions have been variously proposed to correspond to differential activity in neurotransmitter systems (Ebstein, Benjamin, & Belmaker, 2000; Lesch, 1998; Mealey, 1995). Therefore, although disagreement remains over what, if any, mechanisms underlie observed variation along trait

Marcus R. Munafò, Ph.D., Department of Experimental Psychology, University of Bristol, Bristol, United Kingdom; Stephanie Black, M.Sc., MRC National Survey of Health and Development, University College London, United Kingdom.

Correspondence: M. R. Munafò, Ph.D., Department of Experimental Psychology, 12a Priory Road, University of Bristol, Bristol BS8 1TU, United Kingdom. Tel: +(44) 117-9546841; Fax: +(44) 117-9288588; E-mail: marcus.munafo@bristol.ac.uk

ISSN 1462-2203 print/ISSN 1469-994X online
DOI: 10.1080/14622200701188869

dimensions, consensus exists over the construct validity of two of these dimensions (described as extraversion, novelty seeking, or impulsivity, and neuroticism and harm avoidance, respectively), which appear under various guises in all commonly used measurement instruments (Revelle, 1995). Extraversion comprises facets of sociability, impulsivity, and sensation seeking, whereas neuroticism comprises facets of anxiety, negative affect (i.e., depression), and anger. Equally, considerable debate continues over the remaining dimensions.

Certain personality dimensions drawn from personality trait theory have been reported to be associated with aspects of smoking behavior (Gilbert, 1997; Munafò, Johnstone, Murphy, & Walton, 2001). Unfortunately, the literature regarding the association between personality trait variables and smoking behavior is somewhat inconsistent, although a narrative review (Gilbert, 1995) noted that, despite some inconsistencies, both extraversion and neuroticism traits appear to be positively associated with smoking behavior. A recent meta-analysis (Munafò, Zetteler, & Clark, 2007) indicated modest but significant associations between smoking status and both extraversion and neuroticism, as measured using instruments developed from Eysenck's taxonomy (Eysenck, 1959; Eysenck & Eysenck, 1964, 1975, 1991). Using measurement instruments developed by Cloninger's taxonomy (Cloninger, 1987), a recent large-scale survey reported similar findings (Etter, Pélissolo, Pomerleau, & De Saint-Hilare, 2003). Unfortunately these data, derived from case-control observational studies, precluded any conclusions being drawn regarding the direction of causation of these associations. A number of studies have investigated the association between personality and smoking initiation longitudinally in adolescence (e.g., Audrain-McGovern et al., 2004; Harakeh, Scholte, de Vries, & Engels, 2005), typically reporting an association between extraversion or novelty seeking and initiation, with higher scores on these traits associated with an increased likelihood of initiation. However, few studies have followed participants into adulthood to determine the role of personality on both early smoking behavior and later transitions, most notably from smoking to not smoking (i.e., smoking cessation).

Individual differences in extraversion and neuroticism may therefore represent important risk factors for initial smoking initiation and subsequent persistence. Both personality traits and smoking behavior have been reported to be highly heritable (Floderus-Myrhed, Pedersen, & Rasmuson, 1980; Li, Cheng, Ma, & Swan, 2003), with some evidence indicating that they may partially share a common genetic basis (Heath & Madden, 1995). Individuals scoring high on measures of extraversion might be more likely to smoke because the reinforcing properties of nicotine exert a proportionately greater effect than the aversive properties (Glautier, 2004), via common dopaminergic pathways implicated in reward learning and facets of extraversion traits such as impulsivity and sensation seeking (Reuter, Netter, Toll, & Hennig, 2002). Alternatively, the effect might be mediated by higher levels of sociability among those who score highly on these traits, given that individuals with high levels of sociability may be strongly motivated to participate in social events, even if doing so is contingent on adopting behaviors such as smoking (Killen et al., 1997). Both of these putative explanations are consistent with the observed positive associations between higher levels of extraversion and increased likelihood of smoking initiation in adolescents (e.g., Audrain-McGovern et al., 2004; Harakeh et al., 2005). With respect to measures of neuroticism, some evidence indicates that smokers who smoke to control negative affect report higher levels of neuroticism (e.g., Lerman et al., 1998), which may reflect an attempt to self-medicate high basal levels of negative affect or anxiety with nicotine (Eysenck, Grossarth-Maticek, & Everitt, 1991).

