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Impulsivity-related Traits Are Associated with Higher White Blood Cell Counts

Angelina R. Sutin¹, Yuri Milaneschi¹, Alessandra Cannas², Luigi Ferrucci¹, Manuela Uda², David Schlessinger¹, Alan B. Zonderman¹, and Antonio Terracciano¹

¹National Institute on Aging, NIH, DHHS

²Istituto di Neurogenetica e Neurofarmacologia, Consiglio Nazionale delle Ricerche

Abstract

A chronically elevated white blood cell (WBC) count is a risk factor for morbidity and mortality. The present research tests whether facets of impulsivity – impulsiveness, excitement-seeking, self-discipline, and deliberation – are associated with chronically elevated WBC counts. Community-dwelling participants ($N=5,652$) from Sardinia, Italy, completed a standard personality questionnaire and provided blood samples concurrently and again three years later. Higher scores on impulsivity, in particular impulsiveness and excitement-seeking, were related to higher total WBC counts and higher lymphocyte counts at both time points. Impulsiveness was a predictor of chronic inflammation: For every standard deviation difference in this trait, there was an almost 25% higher risk of elevated WBC counts at both time points ($OR=1.23$, 95% $CI=1.10-1.38$). These associations were mediated, in part, by smoking and body mass index. The findings demonstrate that links between psychological processes and immunity are not limited to acute stressors; stable personality dispositions are associated with a chronic inflammatory state.

Keywords

Personality; Impulsivity; White blood cells; Inflammation; Neuroticism; Conscientiousness

Impulsivity is a multifaceted construct that has a prominent role in many psychological theories and processes (Whiteside & Lynam, 2001) and is a key feature in many psychiatric conditions (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Impulsivity has been linked to biomarkers of physical health in cohort-based and clinical populations (Troisi, 2009), but interest in the effect of non-pathological impulsivity on physical health is only starting to gain momentum. For example, impulsivity-related traits are associated with health-risk behaviors, such as smoking (Lipkus, Barefoot, Williams, & Siegler, 1994; Terracciano, Löckenhoff, Crum, Bienvenu, & Costa, 2008) and binge eating (Benjamin & Wulfert, 2005), as well as physiological risk factors, such as obesity (Mobbs, Crépin, Thiéry, Golay, & Van der Linden, 2010; Terracciano et al., 2009), metabolic syndrome (Sutin, Costa et al., 2010), and unhealthy lipoprotein profiles (Sutin, Terracciano, Deiana, Uda et al., 2010). Less is known, however, about the intermediate physiological pathways

between impulsivity-related traits and health outcomes; one such pathway may be through elevated white blood cell (WBC) counts.

The immune system produces WBCs to defend the body against infection. Elevated WBCs increase risk for cardiovascular disease and predict all-cause and cardiovascular mortality (Lee et al., 2001; Ruggiero et al., 2007), independent of other inflammatory factors (Willems, Trompet, Blauw, Westendorp, & De Craen, 2010). Neutrophils and lymphocytes account for most WBCs. Neutrophils, as part of the innate immune system, respond to acute injuries, whereas lymphocytes, as part of the adaptive immune system, determine the specificity of immune response. Neutrophils have a short lifespan, ranging from hours up to a few days, whereas lymphocytes may remain in the blood stream for years. Although a sign of inflammation, WBC counts are only modestly associated with other markers of inflammation, such as CRP and IL-6. In addition, WBCs predict morbidity and mortality, independent of these other common inflammatory markers (Arain et al., 2009; Cavusoglu et al., 2006; Kincl et al., 2010; Willems et al., 2010).

Personality traits, and impulsivity-related traits in particular, have been linked with inflammatory markers, including both IL-6 and CRP (Sutin, Terracciano, Deiana, Naitza et al., 2010). Given that impulsivity-related traits are associated directly with infection (Moffitt et al., 2011), as well as other factors that increase inflammation, such as obesity (Terracciano et al., 2009) and smoking (Terracciano et al., 2008), these traits may be associated with WBCs, independent of IL-6 and CRP. Although the associations between WBCs and broad personality traits tend to be mixed (Miller, Cohen, Rabin, Skoner, & Doyle, 1999), narrower traits, such as impulsivity, may share stronger relations with health-related variables than the broad domains (Paunonen, Haddock, Forsterling, & Keinonen, 2003). In addition, given that the associations between personality and intermediate markers of health tend to be modest (Chapman, Khan et al., 2009; Sutin, Terracciano, Deiana, Naitza et al., 2010), large samples are needed to reliably detect consistent associations.

We used a large population-based sample to test whether trait impulsivity and four specific facets of impulsivity (Whiteside & Lynam, 2001) were associated with WBC counts measured concurrently, three years later, and with change in WBC counts across this interval. By focusing on associations that replicated at two time points we assessed whether impulsivity-related traits were related to chronically higher WBC counts. Measured with the Revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992), we expected N5: Impulsiveness (the tendency to give in to strong impulses), E5: Excitement-Seeking (the desire to engage in risky or dangerous activities for fun), low C5: Self-Discipline (the ability to stay committed to a task or lifestyle amid difficulties and distractions), low C6: Deliberation (the ability to foresee consequences of an action) and a composite of these facets (Impulsivity Index) to be associated with higher total WBC and lymphocyte counts. In addition to these facets, as a point of comparison, we report the associations between WBC counts and the five broad traits that define the Five Factor Model of personality (Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness). Finally, because impulsivity traits are related to obesity (Chapman, Fiscella, Duberstein, Coletta, & Kawachi, 2009; Sutin, Ferrucci, Zonderman, & Terracciano, 2011; Terracciano et al., 2009) and smoking (Terracciano, Löckenhoff, Crum et al., 2008)

and both obesity (Dixon & O'Brien, 2006; Panagiotakos, Pitsavos, Yannakoulia, Chrysoshoou, & Stefanadis, 2005) and smoking (Brown, Giles, & Croft, 2001; Petitti & Kipp, 1986; Sunyer et al., 1996) increase WBC counts, we tested whether body mass index (BMI) and smoking mediated these relations.

Method

Participants

Participants were drawn from the SardiNIA project, a large, on-going multidisciplinary study of the genetic and environmental basis of complex traits and age-related processes (Pilia et al., 2006). Approximately 62% of the population ($N = 6,148$ individuals; 57% female), aged 14 to 102 years, from a cluster of four towns in the Lanusei Valley enrolled in the study. The current study includes 5,652 participants (58% female) who completed the personality questionnaire and had their WBC counts assessed at Time 1. A total of 4,755 participants (58% female) were assessed again for WBCs approximately three years later. Age ranged from 14 to 94 ($M = 42.65$; $SD = 16.93$) at Time 1 and from 17 to 98 ($M = 46.06$; $SD = 16.28$) at Time 2. Each participant signed a consent form approved by the institutional review board in Italy and the USA.

Measures

Personality was assessed using the Italian version (Terracciano, 2003) of the Revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992). Participants filled out the self-report questionnaire (89%) or chose to have the questionnaire read by a trained psychologist (11%). A variable (test administration) that indicated this difference in administration was used as a covariate in all analyses. Raw scores were converted to T-scores ($M=5$, $SD=1$) using American combined-sex norms. We examined the four impulsivity-related facets of the NEO-PI-R, N5: Impulsiveness, E5: Excitement-Seeking, C5: Self-Discipline, and C6: Deliberation, and a composite index of these four facets (the "Impulsivity index," based on the average score after reversing the two Conscientiousness facets). In addition, we report the results for the five broad domains of personality.

Blood samples were drawn from subjects in the early morning after an overnight fast. The blood samples were processed within 24 hours and were stored at RT until they were assayed.