Growing evidence indicates an association between measures of both extraversion and neuroticism and smoking status from cross-sectional observational studies (e.g., Munafò et al., 2007), and for an association between these traits and smoking initiation in adolescents (e.g., Audrain-McGovern et al., 2004; Harakeh et al., 2005), but longitudinal data describing the predictive value of personality measured in adolescence and smoking behavior in early and middle adulthood are relatively lacking. Given that personality traits may exert different influences on smoking behavior at various stages in an individual's smoking career, such as influences on initiation, persistence, and subsequent cessation, it is important to consider the impact of personality on smoking behavior across time. Existing studies that have examined predictors of smoking trajectory have suggested that personality factors measured in adolescence can be weak or nonsignificant predictors of adult smoking behavior (e.g., Chassin, Presson, Pitts, & Sherman, 2000; White, Pandina, & Chen, 2002), However, these studies have not investigated personality traits such as extraversion and neuroticism, which are supposed to reflect individual differences in neurobiological function of possible relevance to addictive behaviors such as cigarette smoking (Chassin et al., 2000), or they have focused on a single facet such as sensation seeking (White et al., 2002).

The primary purpose of the present study was to attempt to clarify the strength and nature of the association between personality and smoking status in early and middle adulthood, using a longitudinal study design. In addition, we hypothesized that both

extraversion and neuroticism would predict the transition among smokers to becoming nonsmokers (i.e., smoking cessation) over time.

Method

Participants

The Medical Research Council National Survey of Health and Development was established in 1946, based on a stratified sample of all single, legitimate births occurring in England, Wales, and Scotland in one week of March 1946 (N=5,362). The sampling procedure and follow-up have been described in detail elsewhere (Wadsworth et al., 1992). Since the survey was set up, 20 data collections have been undertaken: 10 before the children had reached age 16, and the remainder at ages 19, 20, 22, 23, 25, 26, 31, 36, 43, and 53 years. The most recent data collection was in 1999 (age 53), when 3,035 survey members were interviewed, representing 57% of the original sample. When those survey members who had died, emigrated, or permanently refused to participate were excluded from the denominator, this proportion rose to 83% (Wadsworth et al., 2003).

Materials

Personality was measured using the Maudsley Personality Inventory (MPI; Eysenck, 1959). Survey members completed the short-form MPI at age 16. This inventory produces scores on two statistically independent personality dimensions of extraversion and neuroticism. The task for the respondent was to answer 12 questions, for which the response options were "yes," "impossible to decide," or "no." Each question was scored as "yes"=0, "impossible to decide"=1, and "no"=2, and the individual item scores were summated. Six questions related to extraversion and six to neuroticism, so that the possible scoring range for each scale was 0–12. Smoking status (current smoker, ex-smoker, never-smoker) was assessed by self-report at ages 20, 25, 31, 36, 43, and 53 years. Those who classified themselves as current smokers also reported the number of cigarettes smoked per day. Cigarette consumption at each time point was coded into three categories: Category 1 was greater than or equal to 1 cigarette/day and less than or equal to 10; category 2 was greater than 10 and less than or equal to 20; and category 3 was greater than 20.

Data analyses

Our sample for analysis included all participants who had both personality scores at age 16 (N=3,701), and our outcome of interest was smoking status at the different time points between ages 20 and 53. We defined three groups according to the amount of smoking status information available: Complete at all time points (n=1,642), incomplete (n=1,920), and all missing (n=139). We found no significant difference in the means of either of the personality scores between these three groups, but we did find a significant difference between the proportion of males and females, with more females than males in the complete group. The distribution of the neuroticism subscale (range=0–12) appeared to favor even numbers over odd. Therefore, for analysis, we combined the frequencies for adjacent scores in pairs, starting at 0, with the maximum score of 12 unpaired, and then recoded on a new scale (range=0–6) as follows: (0–1) $\rightarrow$ 0, (2–3) $\rightarrow$ 1, (4–5) $\rightarrow$ 2, (6–7) $\rightarrow$ 3, (8–9) $\rightarrow$ 4, (10–11) $\rightarrow$ 5, (12) $\rightarrow$ 6. The extraversion subscale data were then collapsed in the same way for consistency.