Total WBC count ($10^3/\text{ul}$) was performed using standard automated procedures. Absolute neutrophil and lymphocyte counts were calculated by multiplying the corresponding percentage with the total WBC count. At Time 1 and Time 2, respectively, WBCs had a mean of 6.68 ($SD=1.66$) and 6.74 ($SD=1.66$), neutrophils had a mean of 3.81 ($SD=1.28$) and 3.86 ($SD=1.27$), and lymphocytes had a mean of 2.28 ($SD=.68$) and 2.27 ($SD=.68$).

Serum IL-6 levels were measured by Quantikine High Sensitive Human IL-6 Immunoassay (R&D Systems, Inc., Minneapolis, MN), according to manufacturer's instructions. This method employs solid-phase ELISA techniques and has a detection limit of 0.016–0.110 pg/mL, with mean sensitivity of 0.039 pg/mL. The intra-assay coefficient of variations (CVs) were 6.9% to 7.4% over the range 0.43–5.53 pg/mL. Serum levels of high sensitivity

C-reactive protein (hsCRP) were measured by the high sensitivity Vermont assay (University of Vermont, Burlington), an enzyme-linked immunosorbent assay calibrated with WHO Reference Material (Macy et al., 1997). The lower detection limit of this assay is 0.007 mg/ml, with an inter-assay coefficient of variation of 5.14%. Across the entire sample, IL-6 had a mean of 2.75 pg/ml ($SD = 2.35$) and CRP had a mean of 2.71 ug/ml ($SD = 4.84$).

Mediators

We tested two mediators of the personality-WBC relations: BMI and smoking. BMI was calculated (kg/m^2) using staff-assessed height and weight ($M = 25.24$, $SD = 4.65$) and current smoking status was assessed with a single-item question about smoking (21% current smokers).

Analytic Strategy

We tested the association between personality traits and WBCs in several ways. First, we examined the partial correlations between personality and WBC counts measured at Time 1 and Time 2, controlling for sex, age, education, and test administration. Second, we tested whether these associations were moderated by sex or age, using Aiken and West's (1991) methodology for testing interactions. Third, we used logistic regression to test whether personality predicted which participants had WBC counts that exceeded $8.20 \times 10^3/\text{ul}$; this threshold has been found to increase risk for mortality (Brown et al., 2004). Fourth, we examined whether neutrophils and lymphocytes were correlated with personality, controlling for the same set of covariates. Fifth, we tested whether the traits predicted change in WBC counts over the three years by regressing Time 2 counts on Time 1 counts, the covariates, and the traits. Finally, we tested whether BMI and smoking mediated the personality-WBC relations using bootstrapping procedures (Preacher & Hayes, 2008). In all of the analyses, we focus on the findings that replicated across the concurrent and prospective analyses.

Results

The correlations among the covariates and WBCs are shown in Table 1. At both Time 1 and Time 2, higher WBC counts were associated with being male, younger, smoking, and higher BMI. Lymphocytes were associated with these factors and with education. Neutrophils were associated with being male, a current smoker, and having a higher BMI.

As expected, the overall Impulsivity index was associated with higher total WBC counts at both time points (see Table 2). Of the four facets, N5: Impulsiveness and E5: Excitement-Seeking were the most consistently associated with higher WBC counts: Those who had trouble resisting their impulses and those who craved excitement had higher levels of circulating WBCs concurrently and three years later. Neither the Impulsivity index nor any of the individual components was associated with changes in total WBC counts across the three years. These associations were virtually identical when controlling for IL-6 and CRP and neither sex nor age moderated any of the associations across both time points.¹

The logistic regressions mostly paralleled the correlational findings (see Table 2). At both Time 1 and Time 2, for every standard deviation difference in the Impulsivity index there

was an almost 30% higher risk of having WBC counts that exceeded the threshold for risk of mortality. At the facet level, all aspects of trait impulsivity were significant predictors in the logistic analyses, with N5: Impulsiveness and E5: Excitement-Seeking associated with a higher risk of elevated WBCs, and C5: Self-Discipline and C6: Deliberation associated with a lower risk. Further analyses indicated that participants high on N5: Impulsiveness were more likely to have *chronically* elevated WBCs: For every standard deviation difference in N5: Impulsiveness, there was an almost 25% higher risk that WBCs exceeded the threshold for risk of mortality at both time points (OR=1.23, 95% CI=1.10–1.38).