To assess the relationship of personality as measured at age 16 and current smoking behavior at each age between 20 and 53 years, we compared nonsmokers (never-smokers and ex-smokers, combined) with current smokers at each time point. As a result, repeated smoking status observations exist for the same individual over time. These observations are likely to be intercorrelated, which needs to be taken into account so that valid inferences can be drawn and missing outcomes at some of the time points can be accommodated. We analyzed the data using generalized estimating equations methods (Diggle, Liang, & Zeger, 1994), which take into account the correlation between the smoking status variables for the same individual over time and also allow inclusion of all individuals who have at least one outcome measure. This analysis method is a marginal modeling approach, which allows us to obtain population-averaged estimates that are easily interpretable. This analysis was performed with two different working correlation matrices specified. One was unstructured and the other used a structure that allows for serial correlation between smoking status at adjacent time points. Sex and a linear effect for age were included in the model. A more complicated polynomial association with age was found to be unnecessary. To test whether the association between personality at age 16 and smoking status varied with age, we conducted tests for interaction between age and personality for both extraversion and neuroticism in the full model, which contained extraversion and neuroticism scores, sex, and age. This process was repeated with sex instead of age to test whether the association between personality and smoking status varied with sex. A secondary analysis was conducted to assess the relationship of personality (as measured at age 16) with current cigarette consumption in those who reported being smokers at all six time points (i.e.,

continual smokers). The methods used were the same as above: An unstructured working correlation matrix with cigarette consumption the outcome of interest. For this specific analysis, cigarette consumption was coded as a binary outcome with categories 2 and 3 combined, so that light smokers (no more than 10 cigarettes/day) were compared with current heavy smokers (more than 10 cigarettes/day).

To assess whether personality as measured at age 16 predicted who, of the current smokers at 20 years, subsequently stopped smoking, we used a Cox model for analysis of time to event (i.e., first self-report of being an ex-smoker) from an origin at age 20. The proportional hazards assumption was tested by use of time-dependent covariates. If the proportional hazard assumption was not met, the variable was included as a time-dependent covariate with a main effect and an interaction term with time to smoking cessation centered at 33. Because data were collected only at discrete intervals, the time at which the event occurred was assumed to be the time of the first interview at which stopping smoking was reported. Excluded from the analysis were participants who reported being a current smoker at 20 years but for whom no smoking status data were available at 25 years. If information on smoking status was missing at any of the later interviews, follow-up was until the interview preceding the one for which missing data first occurred.

The follow-up of participants who reported being current smokers at all data points was censored at 53 years (i.e., the age at the latest data collection). The analyses were, therefore, performed again using a model that specifically accounted for the interval-censored nature of the data. Results from the two methods were compared to see if any substantive differences existed. Kaplan–Meier estimates were calculated to obtain the probability of smoking cessation at different ages. A secondary analysis was conducted as above with cigarette consumption in the three categories included as a time-updated covariate. Cigarette consumption at each time point was used if available, and if it was not available, we used the most recent previous value that was available prior to each time point. In this final analysis sample (N=1,269), the probabilities of smoking cessation were calculated for those males and females above and below the mid-value extraversion and neuroticism score (i.e., 3) using the Kaplan–Meier method, stratifying first by neuroticism and sex, and then by extraversion and sex.

Results

Personality and smoking status

Analysis suggested that both working correlation matrices specified were reasonable. The results for an unstructured correlation matrix are reported, because we found little difference between the two sets of results. A sample of N=3,562 was available for analysis.

The unadjusted estimates indicated that the odds of being a current smoker increased with personality score for both extraversion (OR=1.13, 95% CI=1.09–1.18, p<.0001) and neuroticism (OR =1.07, 95% CI=1.04–1.11, p<.0001) traits. Sex was significantly associated with being a current smoker (OR=1.32, 95% CI=1.18–1.47, p<.0001), with males more likely than females to be current smokers. Current smoking decreased with increasing age (OR=0.96, 95% CI=0.96–0.97, p<.0001). These relationships were maintained in the fully adjusted model. We found evidence of a significant interaction of age and sex (p<.0001), with the effect of sex weakening with increasing age. No evidence was found for a significant interaction with age for either extraversion (p=.91) or neuroticism (p=.93) traits. The interaction between sex and personality was nonsignificant for both extraversion (p=.16) and neuroticism (p=.12) traits. These results are presented in Table 1.

Data on cigarette consumption for smokers at all the time points between ages 20 and 53 years were available on a subset of 217 subjects. In the unadjusted analysis, the odds of being a heavy smoker increased with higher levels of neuroticism and decreased with higher levels of extraversion, although neither of these associations was statistically significant. The odds of being a current heavy smoker increased with increasing age (OR=1.03, 95% CI=1.02–1.04, p<.0001). Males were more likely than females to be heavy smokers (OR=2.03, 95% CI=1.38–2.98, p=.0003). In the adjusted analysis, the odds of being a heavy smoker increased with neuroticism score, a statistically significant finding (OR=1.14, 95% CI=1.01–1.28, p=.0313). We found evidence of an interaction between extraversion and age (p=.0057), which suggested that the association between current heavy smoking and higher levels of extraversion weakens with age. These results are presented in Table 2.