To rule out the possibility that these relations were due to elevations in WBC because of either inflammatory disease or acute injury, we reran all of the above analyses without participants who had WBC counts that were more than two standard deviations above the mean. The correlations between WBC count and self-discipline and deliberation at Time 1 were reduced to non-significance. All other associations remained significant.

As reported in Table 3, the impulsivity-related traits were associated with lymphocytes, the type of WBC that lasts in the blood for years, but were mostly unrelated to the more short-lived neutrophils. Only the Impulsivity index, but not any of the individual components, was associated with neutrophils at Time 1; this association did not replicate at Time 2. Again, it was the aspects of impulsivity related to cravings and excitement which were associated with lymphocyte counts at both time points.

Consistent with the idea that lymphocytes are more stable than neutrophils, the retest correlation was higher for lymphocytes than neutrophils ($r_s = .71$ and $.54$, respectively, both $p < .01$). The Impulsivity index, as well as N5: Impulsiveness and E5: Excitement-Seeking predicted increases in lymphocytes, but not neutrophils, over the three years of the study. Similar to the total WBC count, all of the above associations were virtually identical when controlling for IL-6 and CRP and neither age nor sex consistently moderated the other personality-lymphocyte² or personality-neutrophil³ associations.

In contrast to the impulsivity-related traits, the associations between the five broad dimensions of personality and the WBC counts were less consistent. Indeed, none of the five traits was associated with total WBC counts (see Table 2) or lymphocyte and neutrophil counts (see Table 3) across both Time 1 and Time 2 and the traits were unrelated to change in these counts across the three years. Conscientiousness and Openness were, however, predictors of clinically-elevated levels of WBCs: For every standard deviation difference in

¹Age moderated some of the associations at Time 1, but not at Time 2. At Time 1, among older participants, high scores on the Impulsivity index ($\beta_{\text{Impulse} \times \text{age}} = .03, p < .05$) and E5: Excitement-Seeking ($\beta_{\text{E5} \times \text{age}} = .03, p < .05$) and low scores on C5: Self-Discipline ($\beta_{\text{C5} \times \text{age}} = -.03, p < .05$) were associated with higher WBC, whereas these traits were less related to WBC counts among younger participants. None of these interactions, however, replicated at Time 2 ($\beta_{\text{interaction}} = -.02, .00$, and $.00$, *ns*, respectively, for the Impulsivity index, E5: Excitement-Seeking, and C5: Self-Discipline).

²Age moderated the association between C5: Self-Discipline and lymphocyte count at Time 1. Specifically, higher scores on C5: Self-Discipline were associated with lower lymphocytes among older, but not younger, participants ($\beta_{\text{C5} \times \text{age}} = -.03, p < .05$). This interaction was not significant at Time 2 ($\beta_{\text{C5} \times \text{age}} = .01$, *ns*).

³Age moderated several of the associations between personality and neutrophils at Time 1. Older participants who scored higher on C5: Self-Discipline ($\beta_{\text{C5} \times \text{age}} = -.03, p < .05$) and C6: Deliberation ($\beta_{\text{C6} \times \text{age}} = -.03, p < .05$), and lower on the Impulsivity index ($\beta_{\text{Impulse} \times \text{age}} = .04, p < .01$) and E5: Excitement-Seeking ($\beta_{\text{E5} \times \text{age}} = .04, p < .01$) had lower neutrophil counts; these traits were unrelated to neutrophil counts among the younger participants. None of these interactions, however, replicated at Time 2 ($\beta_s = -.01, .02, .00$, and $.02$, respectively, for, C5: Self-Discipline, C6: Deliberation, the Impulsivity index, and E5: Excitement-Seeking, all *ns*).