Personality and smoking cessation

All individuals who had reported being a current smoker at 20 years and provided information for at least the first follow-up at 25 years were eligible for inclusion. A sample of 1,342 subjects was available for analysis. For those who were current smokers at age 20, the probability of smoking cessation before age 25 was 0.32; corresponding values were 0.56 before age 36, 0.63 before age 43, and 0.71 before age 53.

Given that we found no difference between the unadjusted personality trait results using a Cox

Table 1. Relationship between personality at age 16 years and being a current smoker between ages 20 and 53 years (n=3,562).

	Unadjusted estimates		Adjusted estimates[a]	
	Odds ratio (95% *CI*)	*p* value	*Odds ratio* (95% *CI*)	*p* value
Age	0.96 (0.96–0.97)	<0.0001	0.97 (0.97–0.97)	<.0001
Sex	1.32 (1.18–1.47)	<0.0001	1.97 (1.62–2.39)	<.0001
Extraversion	1.13 (1.09–1.18)	<0.0001	1.15 (1.11–1.20)	<.0001
Neuroticism	1.07 (1.04–1.11)	<0.0001	1.12 (1.09–1.16)	<.0001
Age × sex			0.99 (0.98–0.99)	<.0001

Note. Results using an unstructured working correlation matrix. [a]Full model includes age, sex, age × sex, extraversion and neuroticism. Increasing age is associated with reduced likelihood of being a current smoker, while male sex, higher extraversion and higher neuroticism are all associated with an increased likelihood of being a current smoker, with the effect of sex decreasing with age.

proportional hazards model and an analysis taking into account the interval-censored nature of the data, the results reported here are from either a proportional hazards analysis or a Cox model allowing time-dependent covariates. The unadjusted analysis indicated that the association between personality and smoking cessation was nonsignificant for both extraversion (HR=0.97, 95% CI=0.93–1.02, p=.29) and neuroticism (HR=0.97, 95% CI=0.93–1.01, p=.10) traits. Sex was modeled as a time-dependent covariate because the association between sex and time to smoking cessation changed over time. At age 20 the rate of smoking cessation was lower for men than for women, although this finding was not significant (HR=0.88, 95% CI=0.70–1.11, p=.27). At age 53 the rate was significantly greater for men than for women (HR=1.93, 95% CI=1.30–2.85, p=.001).

When the analysis was performed again, modeling both personality scores together while controlling for sex as a time-dependent variable, the estimates for both personality scores remained unchanged. The smoking cessation rate changed over time from age 20, when the rate was nonsignificantly lower for men than for women (HR=0.86, 95% CI=0.68–1.09, p=0.20), to age 53, when the rate was significantly greater for men than for women (HR=1.89, 95% CI=1.28–2.80, p=.0015). These results are presented in Table 3.

Among the original sample of 1,342 subjects, data on cigarette consumption were available on a subset of 1,269 subjects. In the fully adjusted model, increased cigarette consumption was associated with a decreased likelihood of smoking cessation, with those smoking 11–20 cigarettes/day less likely to stop smoking than those smoking 1–10 cigarettes/day (HR=0.43, 95% CI=0.36–0.50, p<.0001), and those smoking 21+ cigarettes/day less likely to stop smoking than those smoking 11–20 cigarettes/day. Rate of smoking cessation by sex again varied over time, but at all ages men had a higher rate than women (age 20: HR=1.06, 95% CI=0.82–1.36; age 53: HR=2.49, 95% CI=1.67–3.72). The effect of neuroticism was nonsignificant (p=.43). The association of extraversion with smoking cessation changed over time, with the association at age 20 nonsignificant (HR=1.06, 95% CI=0.97–1.16, p=.21), whereas the association at age 53 was significant (HR=0.83, 95% CI=0.72–0.95, p=.008), with increased extraversion associated with a reduced likelihood of smoking cessation. These results are presented in Table 4.

For females, the probability of stopping smoking before age 53 was 0.73 among those with an extraversion score less than 3, whereas it was 0.63 among those with a score greater than or equal to 3. For males, the probability of stopping smoking before age 53 was 0.80 among those with an

Table 2. Relationship between personality at age 16 years and heaviness of smoking among smokers between ages 20 and 53 years (n=217).