Conscientiousness and Openness, there was about a 10% higher risk of elevated WBC counts (Table 2).

Finally, we tested BMI and smoking as mediators of the impulsivity-WBC relations (see Figure 1). Smoking mediated this association for the Impulsivity index, N5: Impulsiveness and E5: Excitement-Seeking concurrently (point estimates=.0717 [95% CI = .0504–.0927], .0407 [95% CI=.0273–.0563], and .0425 [95% CI=.0287–.0565], respectively) and prospectively (point estimates= .0706 [95% CI = .0520–.0924], .0405 [95% CI=.0265–.0565], and .0424 [95% CI=.0275–.0573], respectively). That is, participants who tended to give in to their cravings and those who loved excitement were more likely to smoke, and smoking, in turn, was associated with higher WBC counts at both time points. BMI was a significant mediator for the Impulsivity index and N5: Impulsiveness: Participants high on these traits had higher WBC counts, in part, because they tended to weigh more both concurrently (point estimates = .0099 [95% CI = .0006–.0202] and .0266 [95% CI = .0189–.0356] and prospectively (point estimates = .0109 [95% CI = .0015–.0227] and .0275 [95% CI = .0194–.0378], respectively).

Turning to the lymphocyte counts, smoking mediated this association for the Impulsivity index, N5: Impulsiveness, and E5: Excitement-Seeking concurrently (point estimates=.0209 [95% CI=.0154–.0277], .0119 [95% CI=.0077–.0166], and .0124 [95% CI = .0092–.0165], respectively) and prospectively (point estimates=.0216 [95% CI=.0151–.0294], .0123, 95% CI=.0074–.0168, and .0130 [95% CI = .0084–.0178, respectively). BMI was a significant mediator for the Impulsivity index and N5: Impulsiveness both concurrently (point estimates = .0036 [.0003–.0078] and .0100 [95% CI = .0069–.0134], respectively) and prospectively (point estimates = .0040 [95% CI = .0003–.0083] and .0100 [95% CI = .0069–.0137], respectively). Smoking and BMI also mediated the association between personality and change in lymphocytes: Impulsive participants showed greater increases in lymphocyte counts across the three years, in part, because they smoked (point estimates = .0048 [95% CI = .0024–.0084], .0027 [95% CI = .0013–.0046] and .0029 [95% CI = .0012–.0049, respectively for the Impulsivity index, N5: Impulsiveness, and E5: Excitement-Seeking) and were overweight (N5: Impulsiveness only: point estimate = .0028 [95% CI = .0011–.0051]).

Discussion

The present study used a large population-based sample to test whether personality traits are associated with chronically higher WBC counts. We found consistent support for the association between WBCs and two aspects of impulsivity: Individuals who cannot control their urges and those who seek stimulation have higher WBC counts concurrently and when measured approximately three years later. These associations were similar across men and women and younger and older individuals and were due, in part, to smoking and obesity.

To our knowledge, this is the first study to report an association between impulsivity-related traits and elevated WBC counts. Our results add to the growing body of research linking personality traits to inflammatory processes (for a review see Segerstrom, 2000). The body has multiple mechanisms to respond to infection, including production of IL-6 and CRP. Personality has been related to these inflammatory markers (Chapman, Khan et al., 2009;

Sutin, Terracciano, Deiana, Naitza et al., 2010), but our results did not change when we included these two markers as covariates. This independence suggests that impulsivity-related traits may have a pervasive relation with inflammatory responses. Such chronic inflammation may be one pathway through which personality is associated with disease progression and premature mortality.