	Unadjusted estimates		Adjusted estimates[a]	
	Odds ratio (95% CI)	*p* value	*Odds ratio* (95% *CI*)	*p* value
Age	1.03 (1.02–1.04)	<0.0001	1.10 (1.05–1.15)	<.0001
Sex	2.03 (1.38–2.98)	0.0003	2.26 (1.52–3.36)	<.0001
Extraversion	0.96 (0.82–1.11)	0.5513	1.44 (1.04–2.01)	.0290
Neuroticism	1.07 (0.96–1.18)	0.2371	1.14 (1.01–1.28)	.0313
Extraversion × age			0.99 (0.98–1.00)	.0057

Note. Results using an unstructured working correlation matrix. [a]Full model includes age, sex, extraversion and neuroticism. Increasing age, male sex, higher extraversion and higher neuroticism are all associated with increased heaviness of smoking, while associated with an increased likelihood of being a current smoker, with the effect of extraversion decreasing with age.

Table 3. Relationship between personality and time to smoking cessation (n=1,342).

	Unadjusted estimates		Adjusted estimates[a]	
	Hazard ratio (95% *CI*)	*p* value	*Hazard ratio* (95% *CI*)	*p* value
Sex	1.93[b] (1.30–2.85)	0.0010	1.89[b] (1.28–2.80)	.0015
Sex × time (centered at 33)	1.02 (1.01–1.04)	0.0050	1.02 (1.01–1.04)	.0049
Extraversion	0.97 (0.93–1.02)	0.2909	0.97 (0.92–1.02)	.1847
Neuroticism	0.97 (0.93–1.01)	0.1024	0.98 (0.94–1.01)	.2096

[a]Full model includes sex, extraversion, neuroticism, and sex × time to smoking cessation interaction. Male sex is associated with an increased likelihood of smoking cessation, with the effect of sex increasing with age. [b]Hazard ratio at age 53. Hazard ratio for sex at age 20 in the fully adjusted model is obtained by setting time to smoking cessation=0 in the formula:

$$\mathrm{Exp}^{[(\text{main effect for sex}) + \text{sex} \times (\text{time to smoking cessation} - 33)]}$$

$$\mathrm{Exp}^{[(0.63554) + 0.02390 \times (-33)]} = 0.86.$$

extraversion score less than 3, whereas it was 0.74 among those with a score greater than or equal to 3.

Discussion

These data from a single cohort followed longitudinally between, for the purposes of this study, 1962 and 1999 indicate that both higher levels of extraversion and higher levels of neuroticism, as measured at age 16, are independently associated with an increased likelihood of subsequently being a current smoker rather than a nonsmoker at all time points, although the observed effect sizes were small. Males also were more likely than females to be current smokers, and increasing age reduced the likelihood of being a current smoker, which is consistent with an attempt by a subset of smokers in the cohort to subsequently stop smoking. The significant interaction of age and sex lends support to our findings that, among smokers, the attempt to stop smoking was more successful in men than in women.

We found evidence for an association between extraversion and smoking cessation, but only after adjustment for sex and cigarette consumption, and no association with neuroticism. The association changed with age from a nonsignificant association at age 20 to a significant negative association at age 53. Therefore, although we found an association between both extraversion and neuroticism, as measured at age 16, and smoking behavior, when we controlled for sex and cigarette consumption, only extraversion predicted the transition from being a current smoker to being an ex-smoker. This association predicted, at older ages, a reduction in the rate of smoking cessation with higher levels of extraversion. We also found evidence that the association between sex and smoking cessation changed over time. The association changed from a nonsignificant association at age 20 to a significant

Table 4. Relationship between personality, cigarette consumption and time to smoking cessation (n=1,269).

	Unadjusted estimates		Adjusted estimates[a]	
	Hazard ratio (95% *CI*)	*p* value	Hazard ratio (95% *CI*)	*p* value
Sex	1.85[b] (1.25–2.73)	0.0022	2.49[b] (1.67–3.72)	<.0001
Sex × time (centered at 33)	1.02 (1.00–1.04)	0.0239	1.03 (1.01- 1.04)	.0032
Extraversion	0.89[b] (0.77–1.02)	0.0968	0.83[b] (0.72–0.95)	.0079
Extraversion × time (centered at 33)	1.00 (0.99–1.00)	0.1240	0.99 (0.99 – 1.00)	.0160
Neuroticism	0.96 (0.92–1.00)	0.0513	0.98 (0.94–1.03)	.4346
Consumption				
1–10	1.00 (Reference)		1.00 (Reference)	
11–20	0.45 (0.38–0.52)	<0.0001	0.43 (0.36–0.50)	<.0001
21+	0.27 (0.20–0.36)	<0.0001	0.23 (0.18–0.31)	<.0001

[a]Full model includes sex, extraversion, neuroticism, cigarette consumption, and sex × time to smoking cessation and extraversion × time to smoking cessation interactions. Male sex is associated with an increased likelihood of smoking cessation, with the effect of sex increasing with age, while higher extraversion and higher cigarette consumption are associated with reduced likelihood of smoking cessation, with the effect of extraversion increasing with age. [b]Hazard ratio at age 53. Hazard ratio for extraversion at age 20 in the fully adjusted model is obtained by setting time to smoking cessation=0 in the formula below:

$$\mathrm{Exp}^{[(\text{main effect for extraversion}) + \text{extraversion} \times (\text{time to smoking cessation} - 33)]}$$

$$\mathrm{Exp}^{[(-0.19272) + -0.00759 \times (-33)]} = 1.06.$$

association at age 53, with men more likely than women to report having stopped.

The longitudinal design of this study is a considerable strength. Although many of those who became smokers did so before the assessment of personality at age 16, they were unlikely at that age to have smoked for an extended period, which reduces the possibility that differences between smokers and nonsmokers on measures of extraversion and neuroticism were related to changes in personality resulting from chronic nicotine exposure, although our data did not allow us to test this possibility directly. In addition, our finding that the association of extraversion with smoking status weakened with age suggests that this trait may be associated primarily with likelihood of early smoking initiation compared with later smoking initiation, although our data lack the temporal resolution to test this possibility directly. Nevertheless, this interpretation is consistent with the literature (Audrain-McGovern et al., 2004; Masse & Tremblay, 1997). Finally, only extraversion, and not neuroticism, appeared to be associated with smoking cessation. This finding may be related to higher levels of extraversion being associated with an increased social support network comprising other smokers, which may increase the perceived social costs of smoking cessation, or may operate via increased strength of reward learning, mediated by dopamine pathways implicated in both reward and extraversion behaviors.

In all cases the observed effect sizes for the association between personality variables and smoking behavior were small, which is consistent with previous longitudinal studies that have investigated psychosocial predictors of smoking behavior such as personality (Chassin et al., 2000; White et al., 2002). One possibility is that aspects of personality and smoking behavior share a common genetic basis, and promising dopaminergic and serotonergic candidate genes have been investigated in relation to both personality (Munafò et al., 2003) and smoking behavior (Munafò, Clark, Johnstone, Murphy, & Walton, 2004). However, another possibility is that direct effects are relatively weak, and that personality variables may exert indirect effects via variables more proximal to smoking behavior, such as risk-taking behaviors that arise both from facets of personality (e.g., impulsivity) and from developmental influences (e.g., Wills, Sandy, & Yaeger, 2000).

The finding of an association between sex and the likelihood of smoking cessation is consistent with reports of sex differences in smoking cessation (Perkins, 2001). When personality and cigarette consumption were taken into account, a strong positive impact of male sex on the likelihood of stopping smoking at older ages remained, suggesting that the sex difference is not explained by the level of consumption, despite our observation that men smoked more cigarettes per day than women. It is also possible that cessation in this cohort reflects largely spontaneous (i.e., unaided) cessation, with substantial variability in cigarette consumption and nicotine dependence accounting for a large proportion of the variance in smoking cessation. Among a treatment-seeking cohort of highly dependent smokers, among whom less variability is found in cigarette consumption, greater sex differences in likelihood of cessation may exist.

Several study limitations should be noted. First, smoking status was assessed by self-report and not validated biochemically. However, the data were collected as part of a larger survey under conditions of anonymity, and we have no particular reason to doubt the veracity of these self-reports. Second, and a related point, this study was not designed explicitly to study the association of personality with smoking behavior or smoking cessation. Therefore, less detailed information is available regarding, for example, smoking cessation than one might ideally wish for, and no information is available on smoking status at age 16. Nevertheless, with respect to the research question posed, these data are appropriate and enable some (albeit limited) conclusions to be drawn. Third, the personality measurement instrument used in the original study is generally no longer used, having been superseded by three subsequent revisions (EPI, Eysenck & Eysenck, 1964; EPQ, Eysenck & Eysenck, 1975, EPQ-R: Eysenck & Eysenck, 1991) within the same conceptual taxonomy, and the factor structures of the personality traits investigated (in particular extraversion) have altered somewhat across these revisions. Nevertheless, neuroticism and (to a lesser degree) extraversion are widely agreed to be traits that are common to all widely used personality models and theories. Fourth, one possibility may be that chronic nicotine exposure results in personality change over time. Although the early measurement of personality at age 16 reduces the likelihood that this possibility will account entirely for the association between personality and smoking status, such an effect may still occur. The single measurement of personality precludes us from testing this possibility. However, substantial evidence indicates that personality change over time is modest. Nevertheless, the assumption that personality at age 16 combines additively to influence likelihood of smoking is a strong one, and we were unable to test more sophisticated possibilities, for example, that personality may share variances with other, unknown variables to predict smoking status. In a long-running cohort such as the National Survey of Health and Development, missing data are inevitable, and these losses may lead to bias.