In addition to total WBC count, Impulsiveness and Excitement-Seeking were consistently associated with lymphocyte counts across the two time points. The association between these traits and higher lymphocyte counts may reflect the tendency of these individuals to get in to situations that expose their immune systems to more pathogens. The relation between lymphocytes and immune function is complex; some types of lymphocytes promote good immune function, whereas others contribute to chronic inflammation (Hansson, Libby, Schönbeck, & Yan, 2002). In the present research, although we did not distinguish between different types of lymphocytes, both smoking and obesity were positively correlated with lymphocyte count. These associations suggest that the total lymphocyte count may predominantly reflect the types of cells that contribute to pathological states. As discussed below, lifestyles associated with impulsivity-related traits may contribute to elevated lymphocyte counts.

Our findings suggest mechanisms (smoking, obesity) that account for part of the relations between impulsivity and inflammation. In addition to these factors, characteristics of the traits may draw individuals to environments that increase WBCs (i.e., tropisms; Friedman, 2000). For example, excitement-seekers may be more likely to get into situations that expose them to infections (e.g., unprotected sex) or engage in activities that put them at risk for injury. Over time this may lead to chronically elevated WBC counts.

The five broad personality domains were not consistently related to either total WBCs or lymphocytes and neutrophil counts. This divergence across levels of personality underscores the importance of looking at the more circumscribed facet level of analysis. For example, all of the facets of Neuroticism share a common core of negative affect, but each facet also has a unique component that may or may not be associated with an outcome of interest. The impulsiveness facet of Neuroticism is more strongly related to factors that increase inflammation, such as smoking and BMI, than the other facets of Neuroticism (Sutin et al., 2011; Terracciano & Costa, 2004). In addition, compared to the other facets, impulsiveness loads more weakly on Neuroticism, and it shares modest associations with Extraversion and Conscientiousness (Costa & McCrae, 1992). Thus, the correlates of this facet are sometimes more consistent with those of the other impulsivity-related facets rather than factor-level Neuroticism. At the aggregate level, Neuroticism is not associated with WBCs, but the aspect of Neuroticism that captures an individual's inability to control impulses is associated with chronic inflammation.

This research has implications for how we understand the connection between psychological processes and physical health. Much of the work on psychological constructs and immune response has focused on acute psychological stressors (Isowa, Ohira, & Murashima, 2006). Our findings suggest that characteristic ways of thinking, feeling, and behaving share long-term relations with immune response. In particular, stable personality traits are associated

with the type of WBCs that remains in the body for years at a time. Acute psychological stress may activate the innate immune system to quickly combat the threat (Schaller, Miller, Gervais, Yager, & Chen, 2010), whereas, by activating the adaptive immune system, impulsivity-related traits may have more long-term consequences for an individual's health.

Our study had several strengths, including a large, population-based sample that spanned the adult lifespan and two measurements of WBC counts, three years apart. Despite these strengths, there are some limitations to consider. First, our sample was derived from a rural area in Sardinia and may not be generalizable. Our findings, however, were consistent with the literature linking impulsivity-related traits to health outcomes and thus are not likely to be sample specific. Second, although the analyses included factors thought to influence WBC levels, it is likely that there are other mediators. For example, behavioral and physiological factors not assessed, such as physical activity, life events, and stress on the hypothalamic–pituitary–adrenocortical (HPA) axis, may also contribute to this association. Third, we assumed that personality would have a long-term effect on WBCs, but chronic inflammation may also have an effect on personality traits. For example, experimentally-inducing infection increases levels of anxiety and depressed mood (Reichenberg et al., 2001). Inflammation may have a similar effect on impulsivity-related traits by reducing the cognitive and emotional resources needed to not give in to impulses, to think before acting, etc. Future research needs to test whether there are reciprocal relations between personality and inflammation. Finally, the correlations between personality and WBCs were modest in magnitude. These associations, however, were consistent with the literature on impulsivity and were of similar magnitude of other studies linking inflammatory markers to psychological processes (Davidson et al., 2009; Gimeno et al., 2009). In addition, the magnitude of the logistic regressions was similar to that of studies linking inflammatory markers to mortality (Willems et al., 2010). Despite these potential limitations, the present research suggests that being impulsive or a thrill seeker increases the risk of chronically-elevated white blood cell counts.

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Figure 1.
Example model of smoking and body mass index mediating the association between N5:
Impulsiveness and white blood cells.

Table 1

Correlations Between Covariates and White Blood Cell Counts

White Blood Cells	Sex	Age	Education	Smoke	BMI	IL-6	CRP
Time 1							
Total WBC count	.17*	-.09**	.01	.29**	.09**	.16**	.17**
Lymphocytes	.12**	-.16**	.05**	.22**	.04**	-.02	-.03*
Neutroils	.10**	-.04**	-.01	.23**	.07**	.19**	.22**
Time 2							
Total WBC count	.17**	-.08**	.00	.27**	.10**	.08**	.08**
Lymphocytes	.10**	-.16**	.05**	.22**	.04**	.01	.04**
Neutroils	.12**	-.03	-.01	.21**	.04*	.07**	.09**

Note. N = 5,652 for Time 1 and N = 4,755 for Time 2. WBC = white blood cell. BMI = body mass index. IL-6 = interleukin-6. CRP = C-reactive protein.

*
p < .05.
**
p < .01.

Table 2

Associations Between Impulsivity-related Traits and White Blood Cell Counts

Trait	Correlations		Logistic Regressions ^{a,b}	
	Time 1	Time 2	Time 1	Time 2
Impulsivity index	.05**	.05**	.02	1.29 (1.15–1.44)**
N5: Impulsiveness	.04**	.04**	.02	1.15 (1.06–1.25)**
E5: Excitement-Seeking	.04**	.04**	.02	1.13 (1.04–1.23)**
C5: Self-Discipline	-.03*	-.02	.02	1.19 (1.09–1.30)**
C6: Deliberation	-.03*	-.03	-.01	.91 (.84–.97)**
Neuroticism	.01	.01	-.01	.92 (.85–.99)*
Extraversion	.02	.04*	.01	1.04 (.96–1.13)
Openness	.02	.03	.03	1.04 (.95–1.14)
Agreeableness	-.01	.01	1.07 (.98–1.17)	1.12 (1.02–1.23)*
Conscientiousness	-.03*	-.03	.02	1.10 (1.01–1.20)*
			.95 (.88–1.04)	.97 (.89–1.06)
			-.01	.89 (.82–.97)**

Note. $N = 5,652$ for Time 1 and $N = 4,755$ for Time 2. Correlations and logistic regressions control for sex, age, education, and test administration (self-administered vs. clinician administered). Change analyses also control for Time 1 WBC. WBC = white blood cell.

^aPer one standard deviation increase in personality.

^bTop 10% of the distribution of WBCs contrasted against the rest of the distribution.

* $p < .05$.

** $p < .01$.

Table 3

Partial Correlations Between Impulsivity-related Traits and Lymphocyte and Neutrophil Counts

Trait	Lymphocytes			Neutrophils		
	Time 1	Time 2	Change	Time 1	Time 2	Change
Impulsivity index	.05**	.06**	.03*	.03*	.02	.01
Impulsiveness	.05**	.06**	.04**	.02	.01	.00
Excitement-Seeking	.04**	.05**	.03*	.02	.02	.01
Self-Discipline	-.02	-.02	-.01	-.02	-.01	.00
Deliberation	-.03*	-.02	-.01	-.02	-.02	-.01
Neuroticism	.01	.01	.02	.00	.01	.01
Extraversion	.02	.04*	.03	.02	.02	.01
Openness	.02	.04*	.02	.02	.01	.01
Agreeableness	-.01	-.01	.00	.00	.01	.02
Conscientiousness	-.02	-.02	-.01	-.02	-.02	-.01

Note. $N = 5,652$ for Time 1 and $N = 4,755$ for Time 2. Correlations control for sex, age, education, and test administration (self-administered vs. clinician administered). Change analyses also control for Time 1 lymphocytes and neutrophils.

* $p < .05$.

** $p < .01$.