Personality measured at age 16 appeared to predict subsequent smoking status from ages 20 to 53. Among those who were smokers at age 20, at older ages a lower level of extraversion predicted an increased likelihood of subsequent smoking cessation when sex and cigarette consumption were taken into account. Nevertheless, these effects are small in magnitude and may operate via variables more proximal to smoking behavior.

Acknowledgments

This work was supported by a Cancer Research UK Programme Grant and the Medical Research Council.

References

Audrain-McGovern, J., Rodriguez, D., Tercyak, K. P., Cuevas, J., Rodgers, K., & Patterson, F. (2004). Identifying and characterizing adolescent smoking trajectories. *Cancer Epidemiology, Biomarkers, and Prevention*, *13*, 2023–2034.

Cervone, D., Shadel, W. G., & Jencius, S. (2001). Social cognitive theory of personality assessment. *Personality and Social Psychology Review*, *5*, 33–51.

Chassin, L., Presson, C. C., Pitts, S. C., & Sherman, S. J. (2000). The natural history of cigarette smoking from adolescence to adulthood in a midwestern community sample: Multiple trajectories and their psychosocial correlates. *Health Psychology*, *19*, 223–231.

Cloninger, C. R. (1987). A systematic method for clinical description and classification of personality variants: A proposal. *Archives of General Psychiatry*, *44*, 573–588.

Diggle, P. J., Liang, K.-Y., & Zeger, S. L. (1994). *Analysis of longitudinal data*. Oxford, U.K.: Oxford University Press.

Ebstein, R. P., Benjamin, J., & Belmaker, R. H. (2000). Personality and polymorphisms involved in aminergic neurotransmission. *European Journal of Pharmacology*, *410*, 205–214.

Etter, J. F., Pélissolo, A., Pomerleau, C. S., & De Saint-Hilare, Z. (2003). Associations between smoking and heritable temperament traits. *Nicotine & Tobacco Research*, *5*, 401–409.

Eysenck, H. J. (1959). *Manual of the Maudsley Personality Inventory*. London: University of London Press.

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

Eysenck, H. J., & Eysenck, S. B. G. (1975). *Manual of the Eysenck Personality Questionnaire*. London: Hodder & Stoughton.

Eysenck, H. J., & Eysenck, S. B. G. (1991). *Manual of the Eysenck Personality Questionnaire–Revised*. London: Hodder & Stoughton.

Eysenck, H. J., Grossarth-Maticek, R., & Everitt, B. (1991). Personality, stress, smoking, and predisposition as synergistic risk factors for cancer and coronary heart disease. *Integrative Physiological and Behavioral Science*, *20*, 309–322.

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

Gilbert, D. G. (1995). *Smoking: Individual differences, psychopathology, and emotion*. Washington, DC: Taylor & Francis.

Gilbert, D. G. (1997). The situation × trait adaptive response (STAR) model of drug use, effects, and craving. *Human Psychopharmacology*, *12*, S89–S102.

Glautier, S. (2004). Measures and models of nicotine dependence: Positive reinforcement. *Addiction*, *99*(Suppl. 1), 30–50.

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy*, *8*, 249–266.

Harakeh, Z., Scholte, R. H., de Vries, H., & Engels, R. C. (2005). Association between personality and adolescent smoking. *Addictive Behaviors*, *100*, 862–870.

Heath, A. C., & Madden, P. A. F. (1995). Genetic influence on smoking behavior. In: J. R. Turner, L. R. Cardon, & J. K. Hewitt (Eds.), *Behavior genetic approaches in behavioral medicine* (pp. 45–66). New York: Plenum Press.

Killen, J. D., Robinson, T. N., Haydel, K. F., Hayward, C., Wilson, D. M., Hammer, L. D., Litt, I. F., & Taylor, C. B. (1997). Prospective study of risk factors for the initiation of cigarette smoking. *Journal of Consulting and Clinical Psychology*, *65*, 1011–1016.

Kubik, A., & Plesko, I. (1998). Trends in cigarette sales and lung cancer mortality in four central European countries. *Central European Journal of Public Health*, *6*, 37–41.

Lerman, C., Caporaso, N., Main, D., Audrain, J., Boyd, N. R., Bowman, E. D., & Shields, P. G. (1998). Depression and self-medication with nicotine: The modifying influence of the dopamine D4 receptor gene. *Health Psychology*, *17*, 56–62.

Lesch, K. P. (1998). Serotonin transporter and psychiatric disorders: Listening to the gene. *The Neuroscientist*, *4*, 25–34.

Li, M. D., Cheng, R., Ma, J. Z., & Swan, G. E. (2003). A meta-analysis of estimated genetic and environmental effects on smoking behavior in male and female adult twins. *Addiction*, *98*, 23–31.

Masse, L. C., & Tremblay, R. E. (1997). Behavior of boys in kindergarten and the onset of substance use during adolescence. *Archives of General Psychiatry*, *54*, 62–68.

McCrae, R. R., & Costa, P. T., Jr. (1997). Personality trait structure as a human universal. *American Psychologist*, *52*, 509–516.

Mealey, L. (1995). The socio-biology of sociopathy: An integrated evolutionary model. *Behavioral and Brain Sciences*, *18*, 523–599.

Mendez, D., & Warner, K. E. (2004). Adult cigarette smoking prevalence: Declining as expected (not as desired). *American Journal of Public Health*, *94*, 251–252.

Munafò, M. R., Bradburn, M., Bowes, L., & David, S. (2004). Investigating subgroups in smoking cessation treatment response. *Nicotine & Tobacco Research*, *6*, 865–867.

Munafò, M. R., Clark, T. G., Johnstone, E. C., Murphy, M. F. G., & Walton, R. (2004). The genetic basis for smoking behavior: A systematic review and meta-analysis. *Nicotine & Tobacco Research*, *6*, 583–597.

Munafò, M. R., Clark, T. G., Moore, L. R., Payne, E., Walton, R., & Flint, J. (2003). Genetic polymorphisms and personality: A systematic review and meta-analysis. *Molecular Psychiatry*, *8*, 471–484.

Munafò, M. R., Drury, M., Wakley, G., Chambers, R., & Murphy, M. (2003). *Smoking cessation matters in primary care*. Oxford, U.K.: Radcliffe Medical Press.

Munafò, M. R., Johnstone, E., Murphy, M. F. G., & Walton, R. (2001). New directions in the genetic mechanisms underlying nicotine addiction. *Addiction Biology*, *6*, 109–117.

Munafò, M. R., Zetteler, J. I., & Clark, T. G. (2007). Personality and smoking status: A meta-analysis. *Nicotine & Tobacco Research*, *9*.

Perkins, K. A. (2001). Smoking cessation in women: Special considerations. *CNS Drugs*, *15*, 391–411.

Peto, R., Chen, Z. M., & Boreham, J. (1999). Tobacco—the growing epidemic. *Nature Medicine*, *5*, 15–17.

Reuter, M., Netter, P., Toll, C., & Hennig, J. (2002). Dopamine agonist and antagonist responders as related to types of nicotine craving and facets of extraversion. *Progress in Neuropsychopharmacology and Biological Psychiatry*, *26*, 845–853.

Revelle, W. (1995). Personality processes. *Annual Review of Psychology*, *46*, 295–328.

Wadsworth, M. E., Butterworth, S. L., Hardy, R. J., Kuh, D. J., Richards, M., Langenberg, C., Hilder, W. S., & Connor, M. (2003). The life course prospective design: An example of benefits and problems associated with study longevity. *Social Science and Medicine*, *57*, 2193–2205.

Wadsworth, M. E. J., Mann, S. L., Rodgers, B., Kuh, D. J., Hilder, W. S., & Yusuf, E. J. (1992). Loss and representativeness in a 43 year follow up of a national birth cohort. *Journal of Epidemiology and Community Health*, *46*, 300–304.

White, H. R., Pandina, R. J., & Chen, P. H. (2002). Developmental trajectories of cigarette use from early adolescence into young adulthood. *Drug and Alcohol Dependence*, *65*, 167–178.

Wills, T. A., Sandy, J. M., & Yaeger, A. (2000). Temperament and adolescent substance use: An epigenetic approach. *Journal of Personality*, *68*, 1127–1152.